

ENVIRONMENTAL AUTHORITY EPML00731213

AMENDMENT APPLICATION SUPPORTING INFORMATION REPORT

DUGALD RIVER MINE

MMG Dugald River Pty Ltd



May 2024

WULGURU TECHNICAL SERVICES

Contact Details	
Company	Wulguru Technical Services Pty Ltd
Project Manager	Madison Jackson
Email	madison@wulgurutechservices.com.au
Mail	PO Box 2553 IDALIA QLD 4810
ABN	79 644 301 655

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1. Introduction

Wulguru Technical Services Pty Ltd (WTS) were engaged by MMG Dugald River Pty Ltd (MMG) to prepare supporting information for an amendment to Environmental Authority (EA) EPML00731213, dated 19 December 2022. The proposed amendment will address matters relating to administrative corrections as well as the construction of a windfarm, ancillary infrastructure and other proposed amendments.

This report is submitted to the Department of Environment, Science and Innovation (DESI) in support of MMG's application to amend the EA and provides a detailed response to the following guidelines:

- *Approval processes for Environmental Authorities* (DES 2019b);
- *Application requirements for activities with impacts to air* (DES 2017a);
- *Application requirements for activities with impacts to land* (DES 2017b);
- *Application requirements for activities with impacts to water* (DES 2017c);
- *Application requirements for activities with noise impacts* (DES 2017d); and
- *Application requirements for activities with waste impacts* (DES 2019a).

Whilst not legislated by the DESI*, State Code 23: Wind farm development* (State of Queensland, 2017), has been referenced for specific guidance relating to the construction and operation of the windfarm.

1.1. Purpose

The purpose of this document is to describe the existing environmental values and assess the potential environmental impacts that may arise from the proposed amendment. A risk assessment has been completed for the identified potential impacts and reasonable and appropriate mitigation measures are proposed.

1.2. Project Location

The Dugald River Mine (DRM) is located approximately 63 km northwest of Cloncurry in north-western Queensland (Figure 1), adjacent to the Knapdale Range. The site encompasses 40 Mining Leases (MLs) and one Mineral Development Lease (MDL) as detailed in Table 1.

Table 1. Granted and Underlying Tenure for DRM and Associated Linear Infrastructure

Permit	Permit Name	Area (ha)	Land Tenure
MDL 79	NA	227.59	59TG40; 36AP23793; 92SP303378
ML 2467	DUGALD 1	16.21	27B15753; 36AP23793
ML 2468	DUGALD 2	16.21	27B15753; 35B15753; 36AP23793
ML 2469	DUGALD 3	16.2	35B15753; 36AP23793; 36B15753
ML 2470	DUGALD 4	16.19	36AP23793; 36B15753
ML 2471	DUGALD 5	16.19	36AP23793
ML 2477	DUGALD 6	32.51	36AP23793
ML 2478	DUGALD 7	129.49	36AP23793; 92SP303378
ML 2479	DUGALD 8	32.37	36AP23793; 92SP303378
ML 2480	DUGALD 9	32.37	36AP23793; 92SP303378
ML 2481	DUGALD 10	129.49	36AP23793; 92SP303378
ML 2482	DUGALD 11	32.37	36AP23793
ML 2496	DUGALD RIVER NO 6	129.49	36AP23793
ML 2497	DUGALD RIVER NO 7	8.09	36AP23793
ML 2498	DUGALD RIVER 8	29.06	36AP23793; 36B15753
ML 2499	DUGALD RIVER 9	28.08	36AP23793
ML 2500	DUGALD RIVER 10	28.35	36AP23793
ML 2501	DUGALD RIVER 11	30.4	36AP23793
ML 2502	DUGALD RIVER 12	31.63	36AP23793
ML 2556	CLANDESTINE 7	127.72	36AP23793; 92SP303378
ML 2557	CLANDESTINE 8	129.14	36AP23793
ML 2558	CLANDESTINE 13	128.5	36AP23793; 92SP303378
ML 2559	CLANDESTINE 14	98.7	36AP23793; 92SP303378
ML 2596	DUGALD RIVER 51	19	36AP23793
ML 2599	DUGALD RIVER 57	44.77	36AP23793; 92SP303378
ML 2601	DUGALD RIVER 61	28.5	36AP23793
ML 2638	KNAPDALE	122.51	36AP23793; 92SP303378
ML 2684	DUGALD NO 12	1.05	36AP23793
ML 2685	DUGALD NO 13	2.45	36AP23793
ML 7496	DUGULD	24.76	27B15753; 35B15753; 36AP23793
ML 90047	KNAPDALE NO 2	8.36	36AP23793
ML 90049	DUGALD SOUTH NO 7	0.31	36AP23793
ML 90050	DUGALD SOUTH NO 8	0.22	36AP23793
ML 90051	SCANLAN NO 6	9.59	36AP23793
ML 90211	DUGALD TSF	642.67	36AP23793; 92SP303378
ML 90212	DUGALD TXS1	100.48	36AP23793; 92SP303378
ML 90213	DUGALD TXS2	31.7	36AP23793; 92SP303378
ML 90218	DUGALD WPIPE	43.49	5AP23793; 36AP23793
ML 90220	DUGALD PLINE	507.93	2BD56; 3635SP274652; 36AP23793; 3AP23793; 4144SP256851; 521CP905413; 7CP905412; 91SP303378; 92SP303378

Permit	Permit Name	Area (ha)	Land Tenure
ML 90230	DACCESS	120.32	2577PH139; 36AP23793; 92SP303378; 211SP136468
ML 90237	DUGALD TXS3	20.5	36AP23793; 92SP303378



Client: Dugald River Mine Pty Ltd
Project number: 2023.03002
CRS: GDA2020 EPSG:7844
Date: 21 March 2023

Print as A3

Figure 1. Project Location

Legend

- Key Features
- State Roads
- Mine Lease

ESRI Satellite

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WULGURU TECHNICAL SERVICES

1.3. Legislative Context

1.3.1. *Environmental Protection Act 1994 (Qld)*

The *Environmental Protection Act 1994* (EP Act) is Queensland's primary piece of environmental legislation. The objective of the EP Act is to 'protect Queensland's environment while allowing for development that improves the total quality of life, both now and in the future, in a way that maintains the ecological processes on which life depends'.

'Environment' is defined under the Act as (section 8):

- Ecosystems and their constituent parts, including people and communities;
- All natural and physical resources;
- The qualities and characteristics of locations, places and areas, however large or small, that contribute to their biological diversity and integrity, intrinsic or attributed scientific value or interest, amenity, harmony and sense of community; and
- The social, economic, aesthetic and cultural conditions that affect, or are affected by, things mentioned in paragraphs (a) to (c).

To ensure the protection of environmental values, MMG are required to meet the requirements of the EP Act and its subordinate legislations.

1.3.2. *Mineral Resources Act 1989 (Qld)*

The *Mineral Resources Act 1989 (Qld)* (MR Act) provides for the assessment, development and utilisation of mineral resources. The MR Act establishes a framework to facilitate mining-related activities through the leasing of prospecting, exploration, mineral development, and mining tenure.

Approval is required to mine minerals specified in the lease and for all purposes necessary to effectually carry on the mining as well as purposes other mining specified in the ML and associated with, arising from, or promoting the activity of mining. Mining and production and associated activities including processing and rehabilitation must be conducted within a ML.

1.3.3. *Planning Act 2016 (Qld)*

The *Planning Act 2016 (QLD)* (Planning Act) establishes the framework of planning instruments that support the operation of the three main systems: plan-making, development assessment and dispute resolution. The Planning Act establishes a system of land-use planning and development assessment which balances:

- the protection of ecological processes and natural systems at local, regional, state and national levels;
- economic development; and
- the cultural, economic, physical and social wellbeing of Queenslanders.

Whilst the Planning Act is not assessable for this project, technical guidance has been referenced, where relevant.

1.3.4. *State Code 23: Wind Farm Development*

The purpose of *State Code 23: Wind farm development* (State of Queensland, 2017) is to ensure that the impacts arising from the construction, operation, and decommissioning of wind farms do not result in unacceptable adverse impacts on individuals, communities, and the natural environment.

Whilst not assessable for this project, State Code 23 has been referenced for technical guidance where relevant.

1.4. Overview of Proposed EA Amendment

Applications to amend an EA must be made in accordance with s.224 and s.225 of the EP Act and meet the application requirements detailed in s.226. An application must also comply with s.226AA, s.226A, s.226B, s.227 and s.227AA to be considered 'properly made'.

This application was determined to be 'properly made' on 9 January 2024.

1.4.1. Administrative Amendments

Table 2 details the proposed administrative amendments to existing conditions. The proposed amendments do not propose any change to the scale or intensity of any activity, nor do they increase the risk of environmental harm. As such, they have been assessed as having negligible risk to environmental values and have not been discussed further.

Where a non-administrative change has been proposed, the potential environmental impacts have been investigated, with the results presented in Section 4.

For completeness, a revised EA is provided in Appendix A for consideration. Revised figures for Schedule K – Maps/Plans have been provided in Appendix B for inclusion in the amended EA.

Table 2. Proposed Administrative Amendments

Condition		Proposed Amendment	Justification
Schedule A – Table 1 (Authorised Mining Activities)		Remove reference to the Plan of Operations. **Proposed condition:** Exploration activities must be consistent with conditions A33 and A34 of this environmental authority.	The Plan of Operations framework is no longer implemented. Disturbance areas and rehabilitation objectives are described in the approved Progressive Rehabilitation and Closure Plan.
A15	The emergency response/contingency plan required under condition A17 must address the following matters as a minimum: (a) response procedures to be implemented to prevent or minimise the risk of environmental harm arising from any emergency event or incident; (b) response procedures to minimise the extent and duration of environmental harm caused by any emergency event or incident; (c) the practices and procedures to be employed to restore the environment or mitigate any environmental harm caused by any emergency event or incident; (d) the resources to be used in response to any emergency event or incident; (e) procedures to investigate the cause of any emergency event or incident and where necessary, implement remedial actions to reduce the likelihood of recurrence of similar emergency event or incident;	Amend the reference from condition A17 to condition A14. **Proposed condition:** The emergency response/contingency plan required under condition A14 must address the following matters as a minimum: (a) response procedures to be implemented to prevent or minimise the risk of environmental harm arising from any emergency event or incident; (b) response procedures to minimise the extent and duration of environmental harm caused by any emergency event or incident; (c) the practices and procedures to be employed to restore the environment or mitigate any environmental harm caused by any emergency event or incident; (d) the resources to be used in response to any emergency event or incident;	The incorrect condition is referenced.

Condition		Proposed Amendment	Justification
	(f) the provision and availability of documented procedures to staff attending any emergency event or incident to enable them to effectively respond; (g) training of staff that will be called upon to respond to any emergency event or incident to enable them to effectively respond; (h) timely and accurate reporting of the circumstance and nature of any emergency event or incident to the administering authority in accordance with conditions of this environmental authority; (i) procedures for accessing monitoring points during any emergency event or incident; and (j) procedures to notify any potentially impacted stakeholder who may be affected by the emergency event or incident.	(e) procedures to investigate the cause of any emergency event or incident and where necessary, implement remedial actions to reduce the likelihood of recurrence of similar emergency event or incident; (f) the provision and availability of documented procedures to staff attending any emergency event or incident to enable them to effectively respond; (g) training of staff that will be called upon to respond to any emergency event or incident to enable them to effectively respond; (h) timely and accurate reporting of the circumstance and nature of any emergency event or incident to the administering authority in accordance with conditions of this environmental authority; (i) procedures for accessing monitoring points during any emergency event or incident; and (j) procedures to notify any potentially impacted stakeholder who may be affected by the emergency event or incident.	
A25	All exploration activities carried out at the licensed place must comply with each of the Standard Environmental Conditions contained in the most recent version of the *Code of Environmental Compliance for exploration and mineral development projects.*	All exploration activities carried out at the licensed place must comply with each of the Standard Environmental Conditions contained in the most recent version of the *Eligibility criteria and standard conditions for exploration and mineral development projects.*	The *Code of Environmental Compliance for exploration and mineral development projects* has been superseded by the *Eligibility criteria and standard conditions for exploration and mineral development projects.*

Condition		Proposed Amendment	Justification
A26	Disturbance due to exploration activities in areas not scheduled to be mined within twelve (12) months must be rehabilitated in accordance with the provisions detailed in the administering authority's *Code of Environmental Compliance for Exploration and Mineral Development Projects*.	Disturbance due to exploration activities in areas not scheduled to be mined within twelve (12) months must be rehabilitated in accordance with the provisions detailed in the administering authority's *Eligibility criteria and standard conditions for exploration and mineral development projects.*	The *Code of Environmental Compliance for exploration and mineral development projects* has been superseded by the *Eligibility criteria and standard conditions for exploration and mineral development projects.*
A27	Where a condition of this environmental authority refers to a matter addressed in the *Code of Environmental Compliance for Exploration and Mineral Development Projects,* the condition of this environmental authority prevails.	Where a condition of this environmental authority refers to a matter addressed in the *Eligibility criteria and standard conditions for exploration and mineral development projects,* the condition of this environmental authority prevails.	The *Code of Environmental Compliance for exploration and mineral development projects* has been superseded by the *Eligibility criteria and standard conditions for exploration and mineral development projects.*
B16	A wash bay for mobile equipment must be installed as part of the mineral concentrate storage facility, for cleaning machinery before exit from the area and to prevent the movement of mineral concentrate outside the building.	Remove condition.	This condition is not relevant to DRM as there is no movement of vehicles in or out of the concentrate shed. The concentrate shed is considered to be a concentrate transfer point; it is not used for storage of concentrate. Concentrate is deposited into the concentrate transfer shed from the processing plant where it is collected by a front-end loader and transferred into two half height shipping containers while the shed is under negative pressure. The containers are then washed. At this point, the doors are opened, and the

Condition		Proposed Amendment	Justification
			containers are removed via a telehandler. The frontend loader does not leave the concentrate shed. Likewise, the telehandler does not enter the concentrate shed. The concentrate transfer shed does contain a sump to capture contaminated water from the washing of the containers and the frontend loader. This sump reports to either the lead or zinc thickener within the processing circuit, depending on what type of concentrate is being loaded.
Schedule C – Table 1 (Release Points)		Remove the reference to "controlled release pipes" in the description of Sediment Dam C and Sediment Dam D. **Proposed condition**: Stormwater runoff from the existing construction camp, the change house and car park, the administration building and data centre, the sewerage treatment plant, water treatment plant and the vehicle wash bay – from the Sediment Dam C spillway.	Water is released via the spillway only. Controlled release pipes are not and have never been used at DRM. Photos of the existing sediment dam spillways are provided in Appendix C.
Schedule C – Table 1 (Release Points)		Amend the reference to the PAF waste rock dumps in relation to the source of water reporting to Sediment Dam G. **Proposed Condition**:	Sediment Dam G does not and has never received runoff from the PAF waste rock dumps.

Condition		Proposed Amendment	Justification
		Stormwater runoff from the clean water catchments adjacent to the PAF waste rock dumps – from the Sediment Dam G spillway.	
Schedule C – Table 3 (Contaminant Release during Flow Events)		Addition of the following release points to the table: • Sediment Dam G to report to North Creek. • Raw Water Dam to report to North Creek. • Sediment Dam C to report to Silvermine Creek. • STP Dam 1 to report to Silvermine Creek. • STP Dam 2 to report to Silvermine Creek. • Sediment Dam D to report to Silvermine Creek.	Schedule C – Table 3 (Contaminant Release during Flow Events defines streamflow monitoring locations to monitor releases from structures authorised in Schedule C – Table 1 (Release Points). Not all relevant release locations, specified in Schedule C – Table 1 (Release Points) are documented in the current table. The proposed amendment provides clarity on the source of the water each streamflow gauge is monitoring. This amendment does not propose the addition of any new release points, nor does it propose any change to how water is released, or water quality is monitored.
C28	The holder of this environmental authority must undertake a review of the water management plan before 1 November each year to ensure that proper and effective measures, practices or procedures are in place so that the mine is operated in accordance with the conditions of this environmental authority and that environmental harm is prevented or minimised.	Remove condition.	This is a duplication of condition A7 that requires any management plan be reviewed every three years. A routine annual review of the water management plan is administratively onerous and duplicates other management processes already implemented by MMG.

Condition		Proposed Amendment	Justification
			MMG implements an Asset Modification Management (Management of Change) Process that requires that all changes on site trigger a review of relevant management processes and documentation. This process provides another avenue for the Water Management Plan to be reviewed, in response to changes on site.
Schedule C – Table 7 (Groundwater Monitoring Locations and Frequency)		Remove Saturday Bore from Schedule C – Table 7 (Groundwater Monitoring Locations and Frequency)	Saturday Bore has collapsed and is no longer serviceable for obtaining groundwater levels or samples for analysis. Removing the bore from Table 7 provides clarity on monitoring commitments. It has been assessed that the removal of the Saturday Bore from the network does not diminish the effectiveness of groundwater monitoring at DRM. Further information is provided in Appendix D.
C18	The release of contaminants must not result in an exceedance of contaminant limits stated in Schedule C – Table 5 (Receiving waters trigger levels and contaminant limits) at the downstream monitoring points specified in Schedule C – Table 4 (Receiving Water and Stream	Revise condition to be consistent with the requirements of Condition C17. **Proposed condition**: The release of contaminants must not result in an exceedance of contaminant limits stated in Schedule C	The results of monitoring conducted at downstream locations is compared to reference sites, as described in C17. The addition of this statement provides clarity to the existing approach. The amendment does not propose any change to

Condition		Proposed Amendment	Justification
	Sediment Reference Sites and Downstream Monitoring Points).	– Table 5 (Receiving waters trigger levels and contaminant limits) at the downstream monitoring points specified in Schedule C – Table 4 (Receiving Water and Stream Sediment Reference Sites and Downstream Monitoring Points). Where the downstream result is the same or a lower value than the reference site value for the quality characteristic during the monitoring event then no action is to be taken.	compliance determinations or reporting of exceedances.
I14	Rehabilitation must commence progressively as soon as areas become available and in accordance with the plan of operations.	Delete condition.	Superseded by conditions imposed by the Progressive Rehabilitation and Closure Plan (PRCP).
I15	Within six (6) months of the commencement of tailings disposal in the tailings storage facility, the holder of this environmental authority must commence trials to establish suitable capping systems for infrastructure on the licensed place including but not limited to the tailings storage facility and all waste rock dumps.	Delete condition.	Superseded by conditions imposed by the Progressive Rehabilitation and Closure Plan (PRCP).
I16	By 1 October 2017 and once every two (2) years thereafter the holder of this environmental authority must submit a report to the administering authority detailing the success and findings from the capping system trials.	Delete condition.	Superseded by conditions imposed by the Progressive Rehabilitation and Closure Plan (PRCP).
I17	By 2 October 2019 the holder of this environmental authority must submit to the administering authority a report nominating the most appropriate capping system for the	Delete condition.	Superseded by conditions imposed by the Progressive Rehabilitation and Closure Plan (PRCP).

Condition		Proposed Amendment	Justification
	tailings storage facility based on the results from trials required by condition I18.		
I18	A Post Mine Land Use Plan must be developed and implemented by the authority holder and submitted to the administering authority upon request. The PMLUP must be developed by an appropriately qualified person and include: (a) schematic representation of final land form inclusive of drainage features; (b) slope designs; (c) cover design (not limited to store and release covers); (d) drainage design; (e) erosion controls; (f) description of experimental design for monitoring of analogue and rehabilitated areas inclusive of statistical design; (g) proposed revegetation methods inclusive of plant species selection, re-profiling, respreading soil, soil ameliorants/amendments, surface preparation and method of propagation;	Delete condition.	Superseded by conditions imposed by the Progressive Rehabilitation and Closure Plan (PRCP).

Condition		Proposed Amendment	Justification
	(h) materials balance including available top soil, and low permeability capping material; (i) geotechnical, geochemical and hydrological studies; (j) chemical, physical and biological properties of soil and water; and a rehabilitation monitoring program as required by condition I20		
I19	A rehabilitation monitoring program must be developed and be implemented on commencement of rehabilitation identified in Schedule I – Table 1 (Dugald River Project Rehabilitation Requirements) by an appropriately qualified person.	Delete condition.	Superseded by conditions imposed by the Progressive Rehabilitation and Closure Plan (PRCP).
I20	The holder of this environmental authority must conduct rehabilitation monitoring in accordance with the program developed in condition (I21) at least once a year including sufficient spatial and temporal replication to enable scientifically justifiable conclusions to be made, as established in the rehabilitation monitoring program.	Delete condition.	Superseded by conditions imposed by the Progressive Rehabilitation and Closure Plan (PRCP).
I21	Verification of rehabilitation success is to be carried for each domain. Monitoring must be carried out for each domain at a minimum sampling intensity of 1:15,000 and must include sufficient replication to enable statistical analysis of results at an acceptable power.	Delete condition.	Superseded by conditions imposed by the Progressive Rehabilitation and Closure Plan (PRCP).

Condition		Proposed Amendment	Justification
I22	A Post Closure Management Plan must be developed and implemented by the authority holder and submitted to the administering authority upon request. The Plan must be implemented for a period of: (a) at least thirty (30) years following cessation of the mining activity (excluding rehabilitation) on the licensed place; or (b) a shorter period if: (i) the licensed place is proven to be geo-technically and geo-chemically stable; and (ii) it can be demonstrated to the satisfaction of the administering authority that no release of contaminants from the licensed place will result in environmental harm.	Delete condition.	Superseded by conditions imposed by the Progressive Rehabilitation and Closure Plan (PRCP).
I23	The Post Closure Management Plan must include the following elements: (a) operation and maintenance of: (i) contaminated water collection and reticulation systems; (ii) contaminated water treatment systems; (iii) the groundwater monitoring network; (iv) final cover systems; and (v) vegetative cover.	Delete condition.	Superseded by conditions imposed by the Progressive Rehabilitation and Closure Plan (PRCP).

Condition		Proposed Amendment	Justification
	(b) monitoring of: (i) surface water; (ii) groundwater; (iii) seepage rates; (iv) erosion rates; (v) the integrity and effectiveness of final cover systems; and (vi) the health and resilience of vegetative cover.		

1.4.2. Non-Administrative Amendments

Additional amendments are proposed relating to a change in activity and/or surface disturbance at DRM. The proposed amendments are summarised in Table 3. The potential environmental impacts of the proposed actions are discussed in Section 4.

Table 3. Proposed Amendments to Site Specific Conditions

Condition	Proposed Amendment	Justification
Schedule A – Table 1 (Authorised Mining Activities)	Additional disturbance area for the construction and operation of a wind farm. This disturbance total incorporates: - 27.78 ha for wind farm pads - 32.32 ha for access tracks - 12.78 ha for laydowns - 0.72 ha for powerline poles - 0.99 ha for switchyard 2 - 1.23 ha for meteorological masts	The wind farm at DRM will have the potential to offset approximately 40% of DRMs power usage (currently sourced from the gas fired Diamantina power station) via renewable energy sources and contribute to MMGs commitment of net zero Scope 1 and Scope 2 emissions by 2050. Detailed technical studies have been completed to assess the potential risks and benefits of the project. An additional powerline is required to support the wind farm. Two laydowns are required for the construction period. The Project has one existing switchyard (Switchyard 1). An additional switchyard (Switchyard 2) is required to support the wind farm. The switchyard will be located on an existing track, resulting in no net increase in surface disturbance. The disturbance area (0.99 ha) has been assigned in the EA for clarity. Potential impacts and control measures are described in Section 4.1 to Section 4.5.
Schedule A – Table 1 (Authorised Mining Activities)	Addition of 0.18 ha disturbance area for construction of a Sewage Treatment Plant at 412059, 7760070	A new sewage treatment plant (STP) is proposed to replace the existing exploration camp STP. The STP will be operated in accordance with the approved environmentally relevant activity threshold, and all existing EA conditions. The new STP will treat effluent to a Class A standard, improving on the current Class C standard from the existing exploration camp STP. Potential impacts are discussed in Section 4.1.1, Section 4.2 and Section 4.3.

Condition	Proposed Amendment	Justification
New condition within Schedule A – General, Exploration	New Condition **Proposed condition**: The holder of the environmental authority must not carry out activities in a category A or B environmentally sensitive area. Activities involving machinery must not be carried out within 1km of a category an environmentally sensitive area or within 50 m of a category B environmentally sensitive area.	The latest version of the Code of Environmental Compliance for exploration and mineral development projects (Eligibility criteria and standard conditions for exploration and mineral development projects) specifies that activities involving machinery must not be carried out within 1 km of a category A environmentally sensitive area or within 500 m of a category B environmentally sensitive area. The proposed amendment is to reduce this buffer to allow machinery to work up to 50 m from a category B environmentally sensitive area. This will allow MMGs exploration program to continue, with appropriate controls to mitigate impact to category B environmentally sensitive areas. Potential impacts to land and control measures are described in Section 4.1.
Schedule A – Table 1 (Authorised Mining Activities)	Addition of Ventilation Shaft 9 at 411466, 7761320 (0.54 ha).	An additional ventilation shaft is proposed to provide airflow to the underground operation. The ventilation shaft will be located on previously disturbed land, resulting in no net increase in disturbance. An area of 0.54 ha has been assigned to the feature. Potential impacts to land and control measures are described in Section 4.1.
Schedule A – Table 1 (Authorised Mining Activities)	Addition of 0.54 ha for groundwater infrastructure.	Additional clearance is required around the existing bores, to allow space for a pump and solar panel. The pumping infrastructure will be used to conduct a feasibility study into potential groundwater extraction. The amendment does not propose ongoing groundwater extraction.
B14 The buildings and structures in place at the licensed place for the storage, stockpiling and loading of mineral concentrate must be	Remove condition	The intent of this condition is to prevent the release of contaminants from a storage shed, during or after a cyclone. The likelihood of a Category 2 cyclone crossing the Cloncurry region is low.

Condition		Proposed Amendment	Justification
	constructed and maintained to withstand a Category 2 cyclone.		Additionally, the concentrate shed is a concentrate transfer point; it is not used for storage of concentrate. Concentrate is deposited into the concentrate transfer shed from the processing plant where it is collected by a front-end loader and transferred into two half height shipping containers while the shed is under negative pressure. This occurs as one continuous process; material is not stockpiled. In the unlikely event that a cyclone did occur in the region, there would be no concentrate stored within the shed, and therefore the risk of loss of concentrate is negligible. The required to prevent release of contaminants is duplicated and adequately managed by the following existing conditions: • Condition A5, The holder of this environmental authority must: (a) install all measures, plant and equipment necessary to ensure compliance with the conditions of this environmental authority; (b) maintain such measures, plant and equipment in a proper condition; and (c) operate such measures, plant and equipment in a proper manner • Condition B1, Unless authorised by this environmental authority, the release of noxious or offensive odour, dust or any other airborne contaminant resulting from the mining activity must not cause environmental harm. • Condition C1, Contaminants that will, or have the potential to cause environmental harm, must not be released directly or

Condition		Proposed Amendment	Justification
			indirectly to any waters except as permitted under the conditions of this environmental authority. • Condition C3, Any spillage of wastes, contaminants or other materials must be cleaned up as quickly as practicable to minimise the release of wastes, contaminants or materials to any stormwater drainage system or receiving waters. • Condition I1, Unless authorised by this environmental authority contaminants that will or may cause environmental harm must not be directly or indirectly released to land. Potential impacts to land and control measures are described in Section 4.1
B15	The construction and state of the buildings and structures in place at the licensed place for the storage, stockpiling and loading of mineral concentrate must be checked for compliance with condition B14 by an appropriately qualified person at least once every three (3) years.	Remove condition.	As above.
Schedule C – Table 2 (Contaminant Release Limits)		Remove cyanide as a monitoring parameter.	Cyanide is not stored onsite or used in any processing activity at DRM. It is noted that footnote 5 in Schedule C – Table 5 (Receiving waters trigger levels and contaminant limits) specifies that monitoring for cyanide is deferred until such time that cyanide is introduced into the mining process. DRM have no intention of using cyanide in processing, therefore the condition is redundant.

Condition	Proposed Amendment	Justification
		If cyanide was introduced in future, this would require an EA amendment, as well as internal change management processes and additions to the monitoring program could be made during either of these processes. Potential impacts to water and control measures are described in Section 4.2.
Schedule C – Table 5 (Receiving waters trigger levels and contaminant limits)	Remove the contaminant limit for total Aluminium, replace the trigger level and contaminant limit for filterable Aluminium with site specific values. A historical dataset is provided in Appendix E.	The existing contaminant limit for total aluminium is derived from the ANZECC 2000 guidelines for recreational purposes (body immersion). This is not a suitable environmental value for the receiving waters of DRM. Alternative triggers and limits are proposed to identify potential environmental impacts. This is discussed further in Section 4.2.
Schedule C – Table 5 (Receiving waters trigger levels and contaminant limits)	Remove cyanide as a monitoring parameter.	Cyanide is not stored or used in processing activities at DRM and is not considered a risk to environmental values. It is noted that footnote 5 specifies that monitoring for cyanide is deferred until such time that cyanide is introduced into the mining process. DRM have no intention of using cyanide in processing, therefore the condition is redundant. If cyanide was introduced in future, this would require an EA amendment, as well as internal change management processes and additions to the monitoring program could be made during this process. Potential impacts to water and control measures are described in Section 4.2
Schedule C – Table 8 (Groundwater Trigger Levels and Contaminant Limits)	Remove cyanide as a monitoring parameter.	Cyanide is not stored or used in processing activities at DRM and is not considered a risk to environmental values. It is noted that footnote 8 specifies that monitoring for cyanide is deferred until such time that cyanide is introduced into the mining process. DRM have no intention of using cyanide in processing, therefore the condition is redundant. If cyanide was introduced in future, this would require an EA amendment, as well as internal change

Condition	Proposed Amendment	Justification
		management processes and additions to the monitoring program could be made during this process. Potential impacts to water and control measures are described in Section 4.2
Schedule D – Table 2 (Hydraulic performance criteria for Regulated Dams)	Remove the hydraulic performance criteria for the Stage 2 PAF Run Off Dam. Revise the associated footnotes to reference the most recent consequence category assessment.	The Consequence Category of a dam is used to determine the level of safety that is applied to the design, construction, and operation of the structure. Hydraulic performance criteria are required for regulated dams that are assessed as a 'significant' or 'high' consequence for the overtopping scenario. The original Failure to Contain assessment for the Stage 2 PAF Run Off Dam (WRM, 2012) determined a hazard category of "significant" based on a presumed "significant" impact of "general environmental harm" and "loss of stock". This resulted in hydraulic performance criteria being assigned in the EA. The initial risk assessment was completed prior to the construction of the dam and prior to any water quality testing being conducted. The results of water quality testing were available and assessed in subsequent assessments in 2014, 2015, 2019 and 2023. Each assessment determined a "low risk" rating for overtopping. Hydraulic performance criteria are therefore not required. More detail is provided in Appendix F and Appendix G. Potential impacts to water and control measures are described in Section 4.2.

0.5 0 0.5 1 km

1:20,000

Client: Dugald River Pty Ltd
Project number: 2023.03002
CRS: GDA2020 EPSG: 7844
Date: 10 April 2024

Print as A3

Figure 2. Proposed Disturbance

Legend

Mine Lease
Existing Disturbanes

Google Satellite

Proposed Disturbances
Proposed GW Bore
Proposed STP
Proposed Vent Shaft 9
Proposed Wind Farm Disturbance

Disclaimer:
Whilst every effort and care has been taken to ensure the accuracy of this report, Wulguru Technical Services Pty Ltd makes no representations or warranties about its accuracy, reliability, completeness or suitability for any particular purpose and disclaims all responsibility and all liability (including without limitation, liability in negligence) for all expenses, losses, damages (including indirect or inconsequential damage) and costs which you might incur as a result of the product being inaccurate or incomplete in any way and for any reason.
Digital data for this report is available on the Queensland Government Spatial Portal at https://qldspatial.information.qld.gov.au.

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1.4.3. Environmentally Relevant Activities

The Environmentally Relevant Activities (ERAs) defined under the Environmental Protection Act 1994 (EP Act) and approved in the EA are listed below (Table 4).

No changes are proposed to the existing ERAs.

Table 4. Approved Environmentally Relevant Activities for DRM as listed in EPML00731213

ERA Number	Description
8-(1)	Chemical storage >50t class 1 or 2
8-(3)	Chemical storage >500m^3 class C1 or C2
8-(4)	Chemical storage >200t solids or gases
15	Fuel burning >500kg per hr
16-(2c)	Extractive >1,000,000t per yr
16-(3c)	Screening >1,000,000t per yr
31-(2b)	Mineral processing >100,000t per yr
33	Crushing, milling, grinding or screening >5,000t per yr
63-(1b)(i)	Sewage treatment >100 to 1500EP – IT or IR
63-(1b)(ii)	Sewage treatment >100 to 1500EP – no IT or IR
Mining – site specific	ML gold ore – 16
Mining – site specific	ML copper ore – 17
Mining – site specific	ML lead, silver or zinc – 18

1.4.4.Notifiable Activities

The following notifiable activities are currently associated with the DRM operation:

- **Notifiable Activity 7: Chemical storage** (other than petroleum products or oil under item 29)—storing more than 10 t of chemicals (other than compressed or liquefied gases) that are dangerous goods under the dangerous goods code.
- **Notifiable Activity 15: Explosives production or storage**—operating an explosives factory under the *Explosives Act 1999*.
- **Notifiable Activity 24: Mine wastes—**storing hazardous mine or exploration wastes, including, for example, tailings dams, overburden or waste rock dumps containing hazardous contaminants; or

  exploring for, or mining or processing, minerals in a way that exposes faces, or releases groundwater, containing hazardous contaminants.
- **Notifiable Activity 25: Mineral processing**—chemically or physically extracting or processing metalliferous ores.
- **Notifiable Activity 37: Waste storage, treatment or disposal**—storing, treating, reprocessing or disposing of waste prescribed under a regulation to be regulated waste, for this

item (other than at the place it is generated), including operating a nightsoil disposal site or sewage treatment plant where the site or plant has a design capacity that is more than the equivalent of 50 000 persons having sludge drying beds or on-site disposal facilities.

No changes are proposed to the existing notifiable activities.

1.4.5. Assessment Level Consideration

Under s.228 of the EP Act, the administering authority must decide whether the proposed amendment is a minor or a major amendment. WTS considers the proposed amendment to be a major amendment, supported by the thresholds detailed in Table 5.

Table 5. Thresholds to be considered a major amendment (threshold) assessment level decision

Consideration	Response
(a) is not a change to a standard condition identified in the EA as a standard condition, other than a condition conversion or replacing a standard condition with a standard condition for the ERA; and	The proposed amendment includes a change to condition A13 in the *"Eligibility criteria and standard conditions for exploration and mineral development projects"*, however the amendment does not significantly increase the level of environmental harm caused by the relevant activity. WTS considers the proposed amendment to be a minor amendment for this reason.
(b) does not significantly increase the level of environmental harm caused by the relevant activity; and	The proposed changes do not significantly increase the level of environmental harm.
It does not change any rehabilitation objectives in the EA in a way likely to result in significantly different impacts on environmental values than the impacts previously permitted under the EA; and	Additional surface disturbance is proposed in the form of access tracks and pads for the development of a wind farm. Rehabilitation objectives will remain as described in the Progressive Rehabilitation and Closure Plan. A revised PRCP has been prepared as part of this amendment application to include the additional proposed disturbance.
(d) does not significantly increase the scale or intensity of the relevant activity; and	The amendment proposes the construction and operation of a wind farm. This is a change to the activity conducted at the Project. MMG considers the proposed amendment to be a major amendment for this reason.
It does not relate to a new relevant resource tenure for the EA that is— (i) a new mining lease; or	The proposed amendments do not relate to a new resource tenure.

Consideration	Response
(ii) a new petroleum lease; or **(25)** a new geothermal lease under the Geothermal Energy Act 2010; or (iv) a new greenhouse gas injection and storage lease under the Greenhouse Gas Storage Act 2009; and	
(f) increases the existing surface area for the relevant activity by 10% or less; and	The proposed amendment will result in >10% increase of the current approved disturbance for DRM. The amendment is considered major due to this reason.
(g) for an EA for a petroleum activity: i. involves constructing a new pipeline that does not exceed 150km in length; and ii. involves extending an existing pipeline by no more than 10% of the existing length of the pipeline;	This is not a petroleum activity.

2. Project Description

2.1. Project Background

The DRM ore body was discovered in the late 1900s following early small-scale mining and prospecting. The explorers identified gossanous zinc/ lead/ silver outcropping between two main drainage features on the plains below the Knapdale Range. Evidence of the outcropping is still visible within a demarcated area of the mines surface features. The surrounding area is littered with surficial copper oxides deposits as well as historic small scale mining features including waste dumps, collapsed shafts and rusted infrastructure (WTS, 2021).

Systematic exploration of the deposit began in the 1950s. Zinifex Australia Limited started the most recent phase of exploration in 2004 who subsequently began the process of gaining State and Federal approvals. During this period, the Project was purchased by MMG with approval being granted in 2012 and the first phase of construction (earth works, waste rock pads and dams and underground development) following in 2013. After a brief pause mid-construction to more thoroughly investigate the mining methodology, the Project was completed early 2017. MMG shipped the first parcel of zinc concentrate later that year (WTS, 2021).

2.2. Proposed Activities

The proposed amendments are summarised in Table 3. Where relevant, additional detail is provided below.

2.2.1. Wind Farm

2.2.1.1. Overview

MMG are seeking approval to establish a wind farm and associated ancillary infrastructure to support the goal of achieving net zero emissions by 2050. The preliminary phase of the Project proposes to install eight, 6.0 MW wind turbines on the Knapdale Range, within the existing mine leases (Figure 3).

The Rotor-swept Area (RSA, i.e. referring to the height range within which the blades of operating wind turbines move (Brett Lane & Associates Pty Ltd, 2005) has been considered at the largest dimensions possible to allow for conservative assessment of potential impacts. Although the final model has not been confirmed, the Goldwind GW 165-5.2/5.6/6.0MW has been used throughout this assessment as a proposed model. This is the largest possible model and provides a conservative assessment. This model has a hub height of 130 m, a rotor diameter of 165 m and an RSA between 47.5 m - 212.5 m height above ground level and a blade rotation area of 21,382 m^2. The turbine specifications are summarised in Table 6.

The windfarm will require the establishment of roads sufficiently sized to accommodate safe transport of wind turbines and ancillary equipment to the proposed locations. The windfarm requires additional

support infrastructure such as underground cabling, meteorological monitoring masts, an additional switchyard and two laydowns.

The additional surface disturbance required for the construction of the wind farm is as follows:

- Approximately 27.78 ha for construction of eight wind turbine pads;
- Approximately 1.23 ha for erection of meteorological masts;
- Approximately 32.32 ha for access tracks to enable safe transport of infrastructure;
- Approximately 12.78 ha for clearing of two temporary laydowns to support construction;
- Approximately 0.72 ha for power infrastructure to connect to the wind farm; and
- An additional switchyard, on previous cleared land (0.99 ha).

Table 6. Wind Turbine Specifications

Description	Specification
Rated Power	6MW each, 48MW total
Voltage	220kB (Primary), 33kV (Secondary)
Hub Height	130 m
Rotor diameter	165 m
Swept area	21,382 m^2
Design Service Life	>20 years

2.2.1.2. Justification

The DRM currently sources electricity from the gas fired Diamantina Power Station and the Dugald River Solar Farm. Energy is currently the highest operating cost for DRM and is subject to high pricing variability. A combination of renewable energy sources will reduce operational costs and stabilise price volatility. These combined outcomes will improve the financial sustainability of the operation.

The Dugald River Solar Farm currently displaces 33% of DRMs electricity related emissions, saving approximately 750t-CO2e per week. Wind energy has the potential to displace a further 40% of the DRM energy requirements, reducing emissions by approximately 1,000t-CO_2e per week. A combined renewable energy approach will result in a reduction of approximately 90kt-CO2e per year, assisting MMG to achieve their commitment of net zero Scope 1 and Scope 2 emissions by 2050.

The intent of the wind farm is to meet the existing electrical demand from the Project. MMG has no intention, at present, to export power to the grid. However, future expansions of the wind farm have the potential to provide power to the wider region, resulting in significant emission reductions.

Extensive monitoring (Appendix H) has been completed at key locations on the Knapdale Range, with data confirming the feasibility of the project. The Knapdale Range provides a favourable location for a wind farm due to:

- Relatively strong, consistent wind speeds and direction;
- Elevated terrain providing increased wind speed; and
- Diurnal wind strengths.

Monitoring has identified a complementary diurnal relationship between solar production during the day and increased average wind conditions over night. A combination of solar and wind energy production has been determined to be the most effective energy solution for DRM.

Due to the steep slopes of the Knapdale Range, cattle do not graze in the area of the proposed turbines. There is no mining infrastructure located along the range, apart from the tailings discharge pipeline to the Tailings Storage Facility. The construction and operation of the wind farm will not impact upon the operation of DRM, or grazing activities on adjacent leases. The area is not identified as an area of high scenic amenity, under the Cloncurry Shire Planning Scheme.

2.2.1.3. Design for Minimal Impact

The wind farm design has been extensively studied and optimised to minimise the potential environmental impact from construction and operation. All feasible avoidance and minimisation techniques have been incorporated into the final design, as presented throughout this application. The proposed design represents the minimum possible disturbance for the Project to operate safely and efficiently.

The final design has:

- Positioned the turbines on the Knapdale Range to maximise productivity, thereby reducing the number of turbines required;
- Positioned the turbines on the Knapdale Range, thereby avoiding any disturbance to grazing lands;
- Maximized the size of the turbines, thereby reducing the number of turbines required;
- Limited the number of turbines to eight, thereby reducing surface disturbance and total Rotor Swept Area;
- Utilised existing tracks to minimise disturbance; and
- Excluded lighting to avoid attraction of aerial fauna, minimising impact to listed aerial and migratory species.

2.2.1.4. Approval Processes and Engagement

As the activity is being conducted on a mining lease, the DESI is the administering authority responsible for assessing potential environmental impact from the activity. In addition to the DESI, MMG has engaged directly with the following parties:

- Department of Climate Change, Energy, the Environment and Water;
- Department of Resources;
- Department of Transport and Main Roads;

- Department of State Development, Infrastructure, Local Government and Planning;
- Civil Aviation Safety Authority;
- Air Services Australia;
- Ergon Energy;
- North West Power System;
- Kalkadoon Peoples;
- Landholders; and the
- Cloncurry community.

All required approvals and guidance will be sought from the relevant parties, concurrent to this EA application.

The additional purpose of ‘Ancillary Power Generation” on ML90211 and ML90213, was approved by the Department of Resources on 21 August 2023. The determinations were made in accordance with Section 298 of the MR Act. The approvals are provided for reference, in Appendix I and Appendix J.

The purpose of ‘Ancillary Power Generation” is limited to power generation to support mining operations. The approval does not permit any export of power to the grid. MMG have no intention, currently, to export power to the grid.

2.2.1.5. Land Preparation

Pads size is variable at each turbine location, due to the terrain of the Knapdale Range. The pads have been designed to accommodate vehicle turn-around at the end of each access road. This is a transport safety requirement to eliminate the risk of reversing down the steep slopes of the Knapdale Range.

Light vehicle access tracks currently exist from the MIA to each turbine pad. These existing tracks will be widened, to accommodate transport of the turbine components. The tracks will be scraped, with vegetation rilled to the side of the tracks. Where present, topsoil will be scraped and rilled to the side of the road for storage until rehabilitation. Bed level crossings will be constructed at seven creek crossings, during road establishment to allow unobstructed surface water flows.

The pads are required to be cleared of vegetation and levelled for stability. Vegetation will be scraped and stockpiled to the side of the pad disturbance. Where required, overhanging branches will be trimmed to provide an open air space for the crane to assemble and lift the turbine components. The turbine pads are proposed to be located on the Knapdale Range where soils are described as very shallow and rocky. Topsoil is not present in a depth valuable for stripping and preserving. Pads will be levelled until a flat surface is achieved. Material will be stockpiled, locally, for use in later rehabilitation.

Hardstands will be constructed for the assembly, construction and erection of the turbines. A construction specification has been developed for the hardstands to ensure the required bearing capacity for the cranes is achieved.

Two laydowns are required for temporary storage during construction works. Large vegetation will be trimmed; vegetation groundcover and topsoil will remain undisturbed and no hardstands will be constructed.

Additional clearing is required for the powerline and meteorological masts. Vegetation will be cleared or trimmed where required for safe access. Groundcover will be retained. A switchyard (Switchyard 2) is proposed to be located on land previously used as a road, therefore no additional clearing or surface disturbance is required for this feature.

2.2.1.6. Construction

The components of the wind farm, including the tower sections, nacelle, generator, hub and blades, will be imported by ship to the Port of Townsville and hauled to site. They will be transported to the final location and constructed at the cleared pad. Two cranes will be utilised to build a larger crane, that will then erect the turbines. Due to crane availability, turbines will be constructed one at a time, over a two-year period.

Access roads will be constructed for all site traffic, including for:

- delivery of turbine components (tower sections, nacelle, generator, hub and blades)
- delivery and relocation of erection cranes; and
- construction, maintenance and decommissioning of the Project.

Bed level crossings will be constructed across drainage lines to allow safe transport of materials to the wind farm pads. Bed level crossings will permit water to flow, unobstructed, along the drainage line with minimal impact to aquatic and riparian ecology.

Two temporary laydown areas have been designated to support construction activities, including park bays for ancillary vehicles, such as light vehicles, elevated work platforms, etc.

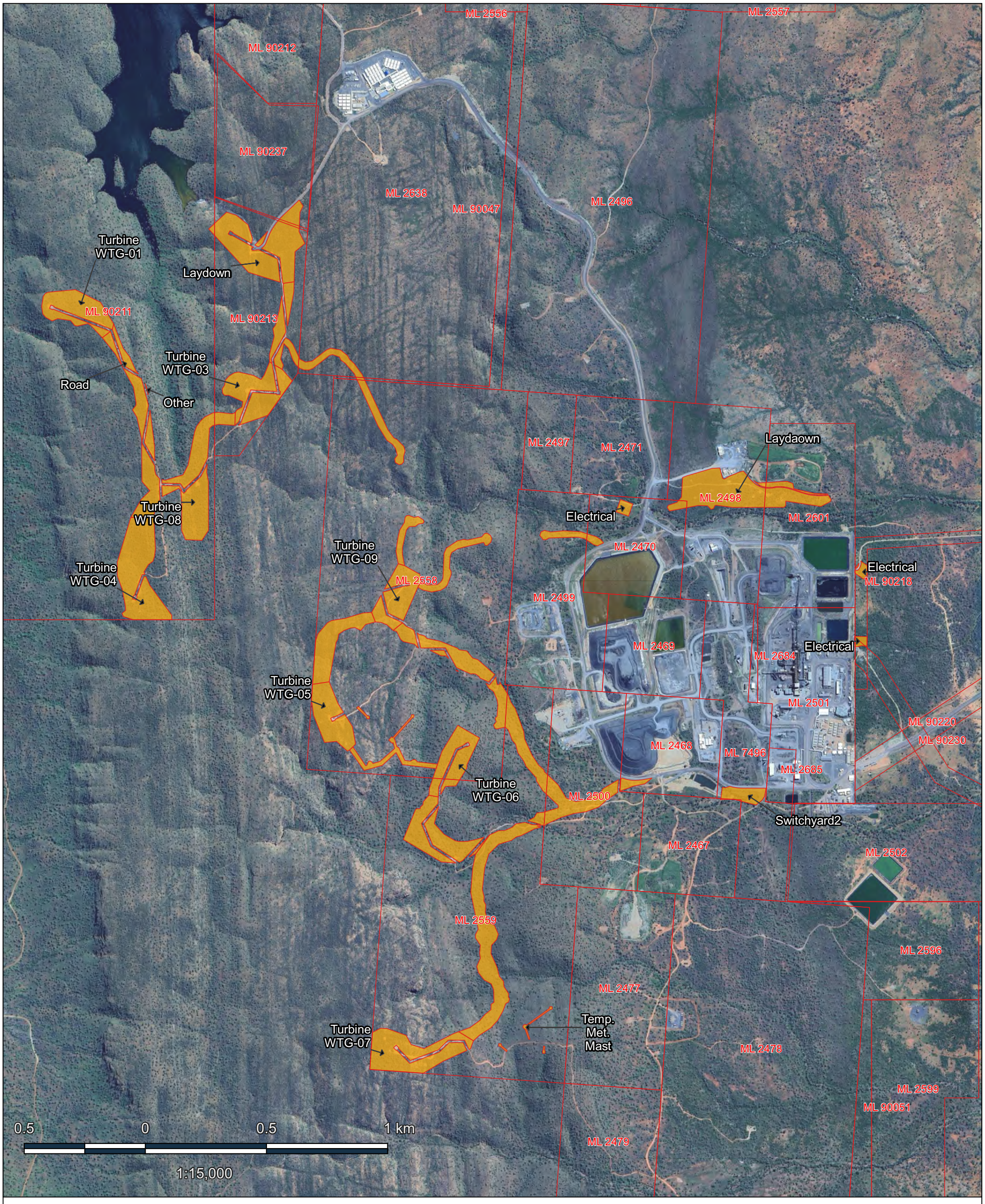
A cable system will be installed to transfer power from each turbine to the existing substation, located within the MIA to the north of the Processing Plant. The cabling will be a combination of underground and above ground lines, supported by two new poles with 1.86 ha required for disturbance.

Two meteorological masts will be installed to monitor wind conditions for the operation of the wind farm. An additional switchyard (Switchyard 2) will be assembled to support the electrical equipment.

2.2.1.7. Maintenance and Rehabilitation

A regular inspection and maintenance regime will be implemented at the turbines. This will occur on a quarterly, bi-annual or annual schedule, depending on the level of maintenance required. The construction pad will be retained throughout operations to facilitate this maintenance. The DRM has an approved Progressive Rehabilitation and Closure Plan (PRCP) for its current operation. This PRCP has been revised to incorporate rehabilitation of the wind farm. At the end of mine life, the wind farm infrastructure will be decommissioned and removed, and the land rehabilitated to a post mine land use of native ecosystem or low intensity grazing. MMG currently do not hold any agreements for the

retention of wind farm infrastructure, however this will be investigated throughout the life of the Project. Any change to rehabilitation objectives, will be described in a revised PRCP, as required.



Client: Dugald River Pty Ltd
Project number: 2023.03002
CRS: GDA2020 EPSG: 7844
Date: 26 April 2024

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Figure 3. Proposed Windfarm and Ancillary Infrastructure

Legend

- Mine Lease
- Proposed Windfarm Features

Google Satellite

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2.2.2. Exploration Camp STP

2.2.2.1. Overview

Approximately 0.18 ha is required for the construction of a new Sewage Treatment Plant (STP) (Figure 4). The STP will replace the existing STP at the exploration camp. The land will be cleared, and a concrete bund constructed for placement of the STP. The STP is a containerised system, a membrane bioreactor, that will be delivered to site on a flatbed truck and lifted to place, within the concrete bund. Exiting services, i.e., pipelines, will be connected to the new STP.

The STP has a capacity of 150 kL/day and will treat sewage to a Class A standard. Effluent will be either utilised for dust suppression via a water cart or disposed to the existing STP dams.

Once the new STP is operational, the existing STP will be demolished and removed from site.

2.2.2.2. Justification

The existing STP at the exploration camp is antiquated and no longer adequate for the site. A new STP will ensure water quality is maintained or improved and there is no risk to persons or the environment.

DRM is currently authorised to conduct both ERA63-(1b)(i) and ERA63-(1b)(ii), Sewage Treatment Operating sewage treatment works, other than no-release works, with a total daily peak design capacity of more than 100 but not more than 1,500 equivalent persons - where treated effluent is discharged from the works to an infiltration trench or through an irrigation scheme, or otherwise. This amendment does not propose any change to the approved ERAs. The new STP will replace the existing and will not increase the volume of effluent generated.

This amendment does not propose any change to any existing conditions within EA Schedule E – Sewage, in relation to the management of effluent or the target water quality. The existing Sewage Effluent Contaminant Release Limits (Schedule E – Table 1), are based on Class C effluent. The proposed system will treat the effluent to a Class A standard, well below the existing EA limits. This will result in an improved environmental outcome.

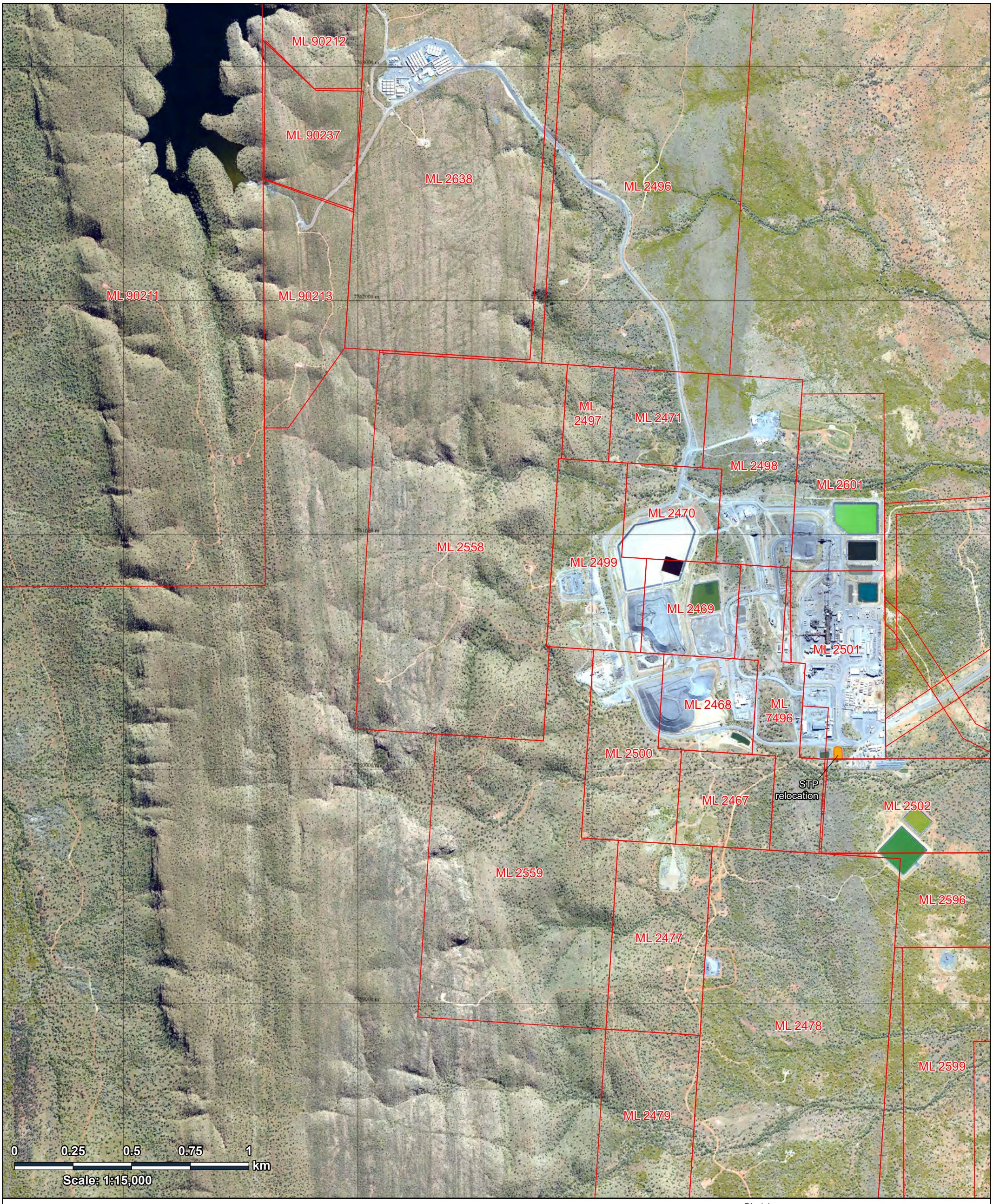


Figure 4. Proposed Sewage Treatment Plant Relocation

Client: MMG Dugald River Pty Ltd
Project Number: 2023.03002
Publication Date: 28/11/2023

Spatial Reference
PCS: GDA2020 MGA Zone 54
GCS: GDA2020
Datum: GDA2020

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Legend

- Mining Lease
- Proposed STP Relocation

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2.2.3. Groundwater Pumping Infrastructure

2.2.3.1. Overview

An additional 0.54 ha of disturbance is proposed across two existing groundwater monitoring bore (Figure 5) locations. The proposed area will be cleared and grubbed. Topsoil is not required to be stripped. The bores will be fitted with a production pump, powered by solar panels, to conduct pumping tests.

On closure, the infrastructure will be removed, and the disturbed area will be ripped and seeded in accordance with the approved PRCP.

2.2.3.2. Justification

MMG currently do not extract any groundwater for use on site. This additional area is to provide sufficient space to operate a solar powered pump for a groundwater extraction feasibility study. This amendment does not propose any additional groundwater bores or propose ongoing groundwater extraction at this time.

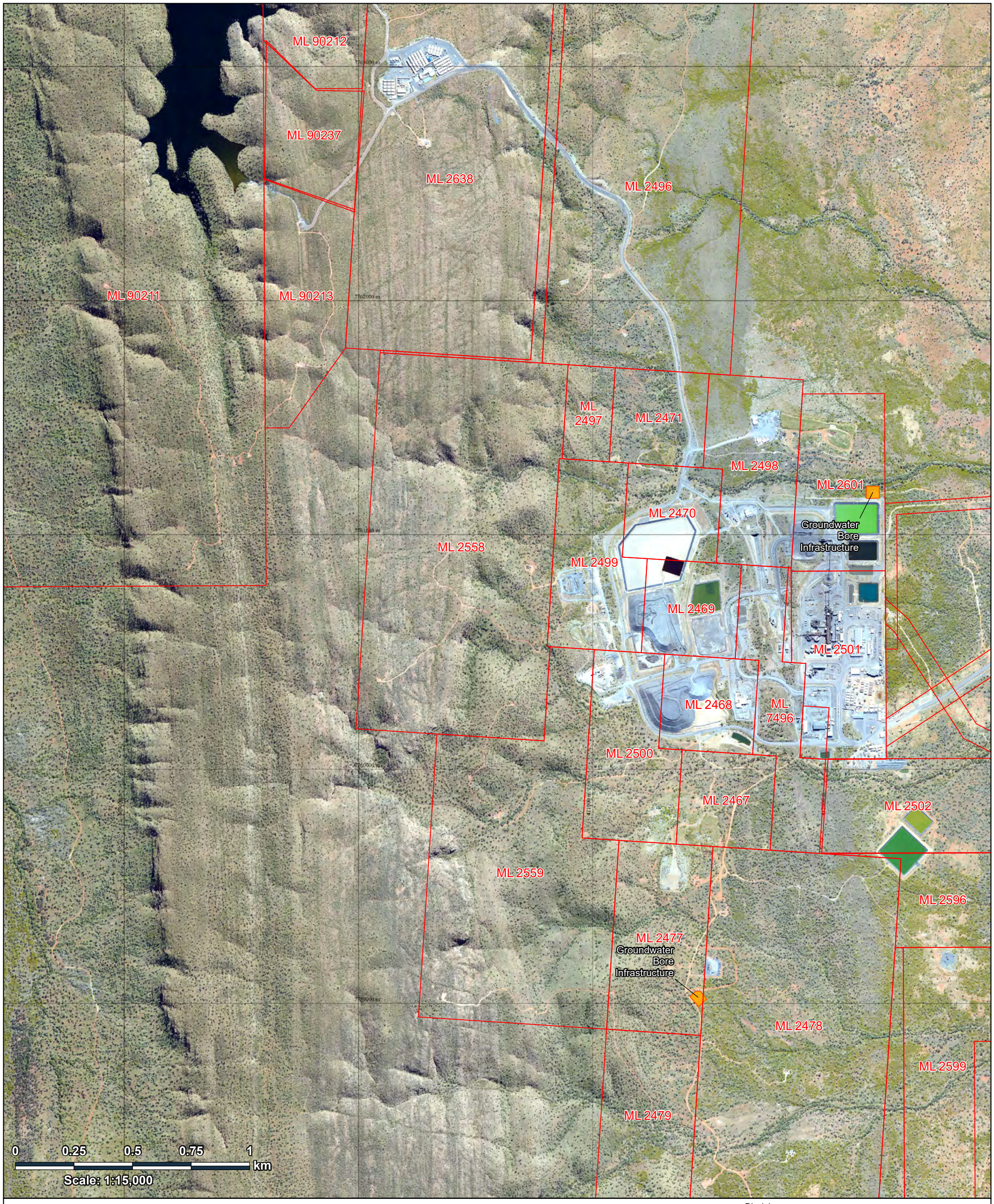


Figure 5. Proposed Groundwater Infrastructure

Client: MMG Dugald River Pty Ltd
Project Number: 2023.03002
Publication Date: 24/11/2023

Spatial Reference
PCS: GDA2020 MGA Zone 54
GCS: GDA2020
Datum: GDA2020

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- Mining Lease
- Proposed Groundwater Infrastructure

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2.2.1. Ventilation Shaft

2.2.1.1. Overview

An additional ventilation shaft is proposed (0.54 ha) to be located on the accommodation village access road, to the north of the MIA (Figure 6). The ventilation shaft will be constructed on a previously disturbed area; no additional surface disturbance is required.

On closure, the infrastructure will be removed, and the disturbed area will be ripped and seeded in accordance with the approved PRCP.

2.2.1.2. Justification

DRM currently has eight ventilation shafts to allow passageway of fresh air to the underground operations. As the mine progresses, additional ventilation systems are required to ensure the safety of the workforce.

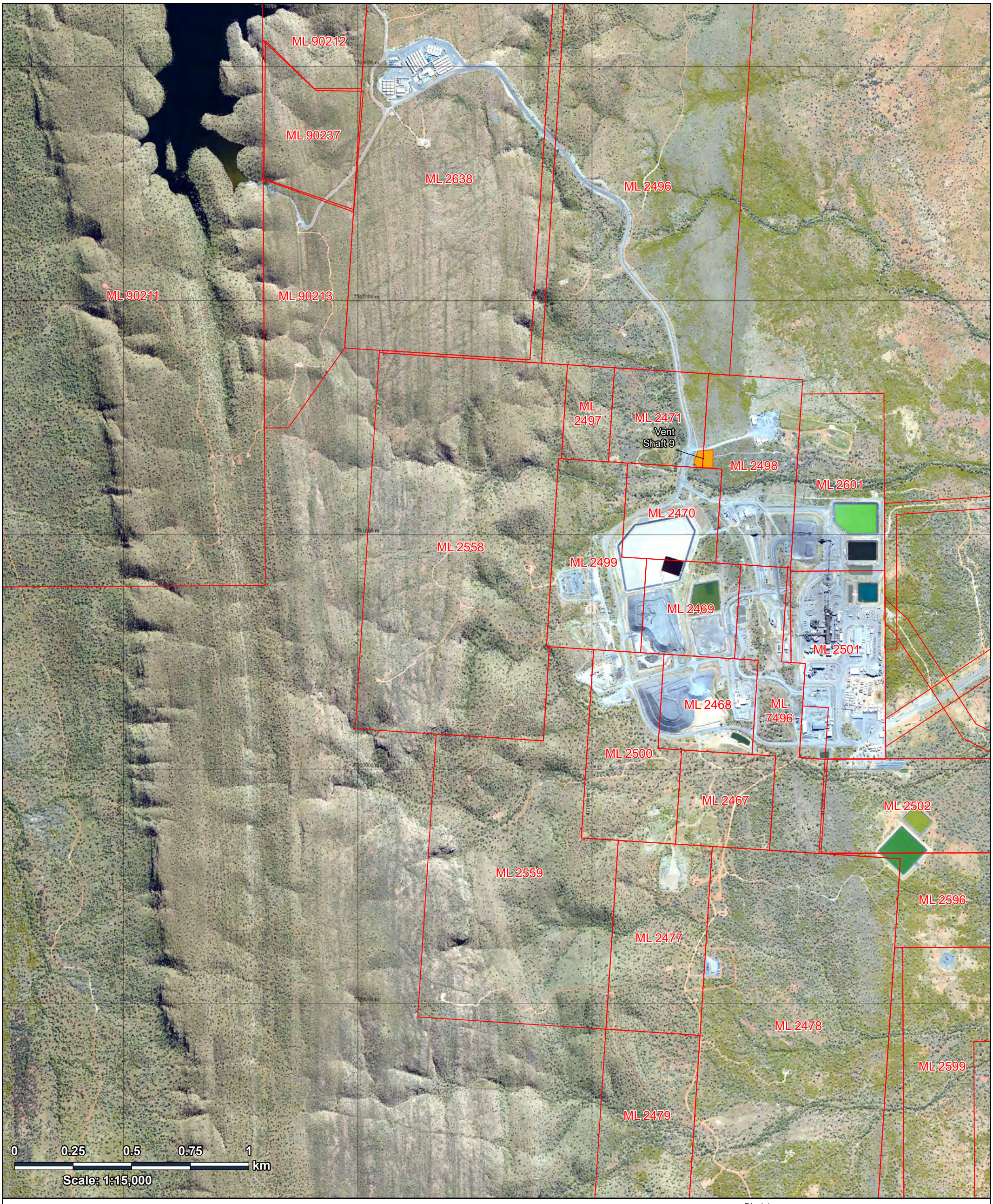


Figure 6. Proposed Vent Shaft Infrastructure

Client: MMG Dugald River Pty Ltd
Project Number: 2023.03002
Publication Date: 28/11/2023

Spatial Reference
PCS: GDA2020 MGA Zone 54
GCS: GDA2020
Datum: GDA2020

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Legend

- Mining Lease
- Proposed Vent Shaft Infrastructure

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3. Existing Environment

3.1. Climate

DRM is situated within the northwest highlands biogeographic region. The bioregion is characterised by distinctive wet and dry seasons with hot conditions and periods of rainfall between November to April, and relatively dry and mild conditions between May to October.

Statistics from the nearest Bureau of Meteorology weather station at the Cloncurry Airport (BOM 2023 – Station ID 29141 1978-current) generalise a 12°C spread of the mean monthly minimum and maximum daily temperatures during summer while increasing to 14°C in winter Figure 7). The highest mean monthly temperatures are recorded in December and the lowest in July (Table 7).

Most rainfall measured at the Cloncurry Airport is received between January and February (Figure 8) with an annual average rainfall of 501.1mm. With only 35 days where rainfall is ≥ 1mm, short and intense storm events are common (Table 8).

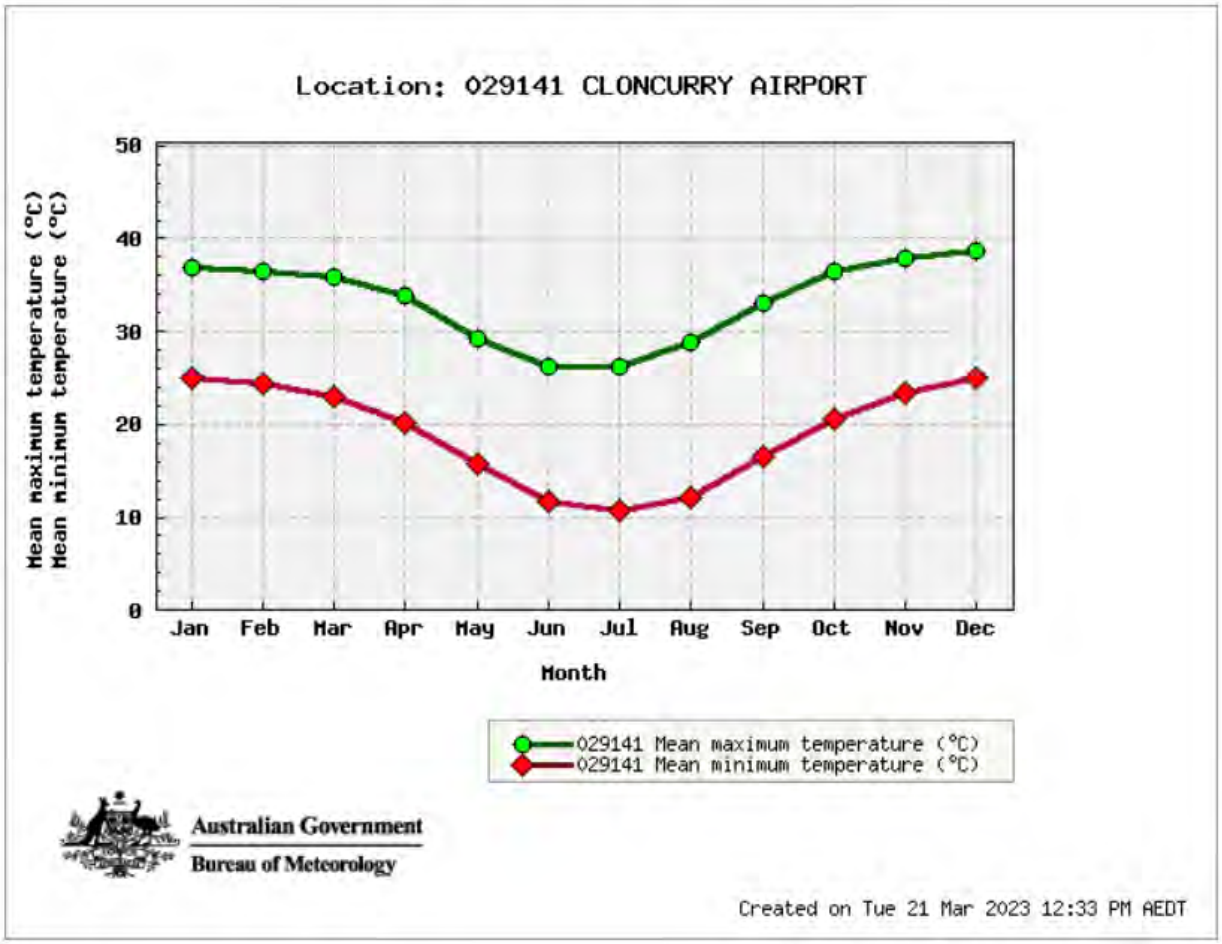


Figure 7. Minimum and Maximum Monthly Mean Temperatures from the Cloncurry Airport (BOM 2023)

Table 7. Mean Monthly Temperatures recorded at the Cloncurry Airport (BOM 2023)

Statistic	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Mean Temp max (ºC)	36.9	36.4	35.9	33.8	29.3	26.2	26.3	28.8	33.1	36.5	37.9	38.7	33.3
Mean Temp min (ºC)	25.1	24.3	23.0	20.2	15.7	11.8	10.8	12.2	16.6	20.6	23.3	25.0	19.0

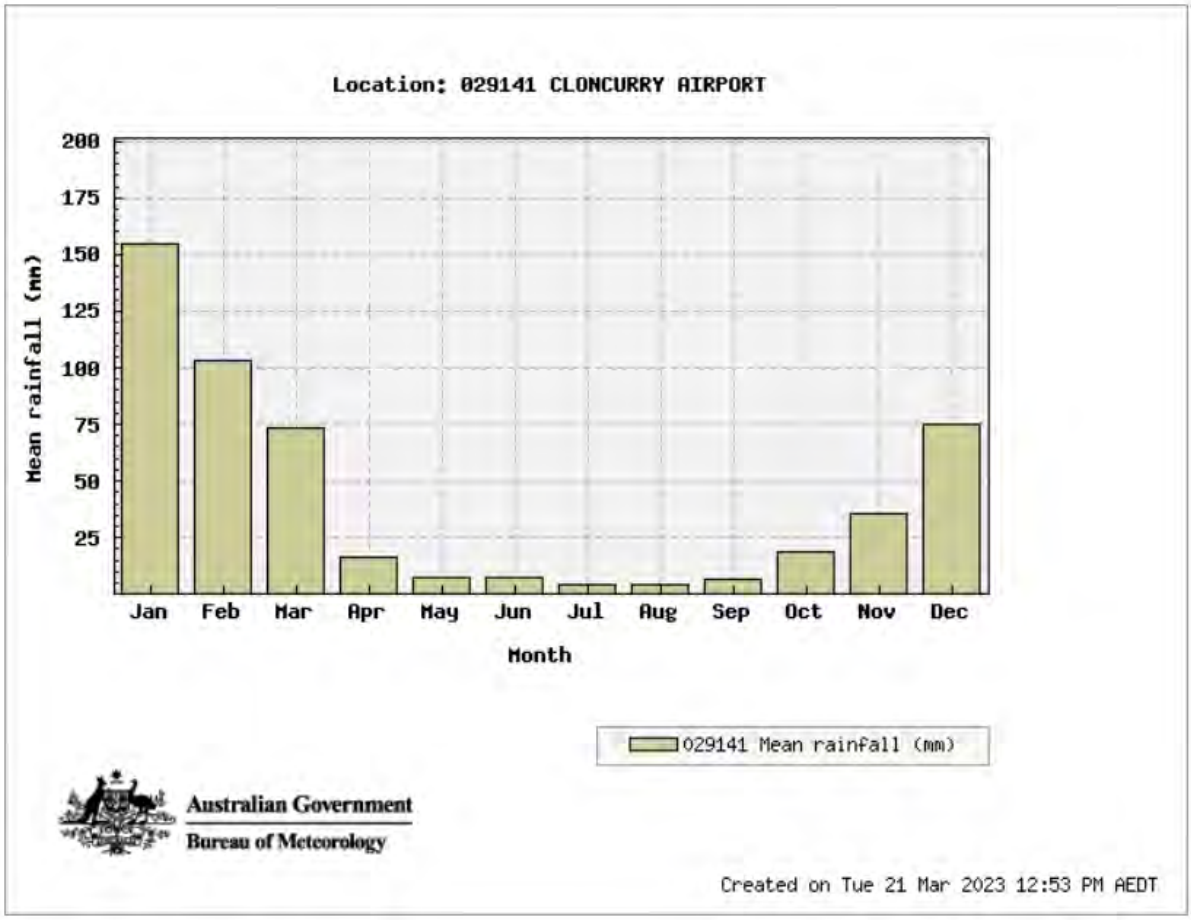


Figure 8. Mean Monthly Rainfall Recorded from the Cloncurry Airport (BOM 2023)

Table 8. Rainfall Statistics Recorded from the Cloncurry Airport (BOM 2023)

Statistic	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Annual
Mean rainfall (mm)	154.8	103.4	73.7	16.0	7.6	7.8	4.3	4.1	6.9	18.8	35.8	75.1	501.1
Days ≥ 1mm	8.3	6.2	4.2	1.4	0.8	0.7	0.5	0.4	1.2	2.0	3.8	5.4	34.9

3.2. Topography and Hydrology

3.2.1. Topography

The DRM is located at approximately 200 m AHD on relative flat, grassy plains. The Knapdale Range is the dominant feature of the region, as the topographical high at approximately 310 m AHD. The Knapdale Range is a north south orientated formation approximately 14km long and 2.5km wide, sharply transitioning to undulating country east to the Dugald River and west to Cabbage Tree Creek at ~200mAHD (Figure 9).

The mining and processing infrastructure is located on the eastern slope of the Knapdale Range with the Tailings Storage Facility sited within the centre valley of the range, formerly draining to the west.

3.2.2. Hydrology

Regionally DRM is situated in the Leichardt and Flinders drainage basins with the Knapdale Range providing the drainage divide between the two catchments (WRM Water & Environment Pty Ltd, 2010). Both the Leichardt and Flinders Rivers drain north into the Gulf of Carpentaria approximately 300 km north of DRM (Figure 9).

Locally, the DRM area is dominated by 1st and 2nd order ephemeral drainage features that flow intermittently during wet season rains. The north west portions of the MLs drain to the north through 1st and 2nd order streams to the Vieuex Rose Creek and Cabbage Tree Creek which flow into Pinnacle Creek, a tributary of the Leichardt River. Drainage to the east and south of the Knapdales enters the Flinders River via Dugald River, a tributary of the Cloncurry River (WTS 2021).

The nearest watercourses, as defined under the Water Act 2000, are Cabbage Tree Creek and the Dugald River, both located outside the mining leases.

The catchments associated with the predominant mine features are listed in Table 9.

Table 9. Local Catchments and Mine Features

Local catchment	Mine features
Silvermine Creek	Mining, processing, mineral waste storage, administration, mine access, village, and logistics
Vieuex Rose Creek	Village
Cabbage Tree Creek	Tailings storage facility

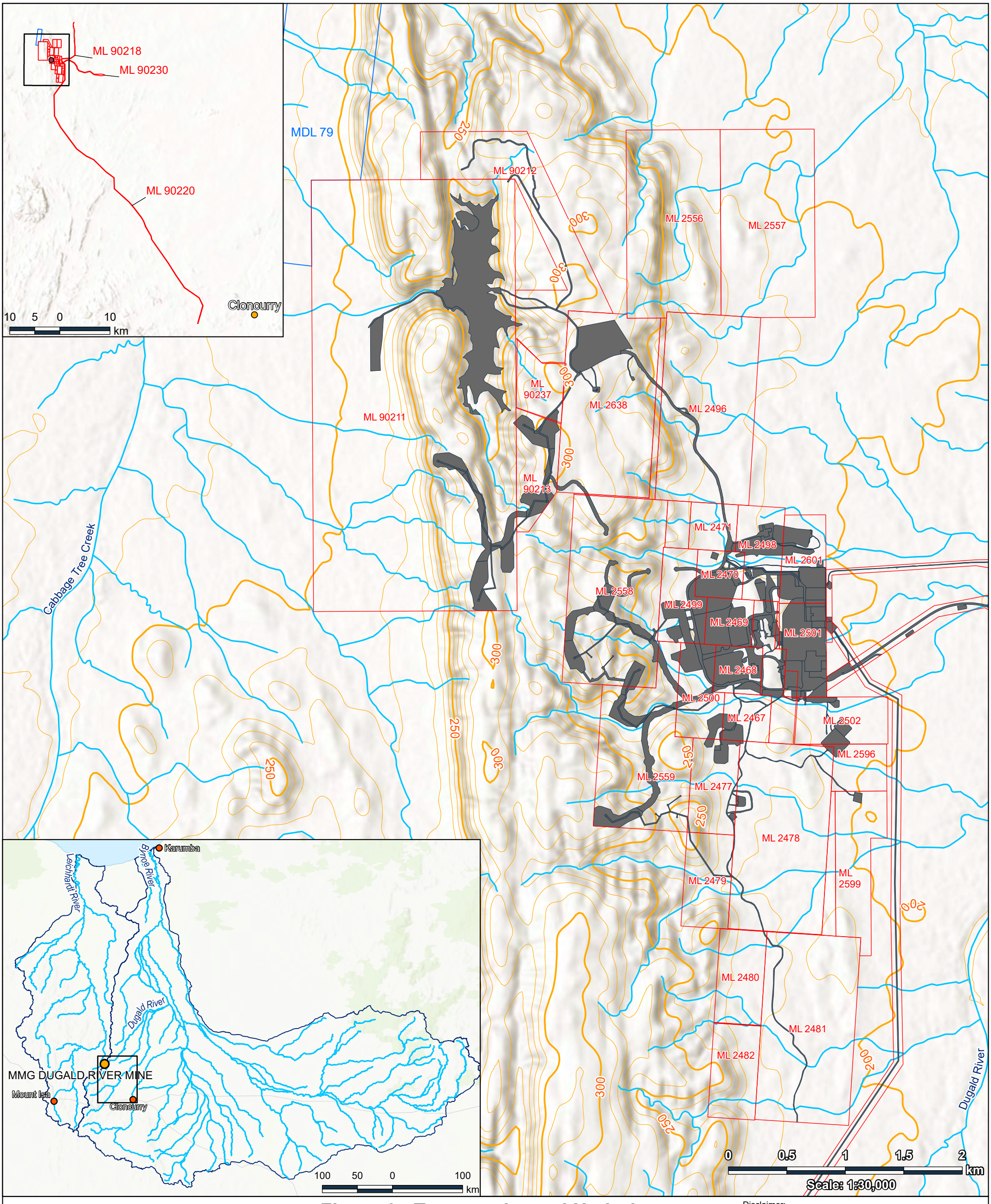


Figure 9. Topography and Hydrology

Client: MMG Dugald River Pty Ltd
Project Number: 2023.03002
Publication Date: 1/12/2023

Spatial Reference
PCS: GDA2020 MGA Zone 54
GCS: GDA2020
Datum: GDA2020

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Legend

- Mining Lease
- Mineral Development License
- Footprint
- Contour (50m)
- Contour (10m)
- Watercourse

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Department of Resources, Dept.of Environment and Science, Esri, HERE, Garmin, FAO, NOAA, USGS, Esri, Geoscience Australia, NASA, NGA, USGS, Esri, USGS

3.3. Waters

3.3.1. Surface Water

3.3.1.1. Environmental Values

The Environmental Protection Policy (Water and Wetland Biodiversity) (EPP Water) details the scheduled water quality basins and their specific management intent. DRM is situated between the Leichardt and Flinders drainage basins with the Knapdale Range providing the drainage divide between the two catchments. No Environmental Values are listed for either the Leichardt or Flinders drainage basins. In the absence of EVs for either catchment, the following EVs have been adopted from the EPP Water Part 3:

- For high ecological value waters—the biological integrity of an aquatic ecosystem that is effectively unmodified or highly valued; or
- For slightly disturbed waters—the biological integrity of an aquatic ecosystem that has effectively unmodified biological indicators, but slightly modified physical, chemical or other indicators; or
- For moderately disturbed waters—the biological integrity of an aquatic ecosystem that is adversely affected by human activity to a relatively small but measurable degree; or
- For highly disturbed waters—the biological integrity of an aquatic ecosystem that is measurably degraded and of lower ecological value than waters mentioned in paragraphs (a) to (c); or
- For waters from which aquatic foods intended for human consumption are taken—the suitability of the water for producing the foods for human consumption; or
- For waters that may be used for aquaculture—the suitability of the water for aquacultural use; or
- For waters that may be used for agricultural purposes—the suitability of the water for agricultural purposes; or
- For waters that may be used for recreation or aesthetic purposes—the suitability of the water for—
    - Primary recreational use; or
    - Secondary recreational use; or
    - Visual recreational use; or
- For waters that may be used for drinking water—the suitability of the water for supply as drinking water having regard to the level of treatment of the water; or
- For waters that may be used for industrial purposes—the suitability of the water for industrial use; or

- The cultural and spiritual values of the water (Environmental Protection Act 1994 (Qld) (b)).

3.3.1.2. Water Quality Trigger Limits

The EA provides receiving water reference sites and downstream monitoring locations (Schedule C – Table 4 of the EA). Each site is monitored and sampled in accordance with Schedule C Table 5 of the EA, presented in Table 10.

Table 10. Receiving Waters Trigger Levels and Contaminant Limits (Schedule C – Table 5 of the EA)

Quality Characteristic	Unit	Trigger Level	Contaminant Limit	Monitoring Frequency
Hardness ($CaCO_3$)	mg/L	For interpretation purposes		<u>Sites on tributaries of Dugald River:</u> Sample daily for the first two days when releases or stream flows commence at interpretative sites. If releases or flows at interpretative sites persist, sample weekly until flow ceases. <u>Dugald River Sites:</u> Sample Dugald River sites daily while there is flows at DR-14, and daily for one week after cessation of flows at SC-38 and SN-23. Sample monthly if flows are present in Dugald River during the wet season. <u>Cabbage Tree Creek sites:</u> Sample CT3-08, CC-05 and CC-15 daily when flows are present at CT3-08 and sample CC-05 and CC-15 daily for
pH	pH Units	6.0 (minimum) 8.6 (maximum)	5.5 (minimum) 9.0 (maximum)	
Electrical Conductivity	µS/cm	435 or 80th percentile of reference whichever is higher	1000	
Total Suspended Solids	mg/L	For interpretation purposes		
Sulfate	mg/L	77 [Duglad River] or 80th percentile of reference whichever is higher	400	
Fluoride	mg/L	80th percentile of reference	2 or 95th percentile of reference whichever is lower	
Aluminium (dissolved)	mg/L	0.055 or 80th percentile of reference whichever is higher	95th percentile of reference	
Aluminium (total)	mg/L	-	0.2	
Arsenic (dissolved)	mg/L	0.013 or	95th percentile of reference	

Quality Characteristic	Unit	Trigger Level	Contaminant Limit	Monitoring Frequency
		80th percentile of reference whichever is higher		two days after flows at CT3-08 cease. Sample CC-05 and CC-15 weekly if flows are present.
Arsenic (total)	mg/L	-	0.5	
Cadmium (dissolved)	mg/L	0.0002 or 80th percentile of reference whichever is higher	95th percentile of reference	
Cadmium (total)	mg/L	-	0.005	
Copper (dissolved)	mg/L	0.0014 or 80th percentile of reference whichever is higher	95th percentile of reference	
Copper (total)	mg/L	-	1	
Cyanide Free	mg/L	0.007 or 80th percentile of reference whichever is higher	0.022	
Cyanide WAD	mg/L	-	0.1	
Lead (dissolved)	mg/L	0.0034 or 80th percentile of reference whichever is higher	95th percentile of reference	
Lead (total)	mg/L	-	0.05	
Manganese (dissolved)	mg/L	1.9 or 80th percentile of reference whichever is higher	95th percentile of reference	
Manganese (total)	mg/L	For interpretation purposes		
Nickel (dissolved)	mg/L	0.011 or	95th percentile of reference	

Quality Characteristic	Unit	Trigger Level	Contaminant Limit	Monitoring Frequency
		80th percentile of reference whichever is higher		
Nickel (total)	mg/L	-	1	
Zinc (dissolved)	mg/L	0.008 or 80th percentile of reference whichever is higher	95th percentile of reference	
Zinc (total)	mg/L	-	20	

3.3.2. Groundwater

3.3.2.1. Environmental Values

The most relevant EVs were derived from the EPP (Water and Wetland Biodiversity) 2019 which include:

- For waters that may be used for agricultural purposes – the suitability of the water for agricultural purposes;
- For waters that may be used for recreation or aesthetic purposes – the suitability of water for:
    - Primary recreational use; or
    - Secondary recreational use; or
    - Visual recreational use
- For water that may be used for drinking water – the suitability of the water for supply as drinking water having regard to the level of treatment of the water;
- For waters that may be used for industrial purposes – the suitability of the water for industrial use; or
- The cultural and spiritual values of the waters.

3.3.2.2. Groundwater Monitoring Network

The DRM groundwater network is described in Table 11 and Figure 10. Note that the Saturday Bore has collapsed and is no longer serviceable for obtaining groundwater levels or samples for analysis.

The groundwater monitoring program focusses on risk associated with the mine infrastructure area. Several bores are located to the west of the Knapdale Range (MB5, MB6, MB9S and MB9D) to monitor for impacts from the TSF.

Table 11. Groundwater Bore Details

Bore	Formation	EA classification	Permeability
MB1	Mount Roseby Schist	Background	7.53×10^{-6}
MB3	Mount Roseby Schist	Background	2.60×10^{-1}
Saturday Bore	Mount Roseby Schist	Background	No data
MB5	Mount Roseby Schist	Compliance	9.21×10^{-2}
MB6	Mount Roseby Schist	Compliance	2.23×10^{-3}
MB9S	Knapdale Quartzite	Compliance	No data
MB9D	Knapdale Quartzite	Compliance	No data
MB2	Mount Roseby Schist	Compliance	4.08×10^{-1}
MB4	Mount Roseby Schist	Compliance	7.52×10^{-2}
GWBFAB	Dugald River Slate	Interpretation	No data
MB1AB	Mount Roseby Schist	Interpretation	No data
MB2AB	Mount Roseby Schist	Interpretation	No data
MB3AB	Mount Roseby Schist	Interpretation	No data
MB4AB	Mount Roseby Schist	Interpretation	No data
SHALL6AB	Mount Roseby Schist	Interpretation	No data

CDM Smith (2021) completed the most recent biennial review of the groundwater monitoring program. The review refers to the ionic composition as being bicarbonate dominant across the bores except for MB3 which is sulfate dominant, and the water quality is described as suitable for stock watering and marginally potable at some locations. CDM Smith (2021) summarised the compliance assessment for DRM as:

- Most analytes were below trigger levels, Hardness Modified Trigger Levels (HMTVs) or below background levels. Copper at MB2 should be assessed using control charting if exceedances of the HMTV are noted in future; and
- Most analytes were below contaminant limits with the exception of fluoride at MB2 (within natural variation) and aluminium at MB9D (potentially due to high suspended sediment in the bore).

3.3.2.3. Groundwater Trigger Limits

EA Schedule C – Table 8 specifies the groundwater quality trigger limits for DRM. Trigger limits are detailed in Table 12.

Table 12. Groundwater Trigger Levels and Contaminant Limits (Schedule C – Table 8)

Quality Characteristic[1]	Unit	Trigger Level[1]	Contaminant limit[2]
pH	pH unit	6.0 (minimum) 8.0 (maximum	6.0 (minimum) 9.0 (maximum)
Electrical Conductivity	µS/cm	1500[6]	2000[6]
Hardness (as $CaCO_3$)	mg/L	For interpretation purposes	
Total Dissolved Solids (TDS)	mg/L	For interpretation purposes	
Major ions	mg/L	For interpretation purposes	
Sulphate (mg/L)	mg/L	150[6]	1000[5]
Fluoride (mg/L)	mg/L	-	2[4]
Aluminium	mg/L	0.055[3]	5[4]
Arsenic[7]	mg/L	0.013[3]	0.5[4]
Cadmium (mg/L)	mg/L	0.0002[3]	0.01[4]
Copper (mg/L)	mg/L	0.0014[3]	1[4]
Cyanide[8]	mg/L	0.007[9]	0.022[10]
Lead (mg/L)	mg/L	0.0034[3]	0.1[4]
Manganese (mg/L)	mg/L	1.9[3]	-
Nickel (mg/L)	mg/L	0.011[3]	1[4]
Zinc (mg/L)	mg/L	0.008[3]	20[4]

[1] All metals and metalloids must be measured as filtered with the exception of fluoride.

[2] All metals and metalloids must be measured as total (unfiltered).

[3] Based on ANZECC/ARMCANZ (2000) Table 3.4.1 (high reliability trigger values) and Section 8.3 moderate or low reliability trigger values if no value available in Table 3.4.1.

[4] Based on ANZECC/ARMCANZ (2000) Table 4.3.2 for livestock drinking water.

[5] Based on ANZECC/ARMCANZ (2000) Section 4.3.3.4;

[6] MMG Dugald River – site specific value

[7] Speciated arsenic concentrations for As (III) and As (V) only required if 13 mg/L is exceeded – note that the sample bottle requirements for As (total species) and As (speciated) may differ.

[8] The requirement to monitor for cyanide is deferred until the time cyanide is introduced into the mining process.

[9] Cyanide as un-ionised HCN, measured as [CN] – based on ANZECC/ARMCANZ (2000) Table 3.4.1, refer also Section 8.3.7.2.

[10] Free Cyanide – based on International Cyanide Management Institute (2009) Implementation Guidance – Standard of Practice 4.5 – receiving surface waterbody guideline value

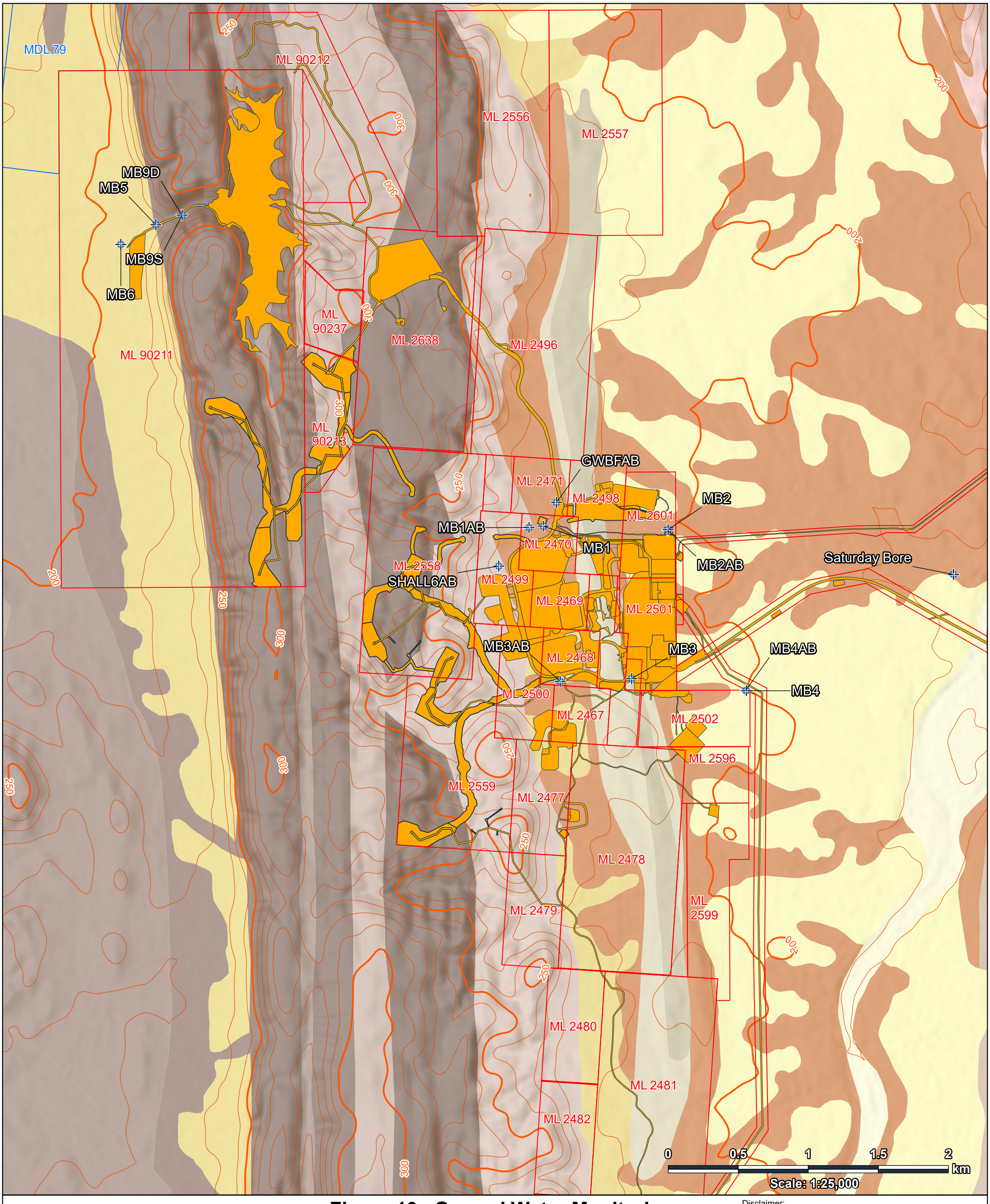


Figure 10. Ground Water Monitoring and Surface Geology

Client: MMG Dugald River Pty Ltd
Project Number: 2023.03002
Publication Date: 24/11/2023

Spatial Reference
PCS: GDA2020 MGA Zone 54
GCS: GDA2020
Datum: GDA2020

Print on A3

Legend

- Mining Lease
- Mineral Development License
- Existing Disturbance
- Contour (50m)
- Contour (10m)
- Monitoring Bore

Surface Geology

- Coocerina Formation (PLpc)
- Corella Formation-c (PLkc-c)
- Dugald River Shale Member (PLpod)
- Dugald River Shale Member/l (PLpod/l)
- Knapdale Quartzite (PLpk)
- Knapdale Quartzite/c (PLpk/c)
- Knapdale Quartzite/q (PLpk/q)
- Knapdale Quartzite/t (PLpk/t)
- Lady Clayre Formation/ d (PLpy/d)
- Lady Clayre Formation/ s (PLpy/s)
- Mount Roseby Schist (PLpo)
- Qa-QLD (Qa)
- TQa-QLD (TQa)
- TQf-QLD (TQf)
- q-Ml (q)

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3.3.3. Hydrogeology

A conceptual hydrogeological model for DRM has been refined by CDM Smith Australia Pty Ltd. CDM Smith (2019) describe the hydrogeology as being recharged predominately via diffuse infiltration from rainfall on the Knapdale Range. Information to date indicates that groundwater flows from west to east beneath the mining and processing areas.

Groundwater movement is generally within the unweathered fracture zones of the Mount Roseby Schist with North and Silvermine Creeks acting as potential preferential flow paths however basal flow contribution is unlikely given the depth to groundwater being > 4 m. Groundwater discharge is seasonal within likely basal flow contribution to the Dugald River.

The permeability of the surrounding sedimentary rock is generally low which is thought to mitigate the potential for a cone of depression from dewatering activities.

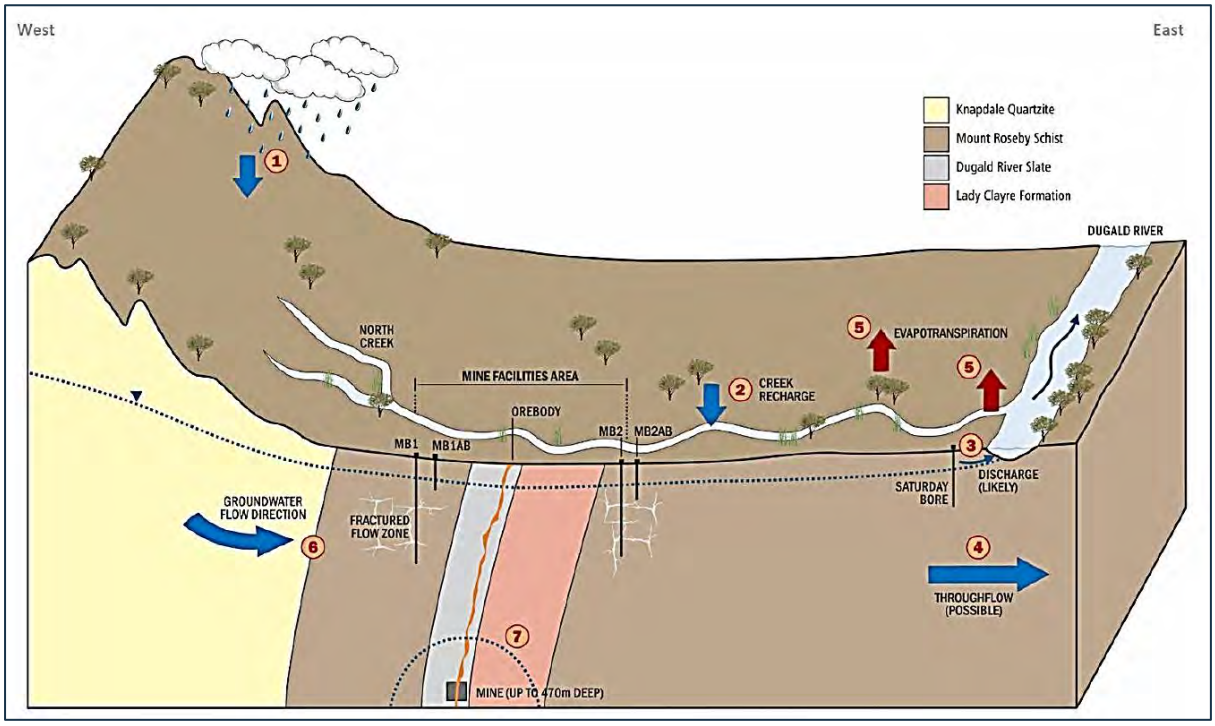


Figure 11. Conceptual Hydrogeological Model for DRM (CDM Smith 2019)

3.4. Soils

The soils of DRM area are dominated by Rudosols with minor areas of Calcarosols (AARC 2010a). Australian Soil Classification (Isbell 2016) define Rudosols as being soils with negligible pedology, minimal development of an A1 horizon or the presence of less than 10% of B horizon material (including pedogenic carbonate) in fissures in the parent rock or saprolite. The soils are apedal or only weakly structured in the A1 horizon and show no pedological colour changes apart from the darkening of an A1 horizon. There is little or no texture or colour change with depth unless stratified or buried soils are present.

Six soil types were described by AARC (2010a) (Table 13). All soil management units are dominated by features that severely limit their productive use in grazing or cropping due to very low plant-available water, erosion potential and limited nutrient availability. Subsequent to the AARC (2010a) soil surveys, several pockets of dispersive red clays were identified during construction activities.

Table 13. DRM Soil Types (AARC 2010a)

Soil Type	Description
Red Plains	The Red Plains Soil Mapping Unit (SMU) consists of red sandy loams to sandy clay loams with a neutral to slightly acidic pH. These soils are Rudosols with weak pedality and a maximum depth of 0.5 m.
Knapdale	The Knapdale SMU consists of brown skeletal sandy clay loams with a neutral to slightly acidic pH. These soils are Rudosols and very shallow (less than 0.2 m thick). They are mostly found on the eastern and western slopes of the Knapdale Range.
Dale	The Dale SMU consists of brown to reddish sandy loams with a slightly acidic pH increasing down the profile. Pedality ranges from weak to moderate with a depth of between 0.5-0.7 m. These soils are Rudosols and are generally found in depressions such as valley floors or plateaus in the Knapdale Range.
Miners	The Miners SMU consists of dark yellowish-brown sandy clay loams to silty loams with a slightly alkaline pH. Pedality is weak with a maximum depth of 0.2 m. These soils are Rudosols and are found on and immediately supporting the outcropping of the Dugald River deposit lode on the eastern side of the Knapdale Range.
Prospectors	The Prospectors SMU consists of dark yellowish-brown clay loams with a slightly acidic pH. Pedality is weak with a maximum depth of 0.2 m. These soils are Rudosols and are found on the toe slope of the western side of the Knapdale Range.
Pocket	The Pocket SMU consists of brown-grey sandy clay loams with an alkaline pH due to elevated levels of calcium carbonate. Pedality is weak. These soils are Calcarosols and are found in small pockets on the eastern and northern side of the Knapdale Range.

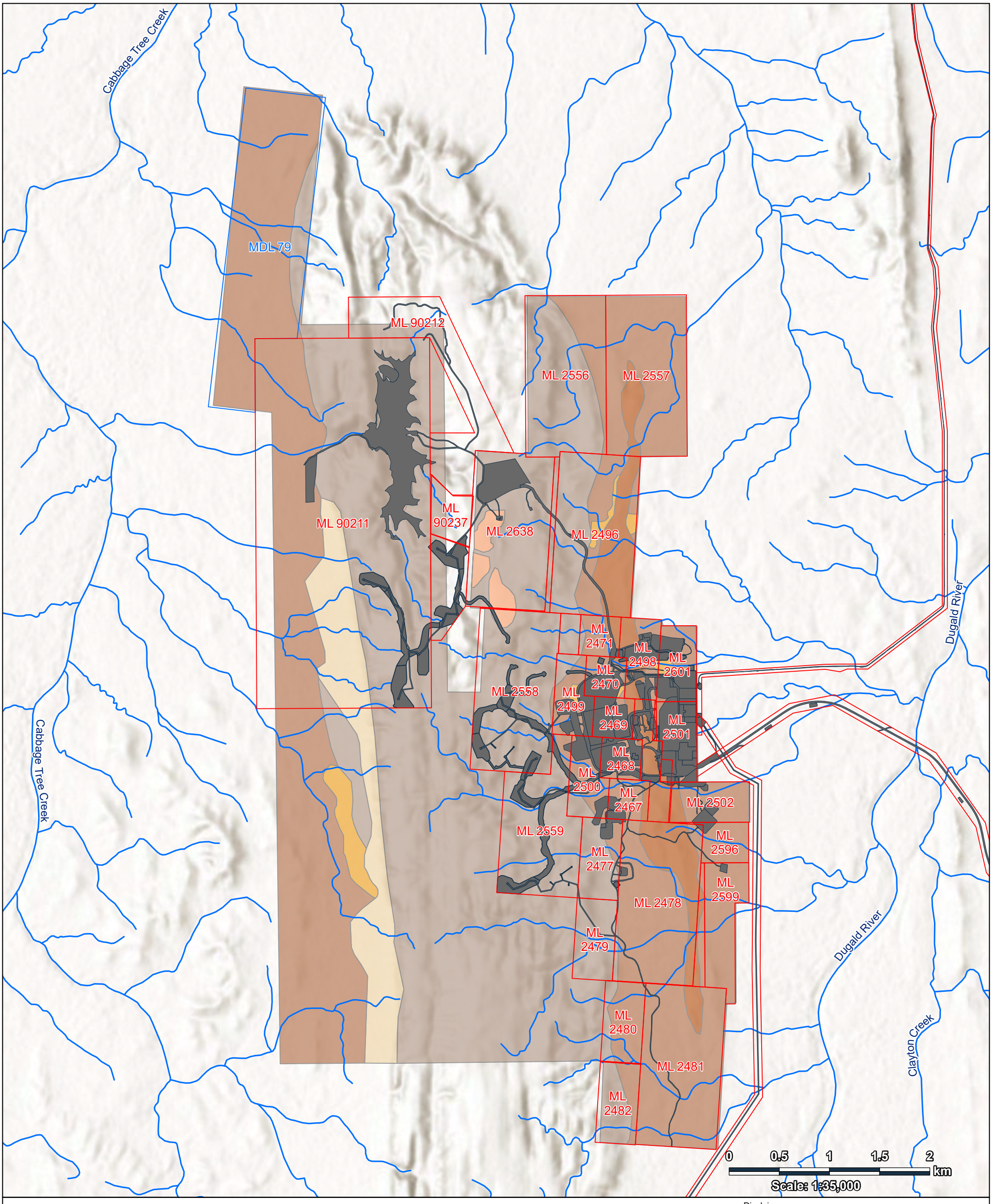


Figure 12. Soils

Client: MMG Dugald River Pty Ltd
Project Number: 2023.03002
Publication Date: 24/11/2023

Spatial Reference
PCS: GDA2020 MGA Zone 54
GCS: GDA2020
Datum: GDA2020

Print on A3

Legend

- Mining Lease
- Mineral Development License
- Watercourse (VM Act)
- Existing Disturbance

Soils

- Dale
- Knapdale
- Miners
- Pocket
- Prospectors
- Red Plain

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3.5. Geology

DRM is located within a north to south trending feature named the Mt Roseby Corridor, within the Eastern Fold Belt of the Mount Isa Inlier (Figure 10). The Mount Roseby Corridor is bordered to the west by the Knapdale Quartzite and to the east by the Mt Roseby Fault. The Knapdale Quartzite forms the Knapdale Range, a local topographic high. The Mount Roseby corridor is comprised of the Mount Roseby Schist Formation which includes the Dugald River Slate Sequence of hanging wall calc-silicates, Dugald River slate (host of the ore body) and the footwall limestone (SGM 2021).

The geology of the rock units mined at DRM were described in EGi (2011). The units are calc-silicate, white mica schist, mafic feldspar porphyry, hanging wall slate, mineralized lode waste, footwall slate, and footwall limestone. Waste mined was found to be predominately non-acid forming (NAF) but areas of potentially acid forming (PAF) rock may be encountered proximal to the ore body and minor volumes within the hanging and foot wall slate. Table 14 describes the four dominant geological units at DRM.

Table 14. Mapped Geology for Dugald River Mine

Geological Unit	Description	Age
Lady Clayre Dolomite	Dolomitic, locally pyrrhotitic siltstone, silty to sandy dolostone and fine-grained, variably dolomitic sandstone	Paleoproterozoic
Knapdale Quartzite	Pink, fine-grained, feldspathic to quartzose, locally micaceous sandstone	Paleoproterozoic
Dugald River Slate Sequence	Dark grey, carbonaceous shale and siltstone and grey mica schist; Ore body; and Dark grey silty, dolomitic limestone and siltstone	Paleoproterozoic
Mount Roseby Schist	Grey muscovite-biotite-quartz schist (psammopelite) and minor quartzite, calc-silicate granofels and limestone; commonly thin-bedded with abundant poikiloblastic scapolite porphyroblasts, particularly in the north	Paleoproterozoic

3.6. Flora and Fauna

3.6.1. Regional Ecosystems

Mapped regional ecosystems (RE) were reviewed using the Queensland Globe interactive mapping tool (Queensland Government 2023). The REs mapped for the proposed disturbance areas are largely heterogeneous REs comprised of 1.11.2a/1.11.2x1 (at 70/30%), 1.11.3x1b/1.3.6x1a (at 90/10%), 1.11.2.a/1.11.2e (at 50/50%) and 1.11.22/1.5.4x3/1.3.7b (at 70/25/5%).

While RE 1.3.7b: *Eucalyptus camaldulensis* fringing woodland, usually with *Lophostemon grandiflorus* and *Melaleuca bracteata* and/or *M. dissitiflora* is considered least concern under the Vegetation Management Act 1999 (VM Act), it has a biodiversity status of endangered due to its importance as seasonal water bird habitat and a regional corridor for fauna. It is therefore a category B Environmentally Sensitive Area (ESA) under Schedule 19 of the *Environmental Protection Regulation 2019*. RE 1.3.7 is mapped as a subdominant RE at an estimated 5% of the total mapped RE area.

Ground truthing surveys (AARC, 2011 and EcoSmart Ecology, 2023) have provided mapped areas delineating 1.3.7b, however these have not yet been foramlised as changes to the mapping via a Property Map of Assessable Vegetation (WTS, 2023).

REs mapped within the proposed disturbance areas are described in Table 15 and Figure 15.

Table 15. Regional Ecosystems Present Within the Proposed Disturbance Area

Regional Ecosystems	Long Description	VM Status*	BD Status#	Special Values
1.3.6x1a Now 1.3.13a	This vegetation community is now mapped as 1.3.13a. *Eucalyptus leucophylla* and/or *Eucalyptus pruinosa subsp. pruinosa* woodland often with *Corymbia terminalis, Eucalyptus camaldulensis* and *Acacia cambagei* with a sparse mixed shrub layer and a sparse ground layer dominated by *Bothriochloa ewartiana* and *Sehima nervosum*, often with *Triodia longiceps*. Occurs on ephemeral watercourses with active beds. Not a Wetland.	LC	OC	1.3.13: Potential habitat for NCA listed species: *Ipomoea antonschmidii, Ptilotus maconochiei.*
1.3.7	*Eucalyptus camaldulensis* fringing woodland, usually with *Lophostemon grandiflorus* and *Melaleuca bracteata* and/or *M. dissitiflora*. Occurs on recent levees and channel deposits of medium and smaller tributaries which are dry for most of the year; alluvial soils. Riverine.	LC	E	1.3.7: Important seasonal water bird habitat; regional corridor for fauna.
1.5.4x3 now 1.5.15	*Aristida contorta* annual grasslands, usually with *Aristida inaequiglumis*, that are bare for most of the year and can be dominated by forbs. Occurs on older alluvium and residual soils. Not a Wetland. (BVG1M: 31b).	LC	NC	None specified
1.11.2a	*Eucalyptus leucophloia* low open woodland or low woodland, sometimes with *Eucalyptus ludophilia*, *Corymbia terminalis*, *Corymbia aparrerinja* or *Eucalyptus normantonensis* usually with a *Acacia* spp. dominated shrub layer and *Triodia* spp. and/or tussock grass understorey. Treeless areas common. Occurs on hills and ranges on strongly folded metamorphic pre-Cambrian rocks; soils skeletal, some red earths. Not a Wetland. (BVG1M: 19a).	LC	NC	1.11.2: Potential habitat for NCA listed species: *Eucalyptus nudicaulis*, *Ipomoea antonschmidii*, *Solanum carduiforme*, *Trachymene glandulosa*.
1.11.2e now 1.11.3a	See 1.11.3a	LC	NC	
1.11.2x1 now 1.7.7a	Low open woodland of *Corymbia capricornia*, commonly with *Eucalyptus leucophloia*. *Eucalyptus miniata*, *Eucalyptus*	LC	NC	1.7.7: Potential habitat for NCA listed species:

	herbertiana and *Corymbia* ferruginea are commonly present in the north. Mixed shrub layer usually including *Grevillea wickhamii*. Ground layer of *Triodia* spp. and *Schizachyrium* fragile. Occurs on silcrete. Not a Wetland. (BVG1M: 19a).			*Ipomoea antonschmidii*.
1.11.3a	Low open woodland of *Corymbia terminalis* and/or *Eucalyptus leucophylla* with *Acacia* spp. dominated shrub layer and ground layer of *Triodia* spp. and/or tussock grasses. Includes areas of *Acacia* spp. shrubland and *Triodia* spp. grassland. Occurs on metabasalts and dolerites; some felsic metavolcanics; skeletal soils, some shallow loams. Not a Wetland. (BVG1M: 19b).	LC	NC	1.11.3: Potential habitat for NCA listed species: *Eucalyptus nudicaulis*.
1.11.3x1b now 1.11.3a	See 1.11.3a	LC	NC	

VM Status = status under the Vegetation Management Act: BD Status# = Biodiversity Status: L – Least Concern. NC – No concern at present, OC – Of concern, E – Endangered.*

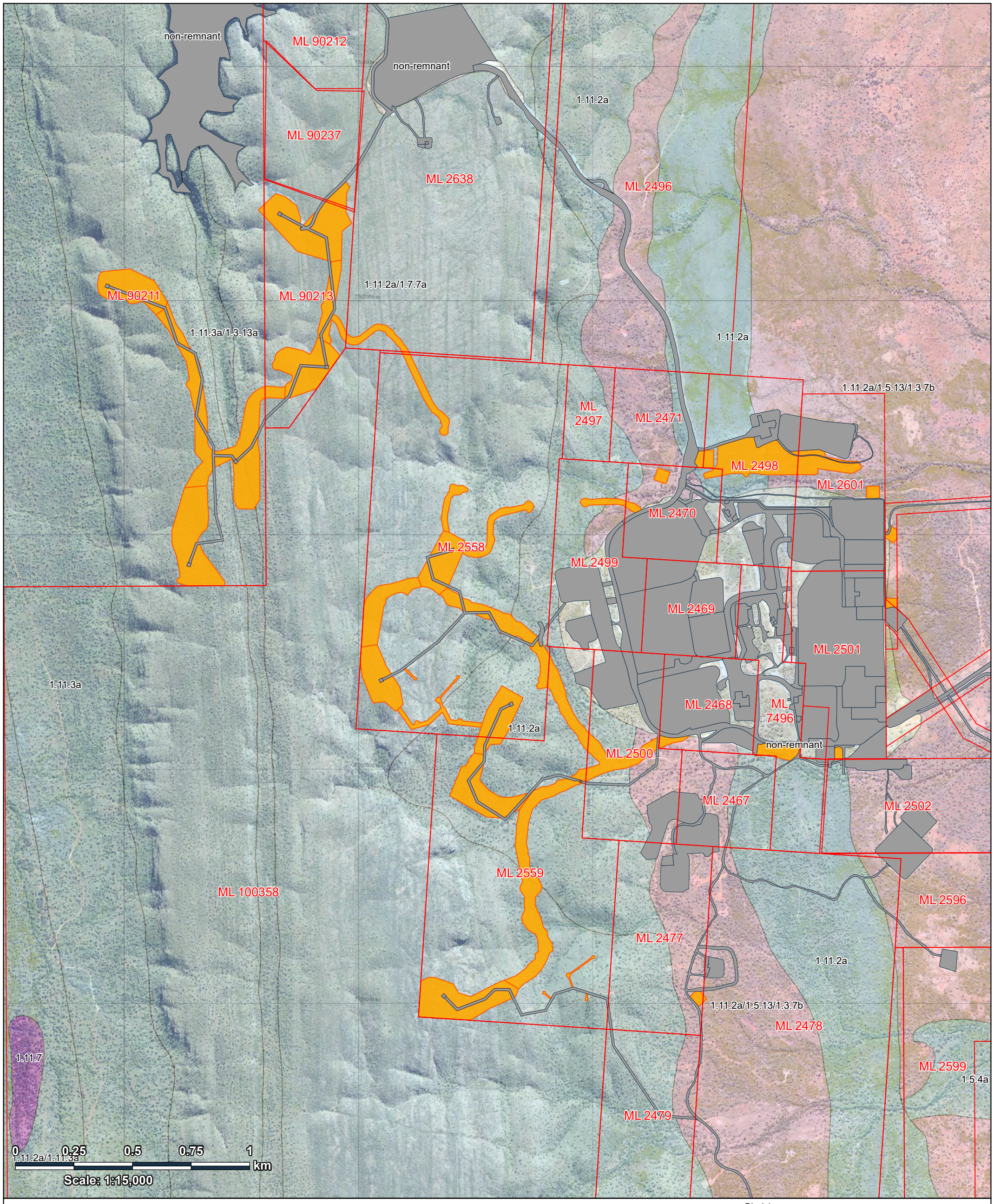


Figure 13. Mapped Regional Ecosystems

Client: MMG Dugald River Pty Ltd
Project Number: 2023.03002
Publication Date: 1/12/2023

Spatial Reference
PCS: GDA2020 MGA Zone 54
GCS: GDA2020
Datum: GDA2020

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Legend

- Mining Lease
- Proposed Disturbance Extent
- Existing Disturbance

Mapped Regional Ecosystem

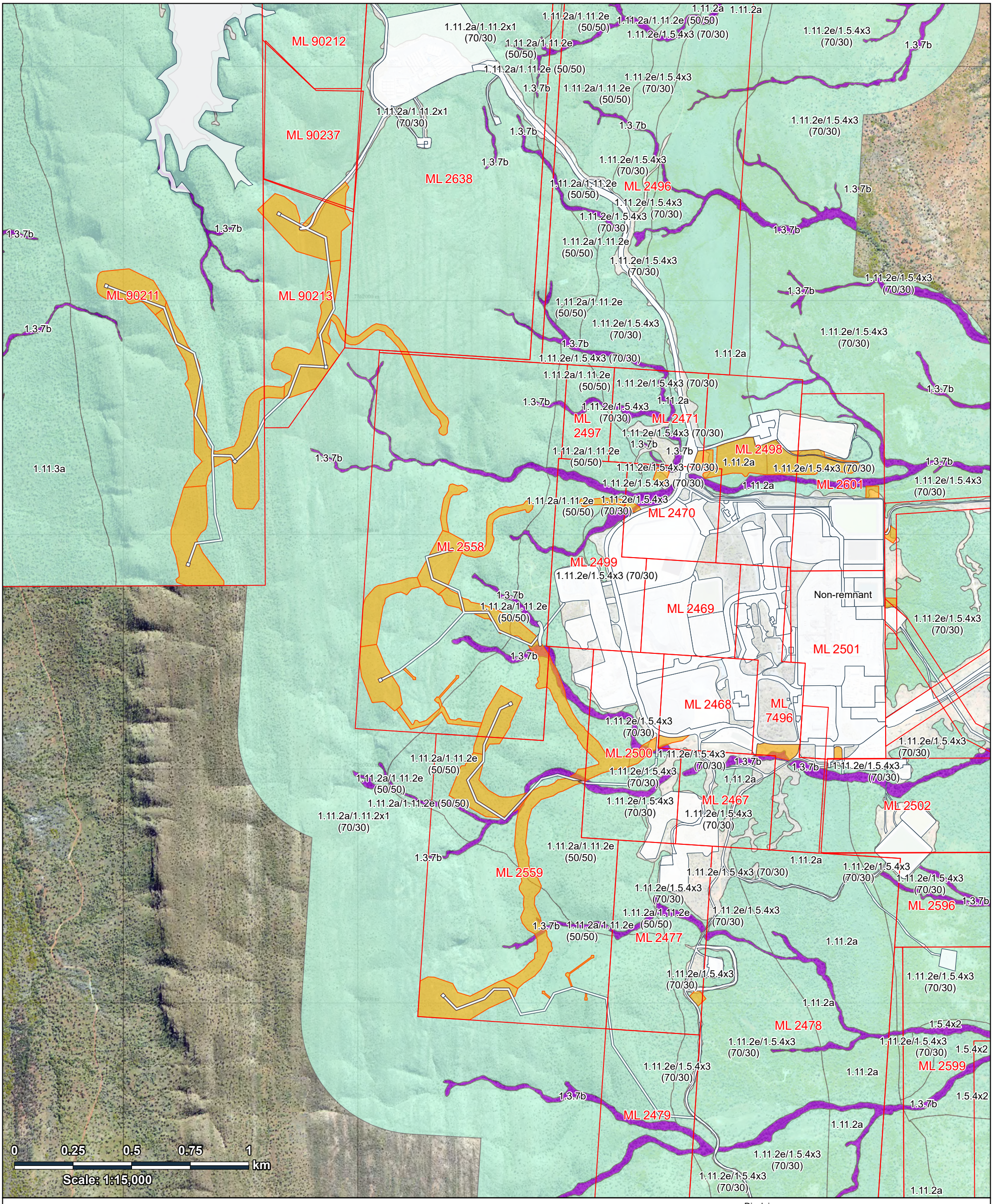
Biodiversity Status

- non-remnant
- Endangered Sub-dominant
- Of Concern Dominant
- No Concern

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Client: MMG Dugald River Pty Ltd
Project Number: 2023.03002
Publication Date: 28/11/2023

Spatial Reference
PCS: GDA2020 MGA Zone 54
GCS: GDA2020
Datum: GDA2020

Print on A3

Figure 14. Ground Truthed Regional Ecosystems

Legend

- Mining Lease
- Proposed Disturbance Extent
- Existing Disturbance

Ground Truthed RE

- Endangered
- No Concern at Present
- Non-remnant

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3.6.2. Matters of National Environmental Significance (MNES)

The Protected Matters Search Tool (PMST) was used to conduct a desktop analysis to determine the presence of any MNES under the *Environmental Protection and Biodiversity Conservation Act 1999* (EPBC) (DAWE 2023).

3.6.2.1. World Heritage Properties

There are no World Heritage Properties present within 50 km of DRM.

3.6.2.2. National Heritage Places

There are no National Heritage Places present within 50 km of DRM.

3.6.2.3. Wetlands of International Importance (Ramsar)

There are no Ramsar wetlands present within 50 km of DRM.

3.6.2.4. Great Barrier Reef Marine Park

The DRM is not within the Great Barrier Reef Marine Park buffer zone.

3.6.2.5. Commonwealth Marine Area

The DRM is not within the Commonwealth Marine Park buffer zone.

3.6.2.6. Listed Migratory and Marine Species

The PMST search tool identified 14 fauna species listed as Migratory under the EPBC Act as having potential to occur within 50 km of the project area. There are 19 species of fauna listed as marine under the EPBC Act as having potential to occur within 50 km of the project area. Each are described in Table 16.

It is noted that additional migratory and marine species were identified in Wildnet Database Species Profile searches. The total species list was considered in the likelihood of occurrence assessments, provided in Appendix K.

Table 16. EPBC listed migratory and marine species identified within 50km of DRM

Taxa	Common Name (*Scientific name*)	EPBC Status	NCA Status	Likelihood of Occurrence
Birds	Common greenshank (*Tringa nebularia*)	M, Ma	SL	Possible
	Common sandpiper (*Actitis hypoleucos*)	M, Ma	SL	Unlikely
	Curlew sandpiper (*Calidris ferruginea*)	CE, M, Ma	CE	Unlikely
	Eastern curlew (*Numenius madagascariensis*)	CE, M, Ma	E	Unlikely
	Fork-tailed swift (*Apus pacificus*)	M, Ma	SL	Possible
	Grey wagtail (*Motacilla cinerea*)	M, Ma	SL	Unlikely
	Barn Swallow (*Hirundo rustica*)	M, Ma	SL	Unlikely
	Latham's snipe (*Gallinago hardwickii*)	M, Ma	SL	Possible
	Oriental plover (*Charadrius veredus*)	M, Ma	SL	Unlikely
	Oriental pratincole (*Glareola maldivarum*)	M, Ma	SL	Unlikely
	Pectoral sandpiper (*Calidris melanotos*)	M, Ma	SL	Unlikely
	Sharp-tailed sandpiper (*Calidris acuminata*)	M, Ma	SL	Possible
	Yellow wagtail (*Motacilla flava*)	M, Ma	SL	Unlikely
	White-bellied Sea-Eagle (Haliaeetus leucogaster)	Ma	SL	Possible
	Black-eared Cuckoo (Chalcites osculans as Chrysococcyx osculans)	Ma	LC	Possible
	Cattle Egret *(Bubulcus ibis as Ardea ibis)*	Ma	LC	Possible
	Rainbow Bee-eater *(Merops ornatus)*	Ma	LC	Known
	Australian Painted Snipe (*Rostratula australis* as *Rostratula benghalensis (sensu lato)*	Ma	E	Possible
Fish	Freshwater sawfish (*Pristis pristis*)	V, M	LC	Unlikely
Reptile	Freshwater crocodile (*Crocodylus johnstoni*)	Ma	LC	Unlikely

Key: V = Vulnerable, E = Endangered, CE = Critically Endangered, M = Migratory, Ma = Marine, SL = Special Least Concern, LC = Least Concern

3.6.2.7. Threatened Ecological Communities

There are no Threatened Ecological Communities considered to be present or potentially present within 50 km of DRM.

3.6.2.8. Listed Threatened Species

The desktop assessment identified the following MNES conservation significant species as having potential to occur within a 50 km radius of the project area:

- 1 species of flora listed as Endangered, Vulnerable, or Near Threatened (EVNT) under the EPBC Act; and
- 15 species of fauna listed as EVNT under the EPBC Act.

These species are listed in Table 17.

Table 17. Threated species mapped to occur within 50 km of DRM

Taxa	Common Name (*Scientific name*)	EPBC Status	NCA Status	Likelihood of Occurrence
Mammals	Ghost bat (*Macroderma gigas*)	V	E	Unlikely
	Greater bilby (*Macrotis lagotis*)	V	E	Unlikely
	Julia Creek dunnart (*Sminthopsis douglasi*)	V	E	Unlikely
Birds	Australian painted-snipe (*Rostratula australis*)	E, M	E	Possible
	Carpentarian grasswren (*Amytornis dorotheae*)	E	E	Possible
	Curlew sandpiper (*Calidris ferruginea*)	CE, M, Ma	CE	Unlikely
	Eastern curlew (*Numenius madagascariensis*)	CE, M, Ma	E	Unlikely
	Gouldian finch (*Erythrura gouldiae*)	E	E	Unlikely
	Grey falcon (*Falco hypoleucos*)	V	V	Possible
	Night parrot (*Pezoporus occidentalis*)	E	E	Unlikely
	Painted honeyeater (*Grantiella picta*)	V	V	Possible
	Red goshawk (*Erythrotriorchis radiatus*)	V	E	Unlikely
Reptile	Gulf Snapping Turtle (Elseya lavarackorum)	E	V	Unlikely
	Plains death adder (*Acanthophis hawkei*)	V	V	Unlikely

Taxa	Common Name (*Scientific name*)	EPBC Status	NCA Status	Likelihood of Occurrence
Fish	Freshwater sawfish (*Pristis pristis*)	V, M, Ma	-	Unlikely
Plant	Mt Isa Mallee *(Eucalyptus nudicaulis)*	E	E	Unlikely

Key: V = Vulnerable, E = Endangered, CE = Critically Endangered, M = Migratory, Ma = Marine, SL = Special Least Concern, LC = Least Concern

3.6.3. Matters of State Environmental Significance (MSES)

3.6.3.1. Regulated Vegetation

The *Vegetation management regulated vegetation management map - version 7.00* maps the entire DRM area as category B remnant vegetation (Figure 16).

3.6.3.2. Regulated Vegetation – Endangered or of Concern Regional Ecosystem

There are no endangered or of concern REs, as defined under the VM Act, mapped as present within the Project area.

3.6.3.3. Regulated Vegetation – Regional Ecosystem Intersecting a Wetland

There are no vegetation management wetlands mapped within the project area and therefore no REs intersecting a wetland.

3.6.3.4. Regulated Vegetation – Intersecting a Watercourse

There are multiple regulated vegetation watercourses mapped within the Project area (Figure 15).

3.6.3.5. Watercourses and Wetlands

Lake Julius, located approximately 40 km west of DRM, is an important dry season refuge for waterbirds as it is a large permanent waterbody found in a semi-arid area. Lake Julius is located upstream of current and proposed activities.

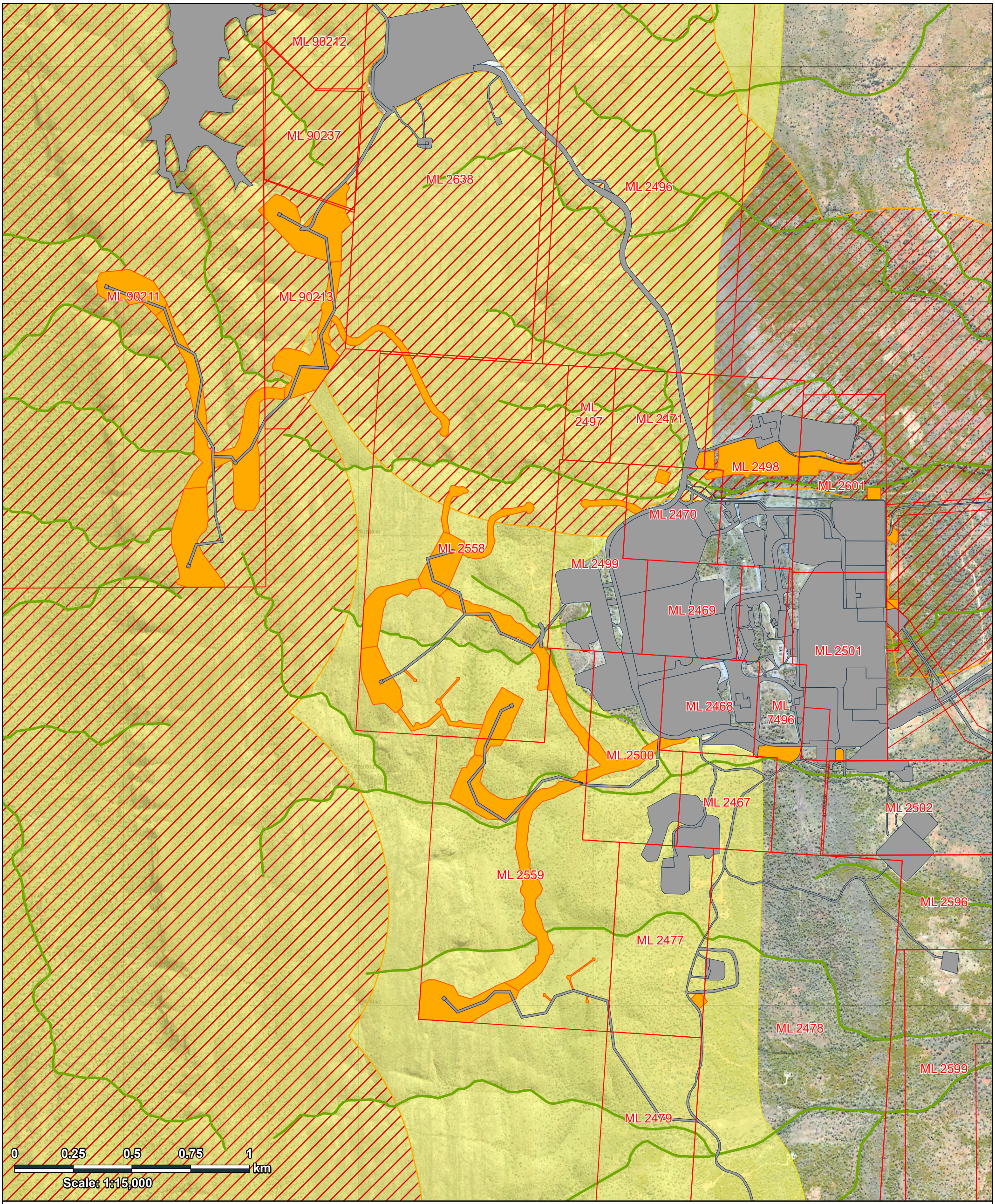
3.6.3.6. Protected Wildlife Habitat and Essential Habitat

With the exception of areas related to the DRM tailings storage facility in the northern section of the Knapdale Range, the entire range and other locally connected areas are mapped as essential habitat on the *Vegetation management essential habitat map no attribute - version 12.00.* Version 12.00 of the essential habitat mapping was released 22 November 2023 and increases the area of mapped habitat significantly from 11.9 ha to 68.7 ha (Figure 15).

The rocky habitat of Knapdale Range supports populations of Purple-necked Rock-wallaby (PNRW) (*Petrogale purpuriecolis*) which is considered a vulnerable species under the *Nature Conservation Act (1992)* (QLD). Local populations are currently monitored under the MMG DRM Purple-necked Rock-wallaby Monitoring Program.

3.6.3.7. Protected Areas

There are no protected areas within 50 km of DRM.



Client: MMG Dugald River Pty Ltd
Project Number: 2023.03002
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Spatial Reference
PCS: GDA2020 MGA Zone 54
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Datum: GDA2020

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Figure 15. Matters of State Environmental Significance

Legend

- Proposed Disturbance Extent
- Existing Disturbance
- Mining Lease
- WH - Endangered Vulnerable
- RV - Watercourse
- RV - Essential Habitat

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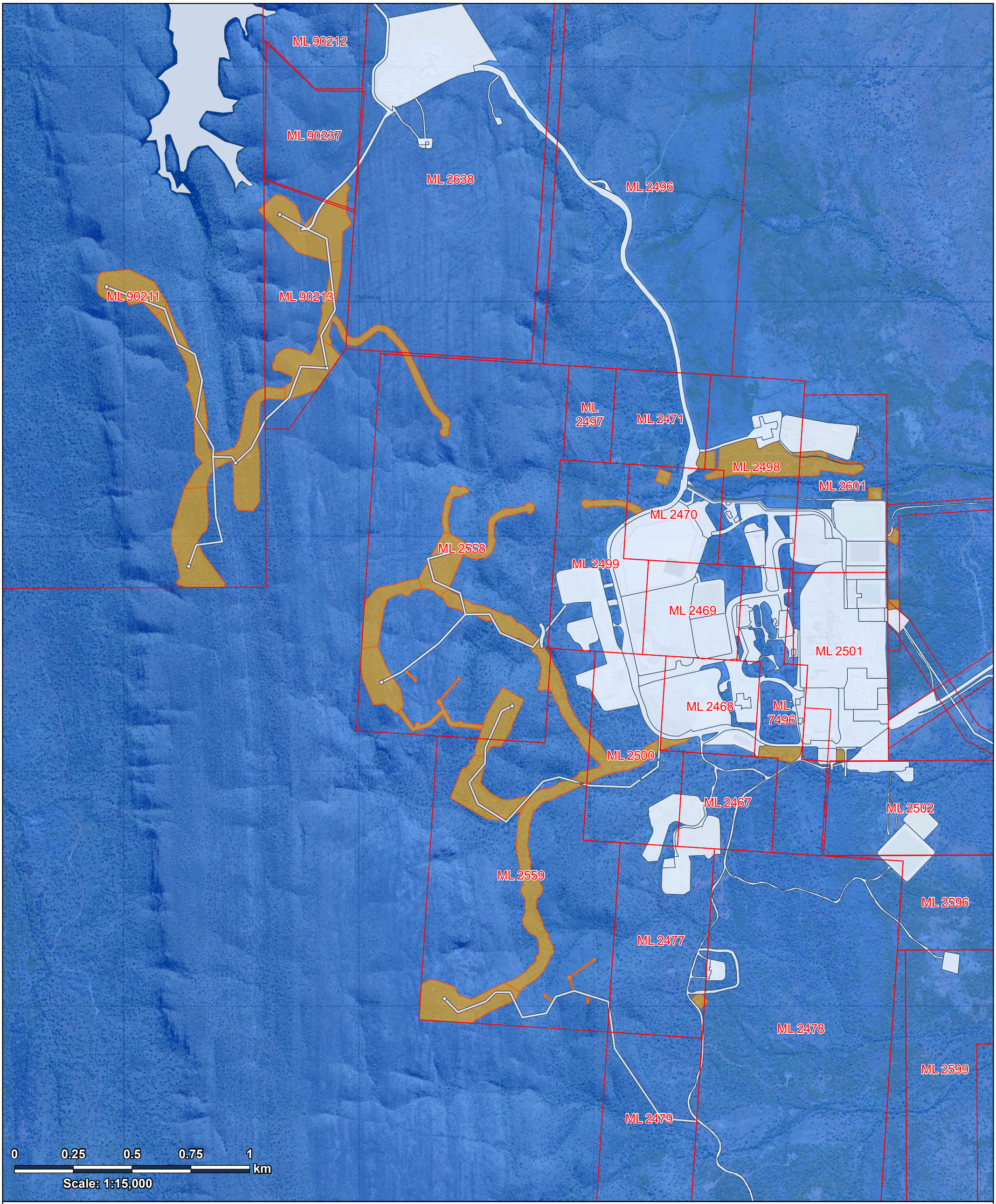


Figure 16. Regulated Vegetation

Client: MMG Dugald River Pty Ltd
Project Number: 2023.03002
Publication Date: 28/11/2023

Spatial Reference
PCS: GDA2020 MGA Zone 54
GCS: GDA2020
Datum: GDA2020

Print on A3

Legend

- Mining Lease
- Existing Disturbance
- Proposed Disturbance Extent

Regulated Vegetation Category

- B
- X

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3.6.4. Environmentally Sensitive Areas

3.6.4.1. Category A

A category A environmentally sensitive area (ESA) is defined as any of the following:

a. any of the following under the Nature Conservation Act 1992:
    (i) a national park (scientific);
    (ii) a national park;
    (iii) a national park (Aboriginal land);
    (iv) a national park (Torres Strait Islander land);
    (v) a national park (Cape York Peninsula Aboriginal land);
    (vi) a conservation park;
    (vii) a special wildlife reserve;
    (viii) a forest reserve;
b. the wet tropics area under the Wet Tropics World Heritage Protection and Management Act 1993;
c. the Great Barrier Reef Region under the Great Barrier Reef Marine Park Act 1975 (Cwlth);
d. a marine park under the Marine Parks Act 2004, other than a part of the park that is a general use zone under that Act.

No category A ESAs are mapped to occur within DRM.

3.6.4.2. Category B

A Category B environmentally sensitive area (ESA) is defined under the Environmental Protection Regulation 2019 as any of the following—

a) any of the following areas under the Nature Conservation Act 1992—
(i) a coordinated conservation area;
(ii) an area of critical habitat or major interest identified under a conservation plan;
(iii) an area subject to an interim conservation order;
b) an area subject to the following conventions to which Australia is a signatory—
(i) the ‘Convention on the Conservation of Migratory Species of Wild Animals’ (Bonn, 23 June 1979);
(ii) the ‘Convention on Wetlands of International Importance, especially as Waterfowl Habitat’ (Ramsar, Iran, 2 February 1971);
(iii) the ‘Convention Concerning the Protection of the World Cultural and Natural Heritage’ (Paris, 23 November 1972);
c) a zone of a marine park under the Marine Parks Act 2004 that is within a general use zone of the marine park under that Act;
d) an area to the seaward side of the highest astronomical tide;
e) the following under the Queensland Heritage Act 1992—

(i) a place of cultural heritage significance;
(ii) a Queensland heritage place, unless there is an exemption certificate issued under that Act;
f) an area recorded in the Aboriginal Cultural Heritage Register established under the Aboriginal Cultural Heritage Act 2003, section 46, other than the area known as the 'Stanbroke Pastoral Development Schedule 19 Environmental Protection Regulation 2019 Current as at 5 April 2023 Page 287 Authorised by the Parliamentary Counsel Holding', leased under the Land Act 1994 by lease number PH 13/5398;
g) a feature protection area, State forest park or scientific area under the Forestry Act 1959;
h) a declared fish habitat area under the Fisheries Act 1994;
i) a place in which a marine plant under the Fisheries Act 1994 is situated;
j) an endangered regional ecosystem identified in the database known as the 'Regional ecosystem description database' published on the department's website.

The following Category B ESA is mapped to occur at DRM (Figure 17):

- Endangered Regional Ecosystem RE 1.3.7b (*Eucalyptus camaldulensis*) woodland on channels and levees.

Some REs may be listed as a category B or category C ESA as well as an MSES; however the way in which the RE is defined differs across legislation. The classification under the VM Act class defines whether the RE is also an MSES, not the classification under the biodiversity status. RE 1.3.7b (*Eucalyptus camaldulensis*) woodland on channels and levees, is present within the Project ML with a VM Act class of 'least concern' and a biodiversity status of 'endangered'. This RE is considered a category B ESA, however, is not considered a MSES.

3.6.5. Non-Native Flora and Fauna

Four introduced species, listed as pest species under the *Land Protection (Pest and Stock Route Management) Act 2002* (LP Act), were detected at DRM during the wet and dry season surveys (AARC 2011). Species observed included:

- House Mouse (*Mus musculus*) listed as a Class 1 pest under the LP Act;
- Dingo (*Canis lupus familiaris*) listed as a Class 2 pest under the LP Act;
- Feral Cat (*Felis catus*) listed as a Class 2 pest under the LP Act; and
- Feral Pig (*Sus scrofa*) listed as a Class 2 pest under the LP Act.

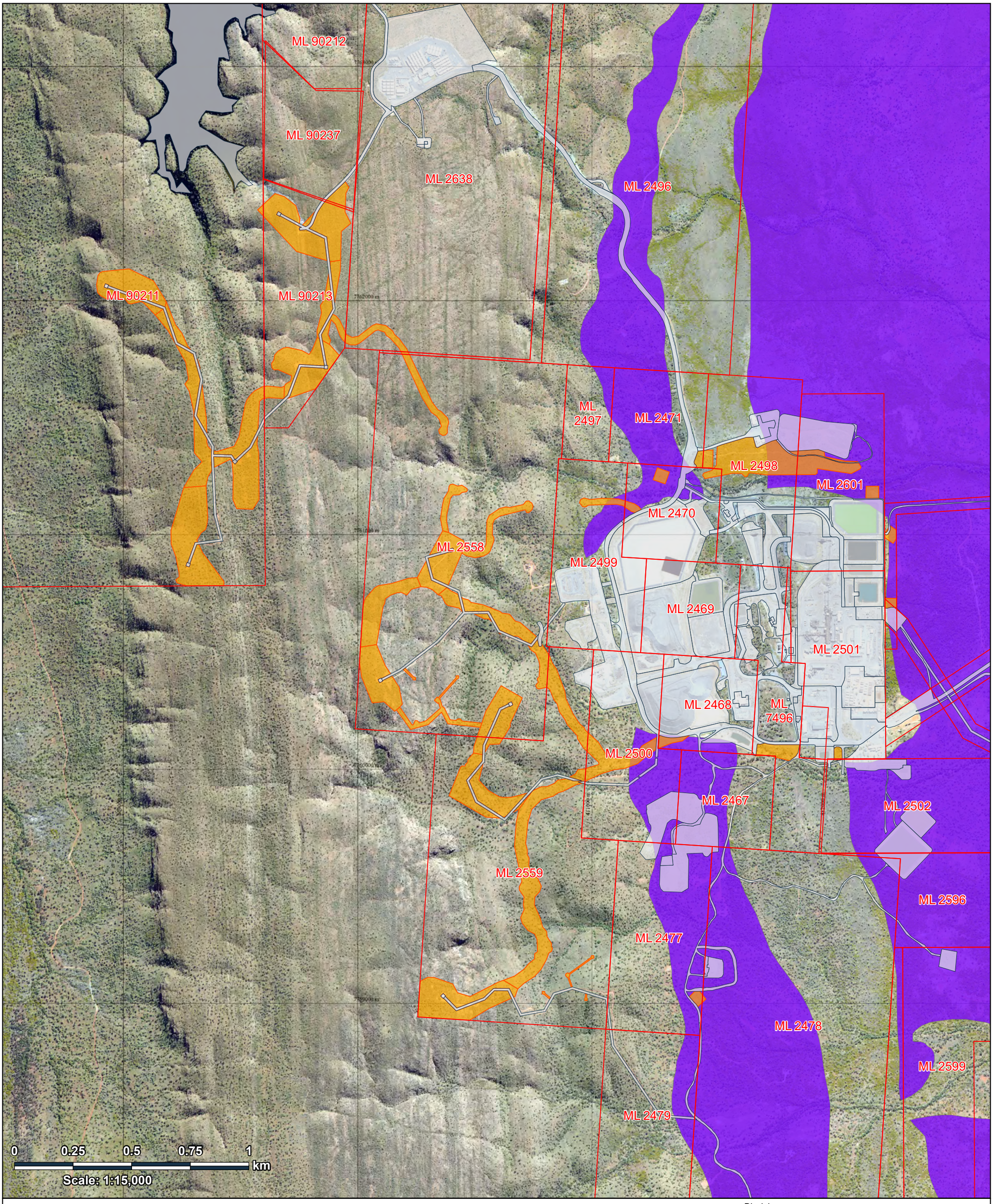


Figure 17. Environmentally Sensitive Areas

Client: MMG Dugald River Pty Ltd
Project Number: 2023.03002
Publication Date: 28/11/2023

Spatial Reference
PCS: GDA2020 MGA Zone 54
GCS: GDA2020
Datum: GDA2020

Print on A3

Legend

- Mining Lease
- Existing Disturbance
- Proposed Disturbance Extent
- Endangered RE

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4. Potential Environmental Impacts and Management

4.1. Land Impacts

In preparing this application, consideration has been given to guideline *ESR/2015/1839 – Application requirements for activities with impacts to land* (DES, 2017b). DES is required to assess the application against the requirements stated in the *Environmental Protection Act 1994* and the EP Regulation to meet the environmental objective and performance outcomes described below:

Environmental Objective

'The activity is operated in a way that protects the environmental values of land including soils, subsoils, landforms and associated flora and fauna.'

Performance Outcome

There is no actual or potential disturbance or adverse effect to the environmental values of land as part of carrying out the activity, or

All of the following:

a) activities that disturb land, soils, subsoils, landforms and associated flora and fauna will be managed in a way that prevents or minimises adverse effects on the environmental values of land, and
b) areas disturbed will be rehabilitated or restored to achieve sites that are:
    i. safe to humans and wildlife;
    ii. non-polluting;
    iii. stable; and
    iv. able to sustain an appropriate land use after rehabilitation or restoration.
c) the activity will be managed to prevent or minimise adverse effects on the environmental values of and due to unplanned releases or discharges, including spills and leaks of contaminants.
d) the application of water or waste to land is sustainable and is managed to prevent or minimise adverse effects on the composition or structure of soils and subsoils.

RISK OF ENVIRONMENTAL IMPACT: MODERATE

4.1.1. Overview of Land Impacts

The proposed amendments and the potential impact to land are described in Table 18. The amendments with potential to impact on land are discussed in further detail below.

Table 18. Land Impacts

Condition	Proposed Amendment	Potential Impact and Mitigation Measures
Schedule A – Table 1 (Authorised Mining Activities)	Additional disturbance area for the construction and operation of a wind farm. This disturbance total incorporates: - 27.78 ha for wind farm pads - 32.32 ha for access tracks - 12.78 ha for laydowns - 0.72 ha for powerline poles - 0.99 ha for switchyard 2 - 1.23 ha for meteorological masts	The potential impacts from the wind farm and its ancillary infrastructure have been extensively studied, with the results discussed in detail below.
Schedule A – Table 1 (Authorised Mining Activities)	Construction of a Sewage Treatment Plant (0.18 ha) at 412059, 7760070.	Effluent will be treated to a Class A standard, which is an improvement on the current Class C treatment standard. Effluent from the STP will be utilised for dust suppression via a water cart or disposed to the existing STP dams. Effective watering practises will ensure that treated effluent does not pond, or discharge to land. All existing management measures for the STP dams will continue to be implemented. The amendment does not propose any change to how sewage is managed onsite, and therefore presents no increase in risk to land.
New condition within Schedule A – General, Exploration	The holder of the environmental authority must not carry out activities in a category A or B environmentally sensitive area. Activities involving machinery must not be carried out within 1km of a category an	Maintaining a buffer from ESAs reduces the risk of impact to areas that may be mapped incorrectly. The DRM mining

Condition		Proposed Amendment	Potential Impact and Mitigation Measures
		environmentally sensitive area or within 50 m of a category B environmentally sensitive area.	leases have been extensively studied and the extent of Category B ESAs is well defined. Utilising ground-truthed data, the risk of unintended impact to ESAs is low. The only ESA on DRM is RE 1.3.7. This RE is allocated a Biodiversity Status of endangered due to its importance as seasonal water bird habitat and a regional corridor for fauna. Exploration activities will not affect the RE in relation to its provision as a season water bird habitat and corridor for fauna. Existing mitigation measures will continue to be implemented.
Schedule A – Table 1 (Authorised Mining Activities)		Addition of Ventilation Shaft 9 at 411466, 7761320 (0.54 ha).	The ventilation shaft will be constructed on previously cleared land. The proposed amendment will not result in any impact to land.
B14	The buildings and structures in place at the licensed place for the storage, stockpiling and loading of mineral concentrate must be constructed and maintained to withstand a Category 2 cyclone.	Remove condition	This condition is not relevant to the activities at DRM due to the location of the site, the low risk of cyclones, and the manner in which the concentrate shed is used. In the unlikely event that a cyclone did occur in the region, there would be no concentrate stored within the shed, and therefore the risk of loss of concentrate is negligible. The risk to land is considered low. All existing management controls for the transfer shed will continue to be implemented.

Condition		Proposed Amendment	Potential Impact and Mitigation Measures
B15	The construction and state of the buildings and structures in place at the licensed place for the storage, stockpiling and loading of mineral concentrate must be checked for compliance with condition B14 by an appropriately qualified person at least once every three (3) years.	Remove condition.	As above.
Schedule C – Table 2 (Contaminant Release Limits)		Remove cyanide as a monitoring parameter.	Cyanide is not stored or used in processing activities at DRM. DRM have no intention of introducing cyanide to site; the impact of cyanide to land is non-existent.
Schedule C – Table 5 (Receiving waters trigger levels and contaminant limits)		Remove the contaminant limit for total Aluminium, replace the trigger level and contaminant limit for filterable Aluminium with site specific values.	The proposed new triggers and limits will provide a more robust assessment of water quality trends and potential impact. The proposed amendment presents a low risk to land.
Schedule C – Table 5 (Receiving waters trigger levels and contaminant limits)		Remove cyanide as a monitoring parameter.	Cyanide is not stored or used in processing activities at DRM. DRM have no intention of introducing cyanide to site; the impact of cyanide to land is non-existent.

Condition	Proposed Amendment	Potential Impact and Mitigation Measures
Schedule C – Table 8 (Groundwater trigger levels and contaminant limits)	Remove cyanide as a monitoring parameter.	Cyanide is not stored or used in processing activities at DRM. DRM have no intention of introducing cyanide to site; the impact of cyanide to land is non-existent.
Schedule D – Table 2 (Hydraulic performance criteria for Regulated Dams)	Remove the hydraulic performance criteria for the Stage 2 PAF Run Off Dam. Revise the associated footnotes to reference the most recent consequence category assessment.	The PAF Stage 2 Runoff Dam has been risk assessed as 'Low Risk' for 'failure to contain – overtopping', therefore hydraulic performance criteria are not required. The proposed amendment presents a low risk to land.

4.1.2. Wind Farm and Ancillary Infrastructure

An ecological assessment has been completed to investigate the potential impacts from the construction, operation and decommissioning of the wind farm. The assessment has considered the following Performance Outcomes described in *State Code 23: Wind Farm Development:*

- PO1 Development is designed and sited to ensure that threatened species and associated habitats and areas of high environmental value are protected from adverse impacts;
- PO2 Development is constructed to ensure that threatened species and associated habitats, and areas of high environmental value are protected from adverse impacts;
- PO3 Development operations ensure that threatened species and birds and bats are protected from adverse impacts;
- PO4 Development operations ensure that areas cleared for the construction of a wind farm are replanted to the maximum extent possible following construction without impeding operations and maintenance of the wind farm; and
- PO5 ensures that the wind farm, including ancillary infrastructure, is designed and sited to minimise crossings of and interference with natural drainage lines and watercourses.

The Ecological Assessment Report is summarised herein, and provided in full in Appendix K. In addition, a Bird and Bat Management Program has been developed (Appendix L)

4.1.2.1. Construction and Decommissioning

The Ecological Impact Assessment (Appendix K) considered the following potential impacts during the construction and decommissioning phases of the project:

- The introduction and/or spread of weed species (such as Prickly Acacia (*Vachellia nilotica*) and Buffel Grass (*Cenchrus* spp.)) due to vehicles or machinery moving across the landscape;
    - Modifying the habitat of native species; or
    - Outcompeting threatened native flora (*Ipomoea antonschmidii*);
- The introduction of pest species or an increase of their populations in the project area;
    - Competing with, predating on, or otherwise harming native species; or
    - Facilitating the infection of native species with diseases/parasites (e.g. hydatid disease (*Echinococcus granulosus*) or toxoplasmosis (*Toxoplasmosis gondii*)); or
    - Modifying the habitat of native species;
- Uncontrolled release of contaminants and waste (e.g. fuel or oil spills, or litter);
    - Directly harming native fauna (e.g. ingestion of litter causing injury or death); or
    - Indirectly harming native fauna through habitat degradation;
- Noise, dust, light pollution, and vibrations from clearing and construction (especially during night-time works);
    - Confusing/disorientating native birds increasing risk of interaction; or

- Disturbing surrounding habitat making it less preferable for native species or conditioning avoidance and affecting normal distribution patterns;

- Construction/clearing activities;
  - Causing injury and/or fatality of native fauna; or
  - Destruction of habitat of native fauna (specifically important in the case of rocky habitat/sub-habitat due to high profile native fauna species reliant on such habitat); or
  - Creating barriers to distribution; or
  - Creating barriers damming flow to downstream water holes; and
- Active work areas including pits, trenches, stockpiles, and other hazardous areas;
  - Causing injury/fatality of native fauna.

The assessment methodologies and findings are presented in Appendix K and are summarised below.

4.1.2.1.1. Regulated Vegetation

All proposed disturbance occurs within areas mapped as category B vegetation (Table 19). The entire DRM lease is mapped as category B vegetation; the proposed disturbance accounts for 2% of the combined MLs.

Table 19. Proposed Disturbance - Regulated Vegetation

Feature	Area (ha)	Regulated Vegetation Category
Wind farm pads	27.78	B
Access tracks	32.32	B
Meteorological masts	1.23	B
Laydowns	12.78	B
Electrical	0.72	B
Switchyard 2	0.99	B
Total windfarm project	**75.82**	**B**
STP	0.18	B
Groundwater infrastructure	0.54	B
Vent shaft 9	0.54	B
Total	**77.08**	**B**

4.1.2.1.2. Regulated Vegetation Essential Habitat

The proposed disturbance will result in the clearing of approximately 68.71 ha of regulated vegetation - essential habitat, for the PNRW (Table 20). The proposed disturbance accounts for <1.5 % of the essential habitat mapped for PNRW within the Knapdale Range.

Table 20. Proposed Disturbance – Essential Habitat

Feature	Disturbance Area (ha)	Disturbance to essential habitat (ha)
Wind farm pads	27.78	27.78
Access tracks	32.32	32.31
Meteorological masts	1.23	1.23
Laydowns	12.78	6.37
Electrical	0.72	0.29
Switchyard 2	0.99	0.03
Total windfarm project	**75.82**	**68.01**
STP	0.18	0
Groundwater infrastructure	0.54	0.26
Vent shaft 9	0.54	0.44
Total	**77.08**	**68.71**

A significant residual impact assessment was completed (Appendix K) which determined that that significant residual impacts to the PNRW as a result of the project will be unlikely. No direct disturbance is proposed to any known PNRW colony. Tracks do not traverse any known or visually suitable PNRW shelter habitat. Construction activities are unlikely to significantly impact the population. The SRI is presented in Table 21.

Table 21. SRI Essential Habitat (PNRW)

Is there a chance or possibility that an action will?	Response
Lead to a long-term decrease in the size of an important population of the species; or	**Unlikely:** Project works in the site are unlikely to lead to a long-term decrease in the size of an important population of the species. There are 611 records of the PNRW on the site over 12 years. There are multiple confirmed and multiple speculated dens around the site, including several along the Knapdale Range near the project area. The Knapdale Range occupies an area of approximately 6000 ha of which only 75 ha (<1.5%) is proposed for development, increasing the total area associated with DRM to 373 ha (~6%). Though total impacts to essential habitat areas is <70 ha, the disturbance area are relatively small and disturbed areas are likely to recruit fodder suitable for foraging by the rock-wallaby
Reduce the area of occupancy of an important population; or	**Unlikely:** Project works in the site are unlikely to reduce the area of occupancy of an important population. There are 611 records of the PNRW on the site over 12 years. There are multiple confirmed and multiple speculated dens around the site, including several along the Knapdale Range near the project area. The Knapdale Range occupies an area of approximately6000 ha of which only 75 ha (<1.5%) is proposed for development, increasing the total area associated with DRM to 373 ha (~6%). Though total impacts to essential habitat areas is almost <70 ha, the disturbance area are relatively small and disturbed areas are likely to recruit fodder suitable for foraging by the rock-wallaby
Fragment an existing important population into two or more populations; or	**Unlikely:** Project works in the site are unlikely to fragment an existing important population. There are 611 records of this species on the site over 12 years. There are multiple confirmed and multiple speculated dens around the site, including several along the Knapdale Range near the project area.

Is there a chance or possibility that an action will?	Response
	The small subpopulations in the denning habitat areas confirmed along the Knapdale Range can be collectively considered as a single population. Temporary disturbance to a subpopulation associated with the clearance and construction phase of the project is unlikely to significantly impact the population as a whole. Due to the relatively low ground disturbance associated with wind farms, the small size of the proposed disturbance footprint, the connectivity of the surrounding habitat, and the small range of rock-wallabies, works within the site are unlikely to fragment any existing populations.
Adversely affect habitat critical to the survival of the species; or	**Unlikely:** Project works in the site are unlikely to adversely affect habitat critical to the survival of the species. There are 611 records of this species on the site over 12 years. There are multiple confirmed and multiple speculated dens around the site, including several along the Knapdale Range near the project area. The purple-necked rock wallaby favours habitat which includes boulder piles, rocky slopes, cliffs and gorges in limestone areas, and sandstone and quartzite outcrops amongst dry Eucalyptus and Acacia woodlands. It also inhabits spinifex grasslands in association with the rocky areas (Rowland, 2012). The ongoing noise pressure and vibrations produced during the operation phases of the project have an unknown potential to disturb surrounding habitat, making it less preferable for rock-wallabies. There may be a risk of conditioning avoidance and affecting normal distribution patterns of rock-wallabies on site. However, due to the small size of the project area and the large area of local habitat available, works within the site are unlikely to adversely affect habitat critical to the survival of the species. Additionally PNRW population numbers have not declined in response to the current mining operations which includes the deposition of tailings within the TSF and ongoing exploratory resource definition drilling which occurs year-round which has occurred year-round since project commencement.
Disrupt the breeding cycle of an important population;	**Unlikely:** It is unlikely that the disturbance associated with project works in the site could disrupt the breeding cycle of an important population. There are 611 records of this species on the site over 12 years. There are multiple confirmed and multiple speculated dens around the site, including several along the Knapdale Range near the project area. The small subpopulations in the denning habitat areas confirmed along the Knapdale Range can be collectively considered as a single population. Temporary disturbance to a subpopulation associated with the clearance and construction phase of the project is unlikely to significantly impact the population as a whole. Additionally MMG will deploy fauna spotter/catchers during clearing operations in accordance with the EA.
Modify, destroy, remove, or isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline; or	**Unlikely:** It is unlikely that the disturbance associated with project works in the site could impact habitat to the extent that the species is likely to decline. There are 611 records of this species on the site over 12 years. There are multiple confirmed and multiple speculated dens around the site, including several along the Knapdale Range near the project area. The PNRW favours habitat which includes boulder piles, rocky slopes, cliffs and gorges in limestone areas, and sandstone and quartzite outcrops amongst dry Eucalyptus and Acacia woodlands. It also inhabits spinifex grasslands in association with the rocky areas (Rowland, 2012). The small subpopulations in the denning habitat areas confirmed along the Knapdale Range can be collectively considered as a single population. Disturbance areas avoid denning areas of the PNRW and

Is there a chance or possibility that an action will?	Response
	temporary disturbance to a subpopulation associated with the clearance and construction phase of the project is unlikely to significantly impact the population as a whole. Additionally MMG will deploy fauna spotter/catchers during clearing operations in accordance with the EA.
Result in invasive species that are harmful to a vulnerable species becoming established in the vulnerable species' habitat; or	**Unlikely:** Project works in the site are unlikely to introduce and/or allow a harmful invasive species to become established in the habitat of the species. Feral cats and European Red Foxes are recognised threats to several similar species and have been detected on site. Several species of invasive flora have been detected on site and have the potential to modify the species' habitat. The project will operate under the *Biosecurity Act 2014* and follow the General Biosecurity Obligation (GBO) to identify and manage any potential invasive species. Weed and Seed and pest management processes are well established for the mine. There is not likely to be an introduction and establishment of a harmful invasive species in the habitat of the species.
Introduce disease that may cause the species to decline; or	**Unlikely:** Project works are unlikely to introduce novel diseases to the site. Hydatid disease (*Echinococcus granulosus*) and Toxoplasmosis (*Toxoplasmosis gondii*) are both recognised diseases that have the potential to threaten rock-wallaby populations. The project will operate under the Biosecurity Act (2014) and follow the General Biosecurity Obligation (GBO) to identify and manage detrimental diseases or pathogens if present. There is not likely to be an introduction of a novel diseases to the rock-wallaby population on site.
Interfere substantially with the recovery of the species.	**Unlikely:** Project works in the site are unlikely to interfere substantially with the recovery of the species. There are 611 records of this species on the site over 12 years. There are multiple confirmed and multiple speculated dens around the site, including several along the Knapdale Range near the project area. Due to the relatively low ground disturbance associated with wind farms, the small size of the site, and the connectivity of the surrounding habitat, works within the site are unlikely to interfere with the recovery of the species.

4.1.2.1.3. Regulated Vegetation – Vegetation Intersecting a Watercourse

The access tracks for the wind farm cross four 1st or 2nd order drainage lines. Due to the required orientation of the access tracks and contours of the Knapdale Range, some drainage lines are crossed on more than one occasion. In total, the project disturbance intersects a drainage line at seven discrete locations.

The proposed wind farm design has been extensively studied and optimised to prevent drainage line crossings as much as practicable. Drainage line crossings have been avoided wherever possible for safety and efficiency of construction. The disturbance proposed in the design reflects the smallest possible footprint for the project.

Approximately 4.1 ha of clearing is required within areas mapped as regulated vegetation, vegetation intersecting a watercourse. A 26 m buffer from mapped watercourses has been used to determine this area. The majority of this disturbance is related to the widening of access tracks to transport turbine

components to the wind farm pads. Disturbance will be minimised as much as possible, to allow safe transport of turbine components. On closure, the disturbance will be rehabilitated.

Table 22. Proposed Disturbance – Regulated Vegetation Intersecting a Watercourse

Feature	Disturbance Area (ha)	Disturbance to Regulated Vegetation – Vegetation Intersecting a Watercourse (26 m buffer applied from watercourse) (ha)
Wind farm pads	27.78	0.87
Access tracks	32.32	2.70
Meteorological masts	1.23	0
Laydowns	12.78	0.08
Electrical	0.72	0
Switchyard 2	0.99	0.32
Total windfarm project	**75.82**	**3.97**
STP	0.18	0
Groundwater infrastructure	0.54	0.13
Vent shaft 9	0.54	0
Total	**77.08**	**4.1**

4.1.2.1.4. Environmentally Sensitive Areas

RE 1.3.7b: *Eucalyptus camaldulensis* fringing woodland, usually with *Lophostemon grandiflorus* and *Melaleuca bracteata* and/or *M. dissitiflora* with a biodiversity status of 'endangered' is mapped to occur as a subdominant (5%) RE across the Project MLs.

Most of the proposed disturbance area has a biodiversity status of no concern at present however endangered RE 1.3.7b: *Eucalyptus camaldulensis* fringing woodland, usually with *Lophostemon grandiflorus* and *Melaleuca bracteata* and/or *M. dissitiflora* was confirmed present within the proposed footprint.

The project is not anticipated to have a significant impact on this ERE, due to the limited size of disturbance.

Table 23. Proposed Disturbance – Environmentally Sensitive Areas

Feature	Disturbance Area (ha)	Disturbance to ESA (ha)
Wind farm pads	27.78	0
Access tracks	32.32	1.31
Meteorological masts	1.23	0
Laydowns	12.78	3.35
Electrical	0.72	0.63
Switchyard 2	0.99	0
Total windfarm project	**75.82**	**5.29**
STP	0.18	0
Groundwater infrastructure	0.54	0.54
Vent shaft 9	0.54	0
Total	**77.08**	**5.83**

4.1.2.1.5. Weeds

EcoSmart Ecology (2023) have previously identified the following weed species within the DRM leases:

- Kapok Weed *(Aerva javanica)* - Common along roadside disturbance areas and drill pads, particularly within the Dugald River Mine footprint.
- Prickly Acacia *(Vachellia nilotica)* - An obvious feature of flat lands at the southern edge of the Knapdale Range, typically in association with drainage lines and grazing country. This species does not appear to have become established on the rocky hills of the Knapdale Range.
- Buffel Grass *(Cenchrus spp.)* - Most prolific on the western side of the range, particularly in association with drainage channels and grazing country; however, occasionally occurs higher up on rocky hills.
- Farmer's Friends/Cobbler's Pegs *(Bidens spp.).* Typically seen in association rocky gullies and adjacent slopes. Generally sparsely distributed but may form dense localised patches.

Weedy species are not typically observed on the rocky upper slopes and plateaux of the Knapdale Range, nor have they been recorded in association with proposed turbine pads (EcoSmart Ecology, 2023).

4.1.2.2. Operation

The Ecological Impact Assessment (Appendix K) and Bird and Management Program (Appendix L) considered the following potential impacts for the operational phase of the project:

- Noise pollution and vibrations from the operation of the wind turbines;
    - Disturbing surrounding habitat making it less preferable for native species or conditioning avoidance and affecting normal distribution patterns.
- Wind turbine structures, primarily rotors and associated RSA (Rotor-swept Area), causing;

- Collisions between aerial fauna and wind turbine rotors or other structures, or barotrauma as a result of flight close to rotors, resulting in injury or fatality. The likelihood of a collision is dependent on a range of factors, including:
  - Design characteristics, such as:
    - the type of wind turbine;
    - lighting of wind turbines; and
    - the layout of the wind farm;
  - site characteristics, including:
    - the ecosystems on the wind farm site;
    - proximity to bird concentrations;
    - the numbers of birds moving across the wind farm site;
    - the behaviours of birds and bats (e.g. soaring at RSA height); and
    - weather conditions (Brett Lane & Associates Pty Ltd, 2005).
- Displacement and barrier effects resulting in greater energetic cost to fauna flying through the area;

- Noise and light pollution, pressure, and vibrations from the operation of the wind turbines;
  - Confusing/disorientating aerial fauna increasing risk of collision; or
  - Disturbing surrounding habitat making it less preferable for native species or conditioning avoidance and affecting normal distribution patterns.

The assessment methodologies and findings are presented in Appendix K and Appendix L and summarised below.

4.1.2.2.1. Aerial Fauna

A Bird and Bat Utilisation Survey (BBUS) (EcoSmart, 2023; WTS, 2024) has been developed with three rounds of monitoring conducted to date, in May 2023, September 2023 and April 2024. Level one bird surveys were conducted as per the approved method outlined in *Wind Farms and Birds: Interim Standards For Risk Assessment* by Brett Lane & Associates (Brett Lane & Associates Pty Ltd, 2005).

A Before and After Control Impact (BACI) survey design was implemented as is recommended in Appendix 1 of the planning guidance provided by the Department of State Development, Infrastructure, Local Government and Planning (2023). A BACI design includes reference sites placed at a sufficient distance (>500 m), from the proposed turbine locations to obtain data outside the zone of influence of the turbines. Data is collected at pre-determined points, with consideration of local weather, site use seasonality and the likelihood of any migratory stopovers or overflight of the locality.

Data is captured to allow for a collision risk assessment to estimate the potential likelihood and consequence of turbine collisions.

Eight monitoring sites were established in 2023, with an additional four established in 2024. Locations were surveyed three times a day at sunrise, midday and sunset periods. The following data was recorded:

- Species
- Number of individuals
- Estimated distance from observer
- Estimated height above observer
- Bearing to record
- Direction of flight
- Behaviour
- Any additional notes on the observation

Bats were monitored at each BBUS monitoring site using Anabat passive high-frequency sound recorders to capture microbats calls. Anabat units were deployed for two consecutive nights per monitoring period. Bat call analysis to identify microbat species present was undertaken by suitable qualified persons; Greg Ford of Balance Environmental (EcoSmart, 2023) and Professor Simon Robson (WTS, 2024).

The reports are available in full in Appendix M and Appendix N.

4.1.2.2.1.1. Birds

The results from the three BBUS conducted to date are presented in Table 24.

All species identified have a classification of 'least concern' under the NC Act. One marine species was recoded both within and outside the RSA. Due to the general habitat similarity between all 12 survey sites, the entirety of the Knapdale Range is considered likely to have very similar patterns of bird and bat activity (Wulguru Technical Services, 2024). Site specific bird presence data is available in Appendix M; however a holistic assessment has been undertaken across the Project.

The following species have not been recorded in BBUS surveys though are known to inhabit the site, having been recorded during previous fauna surveys within the Project area.

- Australian hobby (*Falco longipennis*)
- Black falcon (*Falco subniger*)
- Collared sparrowhawk (*Accipiter cirrocephalus*)
- Spotted harrier (*Circus assimilis*)
- White-browed woodswallow (*Artamus leucorynchus*)
- White-breasted woodswallow (*Artamus superciliosus*)

A collision risk assessment was completed for all bird species identified in the BBUS. Assessments identified no species as having the potential for significant loss of individuals. Four species were identified as having potential repeated loss of individuals either due to abundance and/or high collusion risk susceptibility. These are:

- Black-faced woodswallow (Artamus cinereus)
- Little woodswallow (Artamus minor)

- Masked woodswallow (Artamus personatus)
- Rainbow bee-eater (Merops ornatus)

All other species recorded within the RSA are considered to have the potential for rare or occasional loss of individuals via turbine interaction.

Detailed collision risk assessments are provided in Appendix M.

Table 24. BBUS Species Records (WTS, 2024)

Within/Outside Rotor-swept Area (RSA)	Common Name (*Scientific Name*)	Status*		Count			
		NCA	EPBC	May-23 (EcoSmart)	Sep-23 (EcoSmart)	Apr-24 (WTS)	Total
Within RSA	Australasian Darter (*Anhinga novaehollandiae*)	LC				2	2
	Black Kite (*Milvus migrans*)	LC			1	1	2
	Black-faced Woodswallow (*Artamus cinereus*)	LC			18	11	29
	Black-shouldered Kite (*Elanus axillaris*)	LC		1			1
	Brown Falcon (*Falco berigora*)	LC		2	1		3
	Fairy Martin (*Petrochelidon ariel*)	LC			12		12
	Little Woodswallow (*Artamus minor*)	LC		5	28	30	63
	Masked Woodswallow (*Artamus personatus*)	LC				200	200
	Nankeen Kestrel (*Falco cenchroides*)	LC				1	1
	Rainbow Bee-eater (*Merops ornatus*)	LC	M			9	9
	Varied Lorikeet (*Psitteuteles versicolor*)	LC			1		1
	Wedge-tailed Eagle (*Aquila audax*)	LC		1		4	5
	Whistling Kite (*Haliastur sphenurus*)	LC		1		1	2
	White-faced Heron (*Egretta novaehollandiae*)	LC				1	1
	White-necked Heron (*Ardea pacifica*)	LC		2			2
Outside RSA	Australian Raven (*Corvus coronoides*)	LC		1	1		2
	Black-breasted Buzzard (*Hamirostra melanosternon*)	LC			2		2
	Black-faced Cuckoo-shrike (*Coracina novahollandiae*)	LC		1	11	8	20
	Black-faced Woodswallow (*Artamus cinereus*)	LC		1	1	4	6
	Black-shouldered Kite (*Elanus axillaris*)	LC			1		1
	Brown Falcon (*Falco berigora*)	LC		2			2
	Brown Goshawk (*Accipiter fasciatus*)	LC		2			2
	Budgerigar (*Melopsittacus undulatus*)	LC		22	15		37
	Cockatiel (*Nymphicus hollandicus*)	LC			7		7
	Diamond Dove (*Geopelia cuneata*)	LC			43		43
	Eastern Great Egret (*Ardea alba*)	LC		2			2
	Fairy Martin (*Petrochelidon ariel*)	LC		1	18		19
	Galah (*Eolophus roseicapilla*)	LC			2		2
	Grey-fronted Honeyeater (*Ptilotula plumula*)	LC		7	7		14
	Grey-headed Honeyeater (*Ptilotula keartlandi*)	LC		2	3		5
	Little Friarbird (*Philemon citreogularis*)	LC		7	3	3	13
	Little Woodswallow (*Artamus minor*)	LC		4	21	45	70

Within/Outside Rotor-swept Area (RSA)	Common Name (*Scientific Name*)	Status*		Count			
		NCA	EPBC	May-23 (EcoSmart)	Sep-23 (EcoSmart)	Apr-24 (WTS)	Total
	Mistletoebird (*Dicaeum hirundinaceum*)	LC		1	8		9
	Nankeen Kestrel (*Falco cenchroides*)	LC				2	2
	Painted Finch (*Emblema pictum*)	LC		2			2
	Pied Butcherbird (*Cracticus nigrogularis*)	LC		1		1	2
	Rainbow Bee-eater (*Merops ornatus*)	LC	M		1	1	2
	Rufous-throated Honeyeater (*Conopophila rufogularis*)	LC			2		2
	Silver-crowned Friarbird (*Philemon argenticeps*)	LC		1			1
	Varied Lorikeet (*Psitteuteles versicolor*)	LC		6	18	27	51
	Wedge-tailed Eagle (*Aquila audax*)	LC				1	1
	Willie Wagtail (*Rhipidura leucophrys*)	LC			1	1	2
	Zebra Finch (*Taeniopygia guttata*)	LC		6	1		7

* NCA = *Nature Conservation Act 1992*; EPBC = *Environment Protection and Biodiversity Conservation Act 1999*; CR = Critically Endangered; EN = Endangered; VU = Vulnerable; NT = Near Threatened; SLC = Special Least Concern; LC = Least Concern; Mi = Migratory; M = Marine

4.1.2.2.1.2. Bats

The following bat species have been recorded within the Project area during the 2023 and 2024 surveys:

- Northern free-tailed bat (*Chaerephon jobensis*)
- Gould's wattled bat (*Chalinolobus gouldii*)
- Hoary wattled bat (*Chalinolobus nigrogriseus*)
- Lesser long-eared bat (*Nyctophilus geoffroyi*)
- Lumsden's free-tailed bat (*Ozimops lumsdenae*)
- Yellow-bellied sheathtail bat (*Saccolaimus flaviventris*)
- Inland broad-nosed bat (*Scotorepens balstoni*)
- Bristle-faced free-tailed bat (*Setirostris eleyri*)
- Common sheathtail bait (*Taphozous georgianus*)
- Inland cave bat (*Vespadelus finlaysoni*)
- Litte broad-nosed bat (*Scotorepens greyii*)
- Inland forest bat (*Vespadelus baverstocki*)
- White-striped free-tailed bat (*Austronomus australis*)

As bat presence is measured entirely by call monitoring, relative abundance of bats species is not able to be accurately estimated. Many factors influence the detectability of bat calls, including flight height, distance from recorder, weather and other variables. Additionally, repeated recordings of singular or small numbers of individuals flying close to the bat detector can significantly skew abundance data. As such, bat call records have been interpreted as a confirmation of presence only and not a determinant of relative bat abundance (Wulguru Technical Services, 2024).

Five species of microbat, Gould's wattled bat, the little broad-nosed bat, the northern free-tailed bat, the common sheath-tailed bat and the white-striped free-tailed bat are considered to have the potential to enter the RSA while foraging. Of these, the white-striped free-tailed bat is considered the highest collision risk and have been regular casualties in prior studies, largely due to its high-flying foraging behaviour (Bennett, 2022). The remainder of the bat species detected during surveys generally fly well below the RSA height. A full table of flight heights and collision risks is available in the Bird and Bat Management Plan (Appendix L).

A collision risk assessment was completed for all bat species identified in the BBUS. Assessments identified no species as being high risk of collision. Four species were identified as having moderate risk of collision, based on flying heights. These are:

- Gould's Wattled Bat (*Chalinolobus gouldii*)
- Little Broad-nosed Bat (*Scotorepens greyii*)
- Northern Freetail Bat (*Chaerophon jobensis*)
- Common Sheathtail Bat (*Taphozous georgeanis*)

Detailed collision risk assessments are provided in Appendix M.

4.1.2.2.1.3. Migratory Birds

One listed migratory bird species, the glossy ibis, has historically been recorded from the Project area, though has not been recorded during BBUS surveys. The Project area may be overflown by several migratory bird species during annual events. These species include the sharp-tailed sandpiper (*Calidris acuminata*), Latham's Snipe (*Gallinago hardwickii*), the Caspian tern (*Hydroprogne caspia*) and the common greenshank (*Tringa nebularia*). Spatial analysis (WTS, 2023) of potential fight paths for migratory birds was completed using data from the East Asian-Australian Flyaway Partnership (Appendix K). Presence of listed Migratory bird species within the windfarm area are likely largely restricted to very rare flyovers.

In addition to international migratory events, other species may migrate or be broadly nomadic within Australia, resulting in mass movements and therefore increased risk of interaction with turbines. The masked woodswallow travels northward from its breeding habitat in southern Australia in Autumn, often arriving in extensive flocks mixed with other woodswallow species (Pizzey & Knight, 2012). A large flock (~240 total birds) of masked woodswallows (~200), little woodswallows (~20) and black-faced woodswallows (~20) was recorded during the sunrise survey period at one monitoring location (SW3). Given the timing, this observation is potentially part of the annual arrival of the masked woodswallow to the area. It should also be noted here that the masked woodswallow is not a listed Migratory species, but large-scale movements like these likely increase the risk of collisions with turbines.

Significant residual impact assessments were completed for five key species with the potential to migrate across the DRM leases. All five assessments concluded that the wind farm is unlikely to seriously disrupt the lifecycle of an ecologically significant proportion of the population of these species.

The spatial assessment and discussion are provided in full in Appendix K and Appendix M.

4.1.2.2.2. Purple Necked Rock Wallaby

The PNRW is known to inhabit the Knapdale Range. DRM has implemented a detailed PNRW monitoring program since 2014, tracking the sub-population sizes at nominated monitoring locations.

The results of the monitoring program are summarised in Table 25. The results show an increase in abundance at most monitoring locations, despite mining commencing in 2017. This demonstrates that the PNRW populations have not been affected by noise and vibration from construction, mining and processing activities conducted to date and therefore indicates a certain tolerance of the PNRW to industrial noise and vibration.

The operational phase of the project may cause ongoing disturbance to the PNRW due to noise and vibration from the turbines. There have been no scientific studies into the impact of noise and/or vibration on the PNRW, and it is not well understood the level of tolerance the PNRW has in relation to noise and vibration. As noted above, data to date indicates that mining and processing activities have not impacted upon the population size at monitoring locations.

The PNRW monitoring program will continue to be implemented to identify potential impacts to the population. The PNRW monitoring program will be expanded to include noise monitoring during surveys. This will provide a comparable dataset to identify potential impacts from noise during construction and operation. An adaptive management program, described below, will be implemented if potential impacts are observed.

Table 25. PNRW abundance recorded from 2014 to 2022 (Ecosmart Ecology, 2023)

Site	2014		2015		2016		2017		2018		2019		2020		2021		2022		Mean	Slope
	Apr	Aug	May	Sep	May	Aug	May	Aug	May	Oct	Apr	Oct	Apr	Sep	Apr	Sep	May	Oct		
CNT01	1	2	1	2	3	1	3	4	0	2	1	2	1	3	2	3	3	3	1.9	0.0004
CNT02	4	3	5	5	4	3	3	2	2	4	3	3	3	5	2	4	3	5	3.5	0.0000
CNT03	2	3	5	6	3	3	3	3	2	1	2	1	3	4	2	2	2	3	2.9	-0.0004
CNT04	1	4	6	6	2	3	3	4	3	5	1	6	2	9	9	8	14	11	3.9	0.0024
IMP01	3	3	4	5	3	4	4	4	4	2	5	3	2	4	4	4	2	4	3.7	-0.0001
IMP02	1	3	*	4	4	3	2	3	*	4	2	4	4	3	2	3	3	4	3.1	0.00003
IMP03	2	3	1	3	3	3	4	4	2	4	3	2	3	3	*	4	4	6	2.9	0.0007
IMP04	0	0	0	0	0	0	0	1	2	0	1	2	2	0	0	0	1	2	0.6	0.0006
KR01					4	4	2	4	3	3	3	1	1	*	3	4	4	5	2.8	0.0004
KR05						3	3	1	3	0	2	3	0	4	1	4	4	4	2.1	0.0008
KR07						4	3	4	4	5	6	3	4	4	2	5	3	4	4.1	-0.0002
KR10						2	3	1	4	4	5	2	3	4	2	6	4	5	3.2	0.0008
KR13						4	4	4	3	4	3	4	2	4	0	5	4	7	3.6	0.0007
KR14						3	2	*	5	4	3	0	3	6	2	4	7	7	3.3	0.0019
KR16						2	2	2	1	3	0	1	1	2	0	3	4	2	1.6	0.004
KR18							4	4	3	1	2	4	1	5	1	4	4	6	3.4	0.0011
KR19							3	5	5	5	0	0	2	2	2	4	2	5	2.7	-0.0006
KR20							3	*	2	4	4	5	3	5	3	4	2	4	3.8	-0.0001

*Equipment failure

4.1.3. Concentrate Shed Cyclone Rating

The EA currently prescribes that the concentrate shed be constructed and maintained to withstand a Category 2 cyclone. The intent of this condition is to ensure any buildings or structures storing, stockpiling and loading mineral concentrate are secured to prevent the release of concentrate to the environment during such an event. The activities undertaken at the Project, present a low risk of this occurring due to the manner in which the concentrate shed is used.

The concentrate shed is considered to be a concentrate transfer point; it is not used for storage of concentrate. Concentrate is deposited into the concentrate transfer shed from the processing plant where it is collected by a front-end loader and transferred into two half height shipping containers. This process occurs as one continuous process; material is not stockpiled within the shed. Material is transferred from the processing plant to the shed and into the containers whilst the shed is enclosed and under negative pressure. The shipping containers are then removed from the shed.

In the unlikely event that a cyclone did occur in the region, there would be no concentrate stored within the shed, and therefore the risk of loss of concentrate is negated.

MMG will continue to comply with EA Condition A5 to ensure that concentrate is contained, during all-weather scenarios:

- The holder of this environmental authority must:
  (a) install all measures, plant and equipment necessary to ensure compliance with the conditions of this environmental authority;
  (b) maintain such measures, plant and equipment in a proper condition; and
  (c) operate such measures, plant and equipment in a proper manner.

4.1.4. Sewage Treatment Plant

Approximately 0.18 ha of RE 1.11.2a is required to be cleared for the placement of a new STP. RE1.11.2a is classified as “least concern” under the VM Act and has a Biodiversity Status of “no concern at present”. The STP is a containerised system, that will be placed within a concrete bund. The STP will treat to a Class A standard, before either being used for dust suppression or transferred to the STP dam for evaporation. No irrigation to land is proposed.

The amendment proposes a new STP to replace the existing exploration camp STP. The amendment does not propose any changes to how effluent is managed and is considered to pose a low risk to land. Existing controls will continue to be implemented, as defined in the DRM Sewage Management Plan.

4.1.5. Proposed Buffer for Category B ESA

The “Code of Environmental Compliance for exploration and mineral development projects” was superseded by the “Eligibility criteria and standard conditions for exploration and mineral development projects” in 2016. The latest version of the code specifies that activities involving machinery must not be carried out within 1 km of a category A environmentally sensitive area or within 500 m of a category

B environmentally sensitive area. Maintaining a buffer from ESAs reduces the risk of impact to areas that may be mapped incorrectly and prevents impact from unintended over clearing.

The proposed amendment is to reduce the buffer to allow machinery to work up to 50 m from a category B environmentally sensitive area. This will allow MMGs exploration program to continue, with appropriate ground truthing to confirm the presence and extent of the ESA. Additional controls have been proposed to further minimise risk to ESAs.

4.1.5.1. Category A Environmentally Sensitive Areas

There are no Category A ESAs mapped to occur within DRM. The proposed amendment will not impact upon any category A Environmentally Sensitive Areas. No changes are proposed to working buffers for category A Environmentally Sensitive Areas.

4.1.5.2. Category B Environmentally Sensitive Areas

Desktop searches and field surveys have identified the following category B Environmentally Sensitive Area to occur within the DRM mining leases:

- Endangered Regional Ecosystem RE 1.3.7b (*Eucalyptus camaldulensis*) woodland on channels and levees.

RE 1.3.7 is allocated a Biodiversity Status of endangered due to its importance as seasonal water bird habitat and a regional corridor for fauna.

Avoidance is the first order of preference to managing environmental impacts in or adjacent to an endangered RE (Queensland Government, 2022). No exploration disturbance is proposed within areas confirmed to be a category B ESA. A 50 m buffer will be maintained around areas confirmed to be RE 1.3.7b. Exploration activities will not affect the RE in relation to its provision as a seasonal water bird habitat and corridor for fauna.

The DRM has been extensively studied and the extent of ESAs is well understood across the mining lease. Ground truthing has sufficiently refined the location and extent of RE 1.3.7b across the proposed disturbance areas. Utilising this data, the risk of unintended impact to RE 1.3.7b is low. DRM will continue to implement appropriate controls, as described below, to further mitigate any potential impacts (Section 4.1.10.) from the proposed amendment.

4.1.6.Acid Sulphate Soils

Acid Sulfate Soils (ASS) form in coastal areas lower than 5 mAHD. DRM is located above 5 mAHD and the risk of encountering ASS is considered very low. No impacts relating to ASS are expected.

4.1.7. Waste Storage

The proposed amendment does not include any changes to waste rock management and therefore has not been considered further. Non mineral waste will continue be removed from site by an authorised third-party contractor in accordance with established DRM waste management procedures.

4.1.8.Areas of Regional Interest

Areas of regional interest are managed under the *Regional Planning Interests Act 2014*. No areas of regional interests are identified over DRM, and none are proposed to be impacted.

4.1.9. Soil Erosion Potential

WTS (2022) estimated the erosion potential for DRM based on average rainfall. DRM has very low erosion risk for the majority of the year. The highest erosion risk is experienced in January (156.6 mm) which coincides with the north Queensland wet season.

4.1.10. Management of Land Impacts

4.1.10.1. Wind Farm and Ancillary Infrastructure

A preliminary impact management plan is provided for the clearing and construction phase (Table 26). A detailed construction management plan will be developed prior to works commencing.

MMG will continue to implement detailed monitoring and reporting programs on a regular basis to identify trends as they emerge. In addition, MMG will continue to implement all existing management controls including those described in the Land and Biodiversity Management Plan, Land Clearance Permitting Procedure and Weed Control Program.

Table 26: Preliminary Impact Management Plan - Clearing and Construction Phase

Threat	Impact	Controls/Management			
		Avoid	Minimise	Mitigate	Monitor
Introduction and/or spread of weed species due to vehicle and machinery movements across the landscape.	Modification of native habitats.	Where possible, activities must be planned to avoid movement of vehicles or machinery between properties, corridors, or areas with weed infestations. All equipment that enters site must be washed down on each occasion (including vehicles, earthmovers, generators, etc.)	General vehicle and machinery hygiene procedures implemented to minimise spreading of seeds.	Weed management and control methods will be implemented based on infestation size, location, and species of which it is comprised.	Monitoring performed as per DRM Land and Biodiversity Management Plan and management as per DRM Weed Control Program.
Introduction of pest species or increase of their populations in the project area.	Competing with, predating on, or otherwise harming native species.	Not applicable.	Not applicable.	Implement a pest management plan (PMP) for pest species found in the project area.	Monitoring and management performed as per DRM Land and Biodiversity Management Plan.
	Facilitating the infection of native species with diseases/parasites such as hydatid disease (*Echinococcus granulosus*) or toxoplasmosis (*Toxoplasmosis gondii*) which can be fatal.				
	Indirectly modifying the habitat of native species.				
Contaminants and waste (including litter).	Direct harm to native fauna (e.g. ingestion of waste by a native animal).	All waste generated must be stored, handled, and transported in sealed containers. Project area to be kept free of litter.	Not applicable.	Not applicable.	Monitoring and management performed as per DRM Land and Biodiversity Management Plan.

Threat	Impact	Controls/Management			
		Avoid	Minimise	Mitigate	Monitor
	Indirect harm to native fauna through degradation of their habitat.	All waste generated must be stored, handled, and transported in sealed containers.	Not applicable.	Green waste produced may be used on site for rehabilitation, sediment, or erosion control.	
Noise, dust, light pollution, and vibrations (particularly during night-time works).	Confusion of birds by light causing increased risk of interactions.	Lighting will be shielded so as not to be seen from casual observers (this refers to people but will provide the same cover from passing birds) unless necessary.	Hours and amount of artificial light will be minimised wherever practical.	Not applicable.	Light meters can be used to monitor light pollution and ensure it stays at or below acceptable levels during works.
	Disturbing surrounding habitat making it less preferable for native species or conditioning avoidance and affecting normal distribution patterns	Lights directed away from habitat, or shields used to block light from habitat. Misting or wetting can be used to manage airborne dust particles.	Hours and amount of artificial light and noisy machine operation will be minimised wherever practical to reduce impact on surrounding habitat. Watering down and implementation of sensible driving speeds on the access roads will minimise dust generation and reduce impact on surrounding habitat.		Light meters can be used to monitor light pollution and ensure it stays at or below acceptable levels during works. Air quality, Noise and Vibration monitoring and management performed as per DRM Air Quality, Noise and Vibration Management Plan.

Threat	Impact	Controls/Management			
		Avoid	Minimise	Mitigate	Monitor
Construction or clearing activities.	Injury/fatality of fauna.	Pre-clearance surveys to be undertaken by qualified fauna spotter/catchers to avoid unintentional tampering of animal breeding places. Clearing will be performed sequentially to direct fauna towards adjacent habitat and away from work sites.	All people driving on site to stay on roads to lower risk of hitting an animal. Vehicle speed limits will are in place to further lower risk.	Fauna spotter/catchers operating under an approved rehabilitation permit to check areas prior to work commencing, and to be present during clearing. Fauna will preferably be allowed to move on their own accord, but if this does not occur and access is required immediately then fauna spotter/catchers operating under an approved rehabilitation permit will relocate them. Injured wildlife can be brought to local wildlife carers: **Western Qld Wildlife Rehabilitation Centres:** **Cloncurry – 0419 422 900**	Maintaining records of any fauna interactions on site to inform management adjustments.
	Destruction of native habitat (specifically important in the case of rocky habitat/sub-habitat due to importance of native fauna species reliant on such habitat).	Where possible, avoid the clearing of areas of rocky habitat due to the importance of native fauna species reliant on such habitat.	Not applicable.	Rehabilitate cleared areas that are no longer required after construction has finished.	Monitor and maintain rehabilitated sites to ensure they are progressing as required (control of weeds, etc.).

Threat	Impact	Controls/Management			
		Avoid	Minimise	Mitigate	Monitor
	Creating barriers to distribution of native fauna (namely the Purple-necked Rock-wallaby).	Where possible, avoid the creation of barriers within Purple-necked Rock-wallaby habitat.	Fauna ramps implemented along barriers to allow animals to cross.	Not applicable.	Maintaining records of any fauna interactions on site to inform management adjustments.
	Creating barriers damming flow to downstream water holes.	Install culverts in drainage lines to allow continued flow of water.	Not applicable.	Not applicable.	Ground and surface water monitoring as per DRM Groundwater Management Plan.
Active work areas, pits, trenches, and other hazardous disturbed areas.	Injury/fatality of fauna.	Fencing or coverings should be used to restrict access to all faunae.	Fauna ramps implemented in any pits or trenches to allow animals to escape.	Injured wildlife can be brought to local wildlife carers: **Western Qld Wildlife Rehabilitation Centres:** **Cloncurry – 0419 422 900**	Maintaining records of any fauna injuries/fatalities on site resulting from human activities to inform management adjustments. Open pits and trenches will be checked daily to identify and relocate trapped fauna.

4.1.10.2. Purple Necked Rock Wallaby

The proposed amendment has the potential to impact upon the PNRW due to ongoing noise and vibration during operations. There may be a risk of conditioning avoidance and affecting normal distribution patterns PNRW on site.
However, due to the small size of the project area and the large area of local habitat available, works within the site are unlikely to adversely affect habitat critical to the survival of the species. Additionally PNRW population numbers have not declined in response to the current mining operations which includes the deposition of tailings within the TSF and ongoing exploratory resource definition drilling which has occurred year-round since project commencement.

Significant residual impacts have determined to be unlikely. Existing controls will continue to be implemented, including:

- Minimising disturbance as much as practicable;
- Rehabilitating disturbance areas as soon as practicable;
- Implement noise monitoring as a component of biannual PNRW monitoring;
- Continue to implement the PNRW monitoring program (Condition I10); and
- Continued to report on the findings of the PNRW monitoring program (Condition I12).

4.1.10.3. Aerial Fauna

A Carrion Monitoring Plan will be developed to monitor bird fatality rates during the construction and operation of the wind farm. Results from carrion monitoring will be used to trigger mitigation measures, as defined in the Bird and Bat Management Plan (Appendix L). Impacts and mitigation measures are summarised in Table 27.

Impact triggers have been developed in accordance with relevant standards for wind farms. An impact trigger for threatened species occurs where a carcass (or recognisable part) of a threatened bird or bat species (listed under the NC or EPBC Act) is found under or in close proximity to a turbine during routine carrion monitoring or incidentally during commissioning or operation. For non-threatened birds and bat species, an impact trigger is where two or more of the same species, in two successive searches at the same or adjacent turbine(s) is recorded (i.e. a total of four or more carcasses of the same species in two successive searches at the same turbine) (Brett Lane & Associates Pty Ltd, 2005).

A BBUS has been developed to provide baseline data on bird and bat use of the Project area. The BBUS will continue to be implemented throughout the life of the Project to monitoring trends and identify the suitability and effectiveness of mitigation measures.

Table 27. Impacts and mitigation measures (WTS, 2024)

Potential cause of impact	Monitoring to determine cause of impact	Mitigation measure	Likelihood of impact after implementation of mitigation
Foraging source identified that attracts 'at risk' species to impact areas (e.g. flowering eucalypts, carrion associated with road kills, or spawning of insects).	Conduct additional targeted BBUS to assist in determining activity during these events. Conduct additional carrion monitoring in response to these events to determine if events are linked to impacts.	Trial acoustic or visual deterrents at turbine/s responsible for impact trigger. .	Low Low
Bushfire, low pressure systems and storm fronts creating favourable conditions for aerial foragers.			Low
Low visibility due to wind/rain/fog.			Low

MMG propose the following conditions be applied to facilitate the implementation and reporting of the BBUS program and carrion monitoring program:

a. *A Bird and Bat Utilisation Survey (BBUS) program must be implemented by an appropriately qualified person to monitor and record the effects of the wind farm activity on aerial fauna, including birds and bats. The BBUS must be implemented and maintained for the lift of the environmental authority.*
b. *A report detailing the results of the BBUS must be provided to the administering authority, annually.*
c. *A carrion monitoring program must be implemented by an appropriately qualified person to monitor and record bird mortality, as a result of the wind farm. The bird and bat monitoring program must be implemented and maintained for the lift of the environmental authority.*
d. *Any instance of a threatened bird or bat species identified within carrion searches, in close proximity to a turbine, must be reported to the administering authority within 24 hours.*

4.1.10.4. Effluent Management

Treated effluent will either be stored in a tank attached to the system, to be accessed for dust suppression, or transferred to the STP Dams for evaporation. The following controls are implemented:

- Inspect and maintain equipment and bunds;
- Maintain standby pumps and alarm system;
- Maintain critical spares for pumping infrastructure;
- Utilise STP Dam Stage 2 as the primary storage point, with additional capacity available in STP dam Stage 1, as required;
- Manage effluent quality in accordance with Class C treated effluent guidelines;
- Conduct regular monitoring of water quality; and
- Ensure controlled releases are conducted in accordance with EA Schedule C – Table 1 (Release Points) and Schedule E – Table 1 (Sewage Effluent Contaminant Release Limits.

The STP will continue to be operated in accordance with the DRM Sewage Management Plan and existing EA conditions.

4.1.10.5. Exploration Disturbance

Prior to any exploration work commencing within 50 m – 500 m of a Category B ESA, a site inspection will be undertaken by a suitable qualified ecologist. The ecologist will conduct a ground truthing assessment to determine the actual extent, status, and condition of the ESA. The final location and dimensions of disturbance areas will be determined based on results of the ecological survey. No exploration work will be permitted within 50 m of a confirmed category B ESA.

For all disturbance works, the clearance area will be clearly pegged by the site surveyors, placing pegs at a minimum spacing of 100 m.

A land disturbance permit will be issued in accordance with the MMG Land Clearance and Disturbance Permitting Procedure. The permit will be signed by the MMG project supervisor, equipment operators, equipment spotter, and fauna spotter catcher, to ensure that all conditions of the permit are understood.

The final clearance areas will be recorded in the MMG Land Clearance Spatial Dataset.

4.1.10.6. General Management Controls

4.1.10.6.1. Topsoil Stripping

Topsoil stripping will be conducted via dozers or similar and material will be placed in windrows at the edge of the disturbance area to a maximum height of 2 metres. Topsoil will then be transported to existing Stockpiles listed in Schedule A – Table 1 (Authorised Mining Activities).

4.1.10.6.2. Timing of Works

All clearing work will be undertaken during the dry season (April – November), where possible. Work will not be conducted during significant rain, or when significant rainfall is forecast.

4.1.10.6.3. Waste Rock Management

The proposed amendment does not include any changes to waste rock management and therefore has not been considered further.

4.1.10.6.4. Tailings Management

The proposed amendment does not impact upon tailings disposal and therefore has not been considered further.

4.1.10.6.5. Waste Management

Other than organic waste (i.e., cleared vegetation) and soil to be re-used for remediation, there are no plans for waste storage within the proposed wind farm disturbance area. Waste storage and disposal will comply with established DRM waste management procedures.

Waste impacts and control measures are described in more detail in Section 4.3

4.1.10.6.6. Erosion and Sediment Control

The risk of erosion as a result of the proposed additional disturbance is considered low. However, MMG will implement erosion and sediment controls (ESC) during construction in line with MMG's Erosion and Sediment Control Plan (Appendix O) erosion controls will consist of:

- Conducting construction works during the dry season where possible (April – November);
- Minimising all surface disturbance. Large vegetation will be selectively cleared for the laydowns, STP, vent shaft and groundwater infrastructure to maintain as much groundcover as possible and stabilise soils;
- Stabilising exposed soils as soon as practical. Hardstands will be constructed for the turbine pads as soon as practicable after vegetation is removed to prevent long term exposure and minimise erosion;
- Maintaining vegetative buffer zones where possible;
- Delineating areas required to be disturbed;
- Transporting any removed topsoil to existing stockpiles located away from operational areas; and
- Revegetating final landforms as soon as possible.

4.1.10.6.7. Contamination Identification

The following measures have been implemented to manage any contamination identified from general activities at DRM:

- Surface waters will be monitored biannually during the REMP events;
- Groundwater is monitored quarterly in line with the EA conditions; and
- Where new contamination is identified at DRM, MMG will conduct an investigation to the contamination, and engage a contaminated land specialist to investigate and provide mitigation recommendations.

4.1.10.6.8. Unplanned and Uncontrolled Releases

The proposed additional disturbance does not propose changes to implemented water management strategies. There is unlikely to be any unplanned and uncontrolled releases; surface water flow in the proposed disturbance areas is in response to natural rainfall events only. If an unplanned release does occur, actions will be taken in accordance with the EA.

4.1.10.6.9. Handling and Storage of Chemicals and Fuels

All chemicals and fuels will be stored in accordance with *Australia Standard (AS) 1940 The storage and handling of flammable and combustible liquids*. Chemicals and fuels proposed to be handled and stored onsite will be fuels, oils and greases required for the usual operation of vehicles and plant. Chemicals and fuels are proposed to be stored in appropriate containers (e.g., fuel drums) on bunded pallets or in bunded areas. Minimal volumes will be stored or transported for the wind farm project, with any larger quantities stored at the existing mine infrastructure areas (e.g., workshop).

4.1.10.6.10. Spill Management

Vehicle spills (e.g., oil spills) will be managed using readily accessible onsite spill kits. All employees will be appropriately trained in the use of spill kits including containment, absorption, and recovery. Any spill greater than 20L will be recorded as an incident and appropriately investigated and documented.

4.1.10.7. Progressive Rehabilitation

MMG have a detailed Progressive Rehabilitation and Closure Plan (PRCP) to ensure the environment is returned to an agreed or pre-mine condition. Progressive rehabilitation will be completed as per the defined progressive rehabilitation schedule.

4.1.11. Environmental Offsets Assessment

An Environmental Offset Assessment has been conducted in accordance with the General Guide for the Queensland Environmental Offsets Framework (Department of Environment and Science, 2024) (Figure 18). The assessment is summarised in Table 28 and described in further detail below.

Table 28. Environmental Offset Assessment

Offset Assessment	Outcome
Is the activity a prescribed activity?	Yes – the DRM is a resource activity for which an amendment application, site-specific application or variation application was made.
Does the activity impact on any prescribed environmental matters?	Yes – the proposed Project will impact upon the following matters of State environmental significance: • regulated vegetation intersecting a watercourse; and • essential habitat for the PNRW.
Will impacts from the activity be reasonable and effectively avoided	Yes – Significant design effort has ensured that the design presented in this application reasonably and effectively avoids the MSES as much as practicable.
Will impacts from the activities be reasonably and effectively mitigated	Yes – Significant design effort has ensured that the design presented in this application reasonably and effectively mitigates impact to the MSES as much as practicable.
Is the residual impact significant?	A residual significant impact has been identified for regulated vegetation intersecting a watercourse.
Is an offset a suitable outcome?	Yes.

4.1.11.1. Environmental Offsets Framework

The *Environmental Offsets Act 2014* outlines the framework for environmental offsets with the purpose of counterbalancing significant residual impacts from proposed activities on prescribed environmental matters. A prescribed environmental matter is defined under section 10(1) of the *Environmental Offsets Act 2014* as any of the following matters prescribed under a regulation to be a prescribed environmental matter:

- a matter of national environmental significance;
- a matter of State environmental significance; or
- a matter of local environmental significance.

The following prescribed environmental matters are mapped to occur or potentially occur within the Project area:

- matters of national environmental significance;
    - 15 fauna species listed as Marine or Migratory under the EPBC Act;
    - 1 flora species listed as EVNT under the EPBC Act; and
    - 15 fauna species listed as EVNT under the EPBC Act.
- matters of State environmental significance;
    - regulated vegetation intersecting a watercourse; and

    - essential habitat for the PNRW.
- matters of local environmental significance.
    - None identified within the Cloncurry Shire Planning Scheme.

4.1.11.2. Impacts to Prescribed Environmental Matters

Significant residual impact assessments have been undertaken on each of the above species with a likelihood of occurrence of “possible” or higher, as well as both MSES’s. The assessments determined that the proposed amendment would have no significant residual impact for any EPBC species or essential habitat for the PNRW. Any potential impact from the proposed amendment will be appropriately mitigated with the proposed controls and monitoring programs as described above.

The width of the access track required for transport of infrastructure and vehicles to the turbine pads will result in clearing vegetation across drainage line crossings. The width required is greater than 25 m and therefore a significant residual impact has been triggered for regulated vegetation, intersecting a watercourse.

4.1.11.3. Avoidance and Mitigation

The Queensland Offset Policy defines a mitigation hierarchy of avoid, minimise and lastly offset. Avoidance and minimisation have been implemented with the design of the wind farm and other proposed disturbances, as discussed in Section 2.2.1.3 and summarised below:

- Avoid - A condensed design (limited to eight turbines) has been proposed, avoiding impacts from additional turbines.
- Avoid – Drainage line crosses have been avoided wherever possible to minimise construction requirements and provide the safest transport route;
- Avoid – Additional proposed features (vent shaft 9 and Switchyard 2) have been positioned on previously disturbed land to avoid any additional surface disturbance.
- Mitigate – the Project design has been extensively assessed and manipulated to minimise environmental disturbance whilst providing a safe outcome for construction;
- Mitigate - The turbines have been positioned on the Knapdale Range to maximise efficiency thereby reducing the overall number of turbines and resultant surface disturbance. This design minimises potential impact to prescribed matters such as regulated vegetation intersecting a watercourse and essential habitat.
- Mitigate - Existing disturbance for tracks and pads have been utilised wherever possible to minimise surface disturbance and minimise potential impact to prescribed matters such as regulated vegetation intersecting a watercourse and essential habitat. Existing tracks will be utilised, however they require to be widened to accommodate large vehicles.
- Mitigate – Additional proposed features (groundwater infrastructure and the STP) have been placed within the mine infrastructure areas to minimise disturbance required for additional access tracks and minimising potential impact to prescribed matters such as regulated vegetation intersecting a watercourse and essential habitat.

- Mitigate - The design has excluded lighting to reduce attraction of aerial fauna, minimising impact to listed aerial EVNT and migratory species.
- Mitigate - The design has limited the number of turbines to eight, thereby reducing total RSA and potential impact to listed aerial EVNT and migratory species.

The current Project design demonstrates that all reasonable avoidance and mitigation measures have been incorporated.

It has been determined that after reasonable avoidance and minimisation techniques have been employed, there will be a direct impact to approximately 4.1 ha of regulated vegetation, intersecting a watercourse. Therefore, an offset is a reasonable requirement to be conditioned in this amended EA.

4.1.11.4. Offset Delivery

The Offsets Acts provide flexibility in delivering a conservation outcome through three delivery options:

- Financial settlement offset;
- Proponent – driven offset; or
- A combination of proponent-driven offset and financial settlement offset (Department of Environment and Science, 2024).

MMG propose a financial settlement offset, to be calculated in accordance with the Financial Settlement Offset Calculator (Queensland Government, 2024). An initial offset calculation was completed with the results presented in Table 29. The agreed financial settlement will be paid in full prior to any part of the activity commencing.

Table 29. Offset Calculator

Residual area of impact	Notional offset area (ha)	Offset ($)
4.1 ha	16.40 ha	$92,800.00

All ongoing mitigation measures, as described throughout this application, will continue to be implemented to reduce further impact. After closure, all disturbance will be rehabilitated to a safe, stable and non-polluting condition as described in the PRCP.

4.2. Water Impacts

In preparing this application, consideration has been given to guideline *ESR/2015/1837 – Application requirements for activities with impacts to water* (DES, 2021c). DES is required to assess the application against the requirements stated in the *Environmental Protection Act 1994*, EP Regulation and the EPP Water to meet the environmental objective and performance outcomes described below:

Environmental Objective

'The activity will be operated in a way that protects environmental values of waters.'

Performance Outcome

There is no actual or potential discharge to waters of contaminants that may cause an adverse effect on an environmental value from the operation of the activity.

All of the following:

- The storage and handling of contaminants will include effective means of secondary containment to prevent or minimise releases to the environment from spillage or leaks.
- Contingency measures will prevent or minimise adverse effects on the environment due to the unplanned releases or discharges of contaminants to water.
- The activity will be managed so that stormwater contaminated by the activity that may cause an adverse effect on an environmental value will not leave the Project without prior treatment.
- The disturbance of any Acid Sulfate Soils, or potential Acid Sulfate Soils, will be managed to prevent or minimise adverse effects on environmental values.
- Acid producing rock will be managed to ensure that the production and release of acidic waste is prevented or minimised, including impacts during operation and after the environmental authority has been surrendered.
- Any discharge to water or a watercourse or wetland will be managed so that there will be no adverse effects due to the altering of existing flow regimes for water or a water course or wetland.
- For a petroleum activity, the activity will be managed in a way that is consistent with the coal seam gas water management policy, including the prioritisation hierarchy for managing and using coal seam gas water and the prioritisation hierarchy for managing saline waste.
- The activity will be managed so that adverse effects on environmental values are prevent or minimised.

Environmental Objective

The activity will be operated in a way that protects the environmental values of groundwater and any associated surface ecological systems.

Performance Outcome

Both of the following apply:

- There will be no direct or indirect release of contaminants to groundwater from the operation of the activity.
- There will be no actual or potential adverse effect on groundwater from the operation of the activity.

Or, the activity will be managed to prevent or minimise adverse effects on groundwater or any associated surface ecological systems.

Some activities involving direct releases to groundwater are prohibited by the EP Regulation.

RISK OF ENVIRONMENTAL IMPACT: LOW

4.2.1. Overview of Water Impacts

The proposed amendments and the potential impact to waters are described in Table 30. The amendments with potential to impact on waters are discussed in further detail below.

Table 30. Water Impacts

Condition	Proposed Amendment	Potential Impact and Mitigation Measures
Schedule A – Table 1 (Authorised Mining Activities)	Additional disturbance area for the construction and operation of a wind farm. This disturbance total incorporates: - 27.78 ha for wind farm pads - 32.32 ha for access tracks - 12.78 ha for laydowns - 0.72 ha for powerline poles - 0.99 ha for switchyard 2 - 1.23 ha for meteorological masts	There are no watercourses, as defined under the Water Act within the proposed disturbance areas. The pads do not intersect any drainage lines. The access roads for the wind farm will cross four drainage lines. There is potential for construction activities to impact on water quality through increased traffic leading to erosion. Bed level crossings will be constructed from suitable materials to prevent erosion and allow unobstructed water flows. Suitable erosion and sediment control measures will be implemented to minimise impact.
Schedule A – Table 1 (Authorised Mining Activities)	Construction of a Sewage Treatment Plant (0.18 ha) at 412059, 7760070.	Effluent will be treated to a Class A standard, which is an improvement on the current Class C treatment standard. The amendment does not propose any change to how sewage is managed onsite, and therefore presents no increased risk to waters. Effluent from the STP will be utilised for dust suppression via a water cart or disposed to the existing STP dams. Effective watering practises will ensure that treated effluent does not pond, or discharge to surface waters. All existing management measures for the STP dams will continue to be implemented.
New condition within Schedule A – General, Exploration	The holder of the environmental authority must not carry out activities in a category A	The proposed amendment will not result in any impact to waters.

Condition		Proposed Amendment	Potential Impact and Mitigation Measures
		or B environmentally sensitive area. Activities involving machinery must not be carried out within 1km of a category an environmentally sensitive area or within 50 m of a category B environmentally sensitive area.	All existing mitigation measures will continue to be implemented, including maintaining a 50 m buffer from all watercourses.
Schedule A – Table 1 (Authorised Mining Activities)		Addition of Ventilation Shaft 9 at 411466, 7761320 (0.54 ha).	The proposed amendment will not result in any impact to waters.
B14	The buildings and structures in place at the licensed place for the storage, stockpiling and loading of mineral concentrate must be constructed and maintained to withstand a Category 2 cyclone.	Remove condition.	The proposed amendment will not result in any impact to waters. The concentrate shed is considered to be a concentrate transfer point; it is not used for storage of concentrate. Concentrate is deposited into the concentrate transfer shed from the processing plant where it is collected by a front-end loader and transferred into two half height shipping containers while the shed is under negative pressure. In the unlikely event that a cyclone did occur in the region, there would be no concentrate stored within the shed, and therefore the risk of loss of concentrate, and release of contaminants is negligible. All existing water management controls will continue to be implemented to directly surface flows and reduce the release of contaminants from site to receiving waters.
B15	The construction and state of the buildings and structures in place at the licensed place for the storage, stockpiling	Remove condition.	The proposed amendment will not result in any impact to waters.

Condition	Proposed Amendment	Potential Impact and Mitigation Measures
and loading of mineral concentrate must be checked for compliance with condition B14 by an appropriately qualified person at least once every three (3) years.		
Schedule C – Table 2 (Contaminant Release Limits)	Remove cyanide as a monitoring parameter.	Cyanide is not stored or used in processing activities at DRM. DRM have no intention of introducing cyanide to site; the impact of cyanide to waters is non-existent.
Schedule C – Table 5 (Receiving waters trigger levels and contaminant limits)	Remove the contaminant limit for total Aluminium, replace the trigger level and contaminant limit for filterable Aluminium with site specific values.	The existing Contaminant Limit for total aluminium (0.2 mg/L) is derived from the ANZECC 2000 guidelines for recreational purposes (body immersion). The receiving waters of DRM are not used for recreation purposes therefore the limit is not appropriate. Historic data shows that there is no statistically significant difference between the results for reference and impact locations. This shows Aluminium concentrations presents a low risk to the downstream environment. The proposed new triggers and limits will provide a more robust assessment of water quality trends and potential impact.
Schedule C – Table 5 (Receiving waters trigger levels and contaminant limits)	Remove cyanide as a monitoring parameter.	Cyanide is not stored or used in processing activities at DRM. DRM have no intention of introducing cyanide to site; the impact of cyanide to waters is non-existent.
Schedule C – Table 8 (Groundwater trigger levels and contaminant limits)	Remove cyanide as a monitoring parameter.	Cyanide is not stored or used in processing activities at DRM. DRM have no intention of introducing cyanide to site; the impact of cyanide to waters is non-existent.

Condition	Proposed Amendment	Potential Impact and Mitigation Measures
Schedule D – Table 2 (Hydraulic performance criteria for Regulated Dams)	Remove the hydraulic performance criteria for the Stage 2 PAF Run Off Dam. Revise the associated footnotes to reference the most recent consequence category assessment.	The PAF Stage 2 Runoff Dam has been risk assessed as 'Low Risk' for 'failure to contain – overtopping', therefore hydraulic performance criteria are not required. The proposed amendment presents a low risk to waters.

4.2.2. Aluminium in Receiving Waters

This amendment proposes to remove the Contaminant Limit (Schedule C – Table 5 (Receiving waters trigger levels and contaminant limits)) for total Aluminium and continue monitoring as an interpretative parameter only.

The existing Contaminant Limit for total aluminium (0.2 mg/L) is derived from the ANZECC 2000 guidelines for recreational purposes (body immersion). The receiving waters of the DRM are not suitable for swimming due to low water clarity, unpredictable currents and high bacterial loads. The waters are naturally turbid and seldom, if ever, comply with recreational usage guideline requirement for the bottom to be visible at a depth of 1.2 m (TropWater, 2020). Further, as the surrounding land uses at DRM are pastural, it is unlikely that the receiving waters would be accessed for recreational purposes.

Total aluminium provides a concentration of suspended aluminosilicate silt and clay particles, which is strongly related to total suspended solids and turbidity. The receiving waters of DRM are naturally turbid, meaning total aluminium concentrations will always be elevated compared to clear waters. Both aluminium and total suspended particles are subject to high levels of natural spatiotemporal variability meaning that it is not possible to propose meaning guideline values to assess impact from DRM.

This amendment proposes that monitoring of total aluminium continues for interpretation purposes only. Results to date, indicate that there is no statistically significant difference between the results for reference and impact locations for total aluminium, and that aluminium poses a low risk to the receiving environment.

Currently the trigger level for dissolved aluminium is 0.055mg/l or the 80th percentile of reference values. A review of historical data demonstrates that dissolved aluminium frequently exceeds the trigger limit of 0.055 mg/l at all three reference monitoring locations. There is no statistically significant difference between the results for reference and impact locations. Given this, Ref-80 is not considered to be a useful marker for detecting potential impact from mining activities. This amendment proposes a fixed site-specific value to be implemented as a dissolved aluminium trigger level. A historical dataset is provided for consideration in defining this fixed value.

Currently the contaminant limit for dissolved aluminium is the 95th percentile of the reference value. As discussed above, there is no statistically significant difference between the results for reference and test sites. For the same reasons, the 95th percentile is not a useful tool for detecting anomalous results potentially indicative of impacts. This amendment proposes a fixed site-specific value to be implemented as a dissolved aluminium trigger level. A historical dataset is provided for consideration in defining this fixed value.

4.2.3. Stage 2 PAF Runoff Dam

4.2.3.1. Consequence Category Assessment

A Consequence Category Assessment (CCA) was completed for the Stage 2 PAF Dam in 2023, in accordance with the Manual for assessing hazard consequence and hydraulic performance of

structures (The Manual) (Environmental Protection Act 1994 (Qld) (a)). The results of the assessment are summarised below. A full copy of the report is provided in Appendix F. Additional information regarding the reclassification from 'significant' to 'low' risk is provided in Appendix G.

4.2.3.2. Failure to Contain – Seepage

Under Section 2.1.2.1.a of the Manual, the assessment against the 'Failure to contain – seepage' scenario is applicable to new structures and does not apply to structures approved prior to development of Version 5.02 of the Manual (ATC Williams, 2023). The consequence category was therefore assessed as N/A.

The proposed amendment does not result in any changes to the assigned risk rating for "failure to contain – seepage".

4.2.3.3. Failure to Contain – Overtopping

In the event of an overtopping of PAF Stage 2 Dam, flows would initially pass northeast where they would enter the unnamed tributary of the Dugald River (North Creek). When the unnamed tributary of the Dugald River (North Creek) enters the Dugald River, flow is directed in a southerly direction. The Dugald River then flows north towards the Gulf of Carpentaria. . There are no on-site personnel routinely present in the failure path, nor are there bores for human consumption or third-party infrastructure.

The unnamed tributaries of Dugald River and the Dugald River contain the following:

- Wildlife habitat (endangered or vulnerable);
- Regulated vegetation (essential habitat); and
- Regulated vegetation (intersection a watercourse).

Impacts to these areas would be likely; however, would not be expected to reach the thresholds for a 'Significant' or 'High' consequence impact (ATC Williams, 2023). In the event of an overtopping failure, water quality parameters are expected to be diluted due to significant, prolonged rainfall in the upstream catchment.

Overall, the consequence category has been assessed as 'low' for the overtopping scenario.

4.2.3.4. Failure to Contain – Dam Break

In the event of a dam break failure of the PAF Stage 2 Runoff, flows would pass north east entering Dugald River via the unnamed Dugald River tributaries. The population at risk has been defined as 0, resulting in a 'low' risk rating.

There are no third-party assets in the failure path, therefore the economic loss has been defined as 'low' risk.

In a dam break scenario, water quality is expected to impact upon:

- Wildlife habitat (endangered or vulnerable);

- Regulated vegetation (essential habitat); and
- Regulated vegetation (intersection a watercourse).

The impacts to the areas of MSES are likely to result in the following:

- remediation of damage is likely to take more than 6 months but less than 3 years; or
- significant alteration to existing ecosystems.

The consequence category for general environmental harm has been assessed as being a 'significant' risk.

Overall, the consequence category has been assessed as 'significant' for the dam break scenario.

4.2.3.5. Hydraulic Performance Criteria

Dams assessed as having a "Significant" or "High" consequence for the 'failure to contain – overtopping' must have hydraulic performance objectives which include a design storage allowance (DSA), an extreme storage allowance (ESS) and a mandatory reporting level (MRL). The PAF Stage 2 Runoff Dam has been risk assessed as 'Low Risk' for 'failure to contain – overtopping', therefore hydraulic performance criteria are not required.

Dams assessed as having "Significant" or "High" consequence for the 'failing to contain – dam break' must have hydraulic performance criteria in regard to spillway capacity. The hydraulic performance criteria for the PAF Stage 2 Runoff Dam are provided in Table 31. The PAF Stage 2 Runoff Dam spillway has been designed and constructed to meet this criterion.

Table 31. Hydraulic Performance Criteria

Failure Scenario	Consequence Category	Spillway Capacity AEP	Flood Level for embankment crest levels
Failure to Contain – Dam Break	Significant	1:1,000 AEP	Spillway design peak flood level + wave runup allowance for 1:10 AEP wind

4.2.4. Sewage Treatment Plant

This amendment proposes a new Sewage Treatment Plant (STP) to replace the existing exploration camp STP. The STP will be operated in accordance with the existing Sewage Treatment Management Plan, and EA conditions E1 to E6.

Effluent will be either utilised for dust suppression via a water cart or disposed to the existing STP dams. Effective watering practises will ensure that treated effluent does not pond, or discharge to surface waters. Currently the STP, transfers effluent to the STP Dam Stage 2 for evaporation. STP Dam Stage 1 provides additional and separate capacity in the event of an infrastructure failure. All existing management controls will continue to be implemented on the STP dams.

The existing Sewage Effluent Contaminant Release Limits (Schedule E – Table 1), are based on achieving a Class C effluent. The proposed system will treat the effluent to a Class A standard, achieving an improved water quality than required by the existing EA limits.

The amendment does not propose any change to how sewage is managed onsite, and therefore presents no increased risk to waters.

4.2.5. Groundwater

Additional clearing is proposed around two existing monitoring bores. This additional area is to provide sufficient space to operate a solar powered pump for a groundwater extraction feasibility study. This amendment does not propose any additional groundwater bores or ongoing groundwater extraction.

As described above, the new STP will improve the quality of effluent being generated. This will reduce the contaminants being stored within the STP dams, thereby reducing the risk of contaminant release from the dams to groundwater.

Impacts to ground waters are not anticipated as a result of the proposed amendments. DRM will continue to implement existing water management controls, including ongoing monitoring.

4.2.6. Wind Farm and Ancillary Infrastructure

The Dugald River is the only watercourse, as defined under the *Water Act 2000,* to intersect the DRM mining leases, at the powerline corridor mining lease. No defined watercourses intersect the operational areas or proposed disturbance areas. Dugald River is located approximately 3 km to the east of nearest wind turbine and will not be impacted by any construction works. Cabbage Tree Creek is located, off lease, approximately 2.5 km to the west of the nearest turbine. Cabbage Tree Creek will not be impacted directly by any construction works.

A number of ephemeral drainage lines transect the mining leases. No wind turbines will be located across any drainage lines. The proposed tracks to the pads, cross four drainage lines, as displayed on Figure 18. Bed level crossings will be constructed from suitable material to prevent erosion and allow unobstructed water flows. Bed level crossings will provide better protection to the bed of the stream and once constructed will have minimal maintenance requirements. Crossings will be constructed and maintained in accordance with the *Accepted development requirements for operational work that is constructing or raising waterway barrier work* (Department of Agriculture and Fisheries, 2018).

As described in the Queensland waterways for waterway barrier works spatial data layers (Queensland Globe, 2024), drainage lines within the wind farm project layout have a fish passage attribute of 1. Waterways classified as having a fish passageway attribute of 1 or 2 are usually located in the upper reaches of a drainage catchment and have steeper slopes. This is the case for the Knapdale Range. The biomass of fish populations in these waterways is generally smaller than in downstream reaches. The fish that are present may have stronger abilities, allowing them to navigate past water way barriers with relatively greater ease (Queensland Government, 2023). The drainage lines present within the proposed disturbance layers, are ephemeral systems that rarely flow and do not hold water beyond the

initial flow event. The proposed bed level crossings are unlikely to impact upon fish passageway or fish habitat. The eastern laydown is proposed to be located approximately 20 m north of a drainage line. Large vegetation will be removed; however groundcover and topsoil will not be disturbed. The laydown will be utilised for temporary storage of infrastructure and vehicles. The laydown will be access from the north and will avoid the drainage line. It is not likely to increase erosion potential or result in any impact to the drainage line.

Clearing and construction activities have the potential to impact on water quality through increased erosion. Appropriate sediment and erosion controls will be implemented as described below.

One wetland, Lake Julius is located within the vicinity of DRM. As it is upstream and located approximately 40 km from DRM, no impacts are anticipated as a result of the proposed additional disturbance areas.



Client: Dugald River Pty Ltd
Project number: 2023.03002
CRS: GDA2020 EPSG: 7844
Date: 15 May 2024

Print as A3

Figure 18. Drainage Line Crossing

Legend

- Existing Disturbance
- Proposed Disturbance Extent
- Watercourse (VM Act)
- 10m Contour
- Waterway Crossing

Google Satellite

Disclaimer:
Whilst every effort and care has been taken to ensure the accuracy of this report, Wulguru Technical Services Pty Ltd makes no representations or warranties about its accuracy, reliability, completeness or suitability for any particular purpose and disclaims all responsibility and all liability (including without limitation, liability in negligence) for all expenses, losses, damages (including indirect or inconsequential damage) and costs which you might incur as a result of the product being inaccurate or incomplete in any way and for any reason.
Digital data for this report is available on the Queensland Government Spatial Portal at https://qldspatial.information.qld.gov.au.

WULGURU TECHNICAL SERVICES

4.2.7. Management of Water Impacts

4.2.7.1. Timing of Works

All clearing work will be undertaken during the dry season (April – November), where possible. Work will not be conducted during significant rain, or when significant rainfall is forecast.

4.2.7.2. Drainage Line Crossings

Existing light vehicle access tracks to the wind farm pads currently cross drainage lines on eight occasions. These tracks will be widened to allow transport of wind turbine components and access to the erection cranes. Where the road intersects a drainage line, a bed level crossing will be constructed to allow continued surface water flows, whilst minimising bed erosion. Crossings will be constructed and maintained in accordance with the *Accepted development requirements for operational work that is constructing or raising waterway barrier work* (Department of Agriculture and Fisheries, 2018).

The banks will be stabilised using appropriate materials and construction methods , Detailed designs will be prepared as part of the Construction Management Program, prior to works commencing.

The MMG Erosion and Sediment Control Plan will continue to be implemented, specifically in regard to inspections and maintenance of the crossings.

4.2.7.3. Erosion and Sediment Control

The risk of erosion as a result of the proposed additional disturbance is considered low. However, MMG will implement erosion and sediment controls (ESC) in accordance with MMG's Erosion and Sediment Control Plan (Appendix O). Erosion controls will consist of:

- Conducting construction works during the dry season where possible (April – November);
- Minimising all surface disturbance. Large vegetation will be selectively cleared for the laydowns, STP, vent shaft and groundwater infrastructure to maintain as much groundcover as possible and stabilise soils;
- Stabilising exposed soils as soon as practical. Hardstands will be constructed for the turbine pads as soon as practicable to prevent long term exposure and minimise erosion;
- Maintaining vegetative buffer zones where possible;
- Delineating areas required to be disturbed;
- Transporting any removed topsoil to existing stockpiles located away from operational areas; and
- Revegetating final landforms as soon as possible.

A detailed Construction Management Plan will be developed prior to works commencing to describe specific ESC measures including the locations, type and monitoring requirements for the measures.

4.2.7.4. Discharges and Releases

The release of contaminants to waters at DRM is only authorised at the points specified in Schedule C – Table 1 (Release Points) of the EA.

Treated sewage effluent may be release to waters and is monitored in accordance with Schedule E – Table 1 (Sewage Effluent Contaminant Release Limits). Sewage will be treated to a Class A standard prior to transfer to the STP dam, readily achieving the existing defined release limits.

This amendment does not propose any change to discharge and/or release conditions.

4.2.7.5. Unplanned and Uncontrolled Releases

No additional discharges or releases are associated with the proposed amendments. All existing water management controls will continue to be implemented.

4.2.7.6. Handling and Storage of Chemicals

All chemicals and fuels will be stored in accordance with *Australia Standard (AS) 1940 The storage and handling of flammable and combustible liquids*. Chemicals and fuels proposed to be handled and stored onsite will be fuels, oils and greases required for the usual operation of vehicles and plant. Chemicals and fuels are proposed to be stored in appropriate containers (e.g., fuel drums) on bunded pallets or in bunded areas. Minimal volumes will be stored or transported for the wind farm project, with any larger quantities stored at the existing mine infrastructure areas (e.g., workshop).

4.2.7.7. Spill Management

Vehicle spills (e.g., oil spills) will be managed using readily accessible onsite spill kits. All employees will be appropriately trained in the use of spill kits including containment, absorption, and recovery. Any spill greater than 20 L will be recorded as an incident and appropriately investigated and documented.

4.2.8. Monitoring of Water Impacts

4.2.8.1. Receiving Environment Monitoring Program

A Receiving Environment Monitoring Program (REMP) has been implemented at DRM that encompasses event-based surface water sampling, stream sediment sampling and macroinvertebrate and fish sampling. The REMP will continue to be carried out to capture any potential impacts from the proposed additional disturbance and a report will be prepared annually in line with the EA.

4.2.8.2. Groundwater Monitoring

The EA requires groundwater quality and levels to be monitored at the locations and frequencies outlined in Schedule C – Table 7 (Groundwater Monitoring Locations and Frequency). Groundwater monitoring will continue as described in the EA.

4.2.8.3. Sewage Effluent Monitoring

Sewage effluent will continue to be monitored in accordance with Schedule E – Table 1 (Sewage Effluent Contaminant Release Limits).

4.2.1. Summary of Water Impacts

The proposed amendments do not introduce any additional contaminants or propose any changes to water management at DRM.

Construction activities will be planned with appropriate erosion and sediment control measures to mitigate any potential impact to waters. No impacts are expected during the operation of the wind farm, or any other proposed amendments.

The proposed amendments are a low risk to waters.

4.3. Waste Impacts

In preparing this report, consideration has been given to guideline *ESR/2015/1836 – Application requirements for activities with waste impacts* (DES, 2019a). DES is required to assess the application against the requirements stated in the *Environmental Protection Act 1994*, the Environmental Protection Regulation 2019 (EP Regulation) and the *Waste Reduction and Recycling Act 2011* to meet the environmental objective and performance outcomes described below:

Environmental Objective

'Any waste generated, transported, or received as part of carrying out the activities is managed in a way that protects all environmental values'.

Performance Outcome

- Waste generated, transported, or received, is managed in accordance with the waste and resource management hierarchy in the *Waste Reduction and Recycling Act 2011*; and
- If waste is disposed of, it is disposed of in a way that prevents or minimises adverse effects on environmental values.

RISK OF ENVIRONMENTAL IMPACT: LOW

4.3.1. Overview of Waste Impacts

The potential waste impacts from the proposed amendments are summarised in Table 32. Where required, additional detail is provided below.

Table 32. Waste Impacts

Condition	Proposed Amendment	Potential Impact
Schedule A – Table 1 (Authorised Mining Activities)	Additional disturbance area for the construction and operation of a wind farm. This disturbance total incorporates: - 27.78 ha for wind farm pads - 32.32 ha for access tracks - 12.78 ha for laydowns - 0.72 ha for powerline poles - 0.99 ha for switchyard 2 - 1.23 ha for meteorological masts	Additional waste, such as fibreglass, steel, grease, etc, will be generated from the construction, operation, maintenance and decommissioning of the wind farm. Waste will be disposed of in accordance with the manufacturer specifications and established waste management procedures.
Schedule A – Table 1 (Authorised Mining Activities)	Construction of a Sewage Treatment Plant (0.18 ha) at 412059, 7760070.	The amendment does not propose any change to how sewage is managed onsite, and therefore presents no increase in risk to environmental values. Effluent from the STP will be utilised for dust suppression via a water cart or disposed to the existing STP dams. Any solids or sludge will be removed from site by a

Condition		Proposed Amendment	Potential Impact
			licenced third-party contractor (Cleanaway), as per the existing process.
New condition within Schedule A – General, Exploration		The holder of the environmental authority must not carry out activities in a category A or B environmentally sensitive area. Activities involving machinery must not be carried out within 1km of a category an environmentally sensitive area or within 50 m of a category B environmentally sensitive area.	The proposed amendment will not result in any change to waste generation, storage or disposal from drilling activities. All existing mitigation measures will continue to be implemented.
Schedule A – Table 1 (Authorised Mining Activities)		Addition of Ventilation Shaft 9 at 411466, 7761320 (0.54 ha).	The proposed amendment will not result in any change to waste generation, storage or disposal.
B14	The buildings and structures in place at the licensed place for the storage, stockpiling and loading of mineral concentrate must be constructed and maintained to withstand a Category 2 cyclone.	Remove condition	The proposed amendment will not result in any change to waste generation, storage or disposal.
B15	The construction and state of the buildings and structures in place at the licensed place for the storage, stockpiling and loading of mineral concentrate must be checked for compliance with condition B14 by an	Remove condition.	The proposed amendment will not result in any change to waste generation, storage or disposal.

Condition	Proposed Amendment	Potential Impact
appropriately qualified person at least once every three (3) years.		
Schedule C – Table 2 (Contaminant Release Limits)	Remove cyanide as a monitoring parameter.	The proposed amendment will not result in any change to waste generation, storage or disposal.
Schedule C – Table 5 (Receiving waters trigger levels and contaminant limits)	Remove the contaminant limit for total Aluminium, replace the trigger level and contaminant limit for filterable Aluminium with site specific values.	The proposed amendment will not result in any change to waste generation, storage or disposal.
Schedule C – Table 5 (Receiving waters trigger levels and contaminant limits)	Remove cyanide as a monitoring parameter.	The proposed amendment will not result in any change to waste generation, storage or disposal.
Schedule C – Table 8 (Groundwater trigger levels and contaminant limits)	Remove cyanide as a monitoring parameter.	The proposed amendment will not result in any change to waste generation, storage or disposal.
Schedule D – Table 2 (Hydraulic performance criteria for Regulated Dams)	Remove the hydraulic performance criteria for the Stage 2 PAF Run Off Dam. Revise the associated footnotes to reference the most recent consequence category assessment.	The proposed amendment will not result in any change to waste generation, storage or disposal.

4.3.2.Overview of Waste

In preparing supporting information relating to waste impacts, due consideration has been given to the waste and resource management hierarchy (Figure 19). Measures proposed for the minimisation and management of waste have been considered in line with this hierarchy with disposal considered to be the final option.

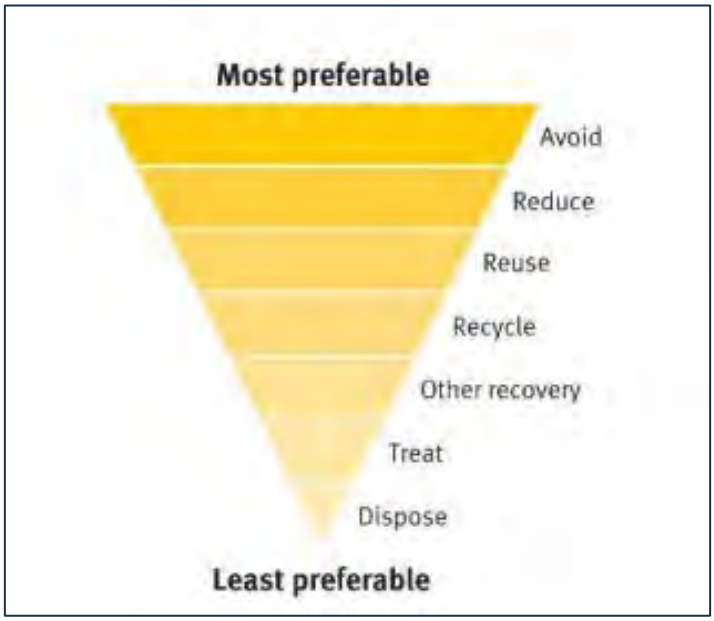


Figure 19. Waste and resource management hierarchy

4.3.3. Types of Waste at DRM

Waste generated at DRM is typical of remote mining operations. Table 33 summarises the varied waste streams and their management groups. The proposed amendment will not result in any change to the waste types and volumes will remain within the current ERA thresholds.

Table 33. Waste Types at DRM

Waste Type	Management Group	Management Strategy
Mineral Waste – PAF	Mineral Waste	Temporary storage onsite for use in underground fill
Mineral Waste – NAF	Mineral Waste	Temporary storage onsite for use in site maintenance and closure rehabilitation
Tailings	Mineral Waste	Use in paste fill and surplus storage in the TSF
Putrescible domestic	Non-Mineral Waste	Disposed of via a third-party contractor
Non-putrescible domestic	Non-Mineral Waste	Disposed of via a third-party contractor
Recyclables	Non-Mineral Waste	Recycled via a third-party contractor
Scrap steel	Non-Mineral Waste	Recycled via a third-party contractor
Sewage	Non-Mineral Waste	Evaporation ponds
Septic and grease waste	Non-Mineral Waste	Disposed of offsite via a third-party regulated waste transporter
Chemicals	Non-Mineral Waste	Disposed of offsite via a third-party regulated waste transporter
Hydrocarbons	Non-Mineral Waste	Recycled offsite via a third-party regulated waste transporter
Other regulated wastes (batteries etc)	Non-Mineral Waste	Disposed of offsite via a third-party regulated waste transporter
Tyres	Non-Mineral Waste	Recycled offsite via third-party contractor
Inert construction	Non-Mineral Waste	Disposed of or recycled offsite via third-party contractor

4.3.4. Sewage Treatment Plant

This amendment proposes a new Sewage Treatment Plant (STP) to replace the existing exploration camp STP. The STP has a capacity of 150kL/day and will treat sewage to a Class A standard. Effluent will be either utilised for dust suppression via a water cart or disposed to the existing STP dams. The STP will be operated in accordance with the Sewage Treatment Management Plan, and EA conditions E1 to E6.

The existing Sewage Effluent Contaminant Release Limits (Schedule E – Table 1), are based on Class C effluent. The proposed system will treat the effluent to a Class A standard, well within the existing EA limits.

The amendment does not propose any change to how sewage is managed onsite, and therefore presents no increase in risk to environmental values.

Once the new STP is operational, the existing STP will be decommissioned and disposed of via a third-party waste contractor (Cleanaway).

4.3.5. Wind Farm Waste

The wind farm will have a regular inspection and preventative maintenance regime to prolong the life of the infrastructure. When required, components (e.g. the nacelle or blades) may need to be replaced. Any waste generated from maintenance activities will be disposed of in accordance with the manufacturer specifications and relevant waste regulations. Grease used in the nacelle will be disposed of in accordance with existing regulated waste procedures.

DRM is not authorised to dispose of any waste onsite, other than that approved under condition G3. All waste not authorised to be disposed on site will be removed and disposed at a facility authorised to receive such waste.

At the end of the wind farm life, all infrastructure, cabling, and footings will be removed and disposed at an authorised facility.

4.3.6. Management of Waste Impacts

4.3.6.1. Waste Storage

Waste will continue to be stored in accordance with established DRM waste management procedures. Waste will continue to be stored in suitable receptables at designated locations whilst awaiting removal and disposal.

Any stripped topsoil will then be transported to existing Stockpiles listed in Schedule A – Table 1 (Authorised Mining Activities).

4.3.6.2. Waste Tracking and Documentation

Waste tracking and documentation for regulated waste generated by day-to-day activities (i.e., waste oil and grease) will be managed by the service contractor(s), in compliance with QLD regulated waste tracking requirements, under the EP Regulation.

4.3.6.3. Waste Disposal

The waste hierarchy will continue to be implemented, with waste disposal the last option. Waste will continue to be disposed in accordance with established DRM waste management procedures. All general and regulated waste (other than mineral waste) will be removed from DRM and disposed at a licenced facility.

Effluent from the STP will be utilised for dust suppression via a water cart or disposed to the existing STP dams. Any solids or sludge will be removed from site by a licenced third-party contractor (Cleanaway), as per established processes.

4.3.7. Summary of Waste Impacts

Additional waste will be generated from the construction, operation, maintenance and decommissioning of the proposed activities. The waste management hierarchy will be implemented for all wastes, with disposal as being the last option. When required, all waste not authorised to be disposed of onsite, will be removed by a licenced third party and disposed at a facility authorised to accept such waste.

DRM will continue to implement existing sewage treatment and effluent disposal controls at the proposed new STP.

DRM will continue to implemented established waste management controls including engaging suitable third party contractors for technical guidance, waste transport and disposal.

The proposed amendment is low risk to waste.

4.4. Air Impacts

In preparing this application, consideration has been given to guideline *ESR/2015/1840 – Application requirements for activities with impacts to air* (DES, 2017a). DES is required to assess the application against the requirements stated in the *Environmental Protection Act 1994*, EP Regulation and Environmental Protection (Air) Policy 2019 (EPP Air) to meet the environmental objective and performance outcomes described below:

Environmental Objective

'The activity will be operated in a way that protects environmental values of air:'

Performance Outcome

There is no discharge to air of contaminants that may cause an adverse effect on the environment from the operation of the activity, or

All of the following:

- Fugitive emissions of contaminants from storage, handling and processing of materials and transporting materials within the site are prevented or minimised.
- Contingency measures will prevent or minimise adverse effects on the environment from unplanned emissions and shut down and start up emissions of contaminants to air.
- Releases of contaminants to the atmosphere for dispersion will be managed to prevent or minimise adverse effects on environmental values.

RISK OF ENVIRONMENTAL IMPACT: LOW

4.4.1. Air Impact Overview

The potential impacts to air are discussed in Table 34. Further detail is provided below where required.

Table 34. Air Impacts

Condition	Proposed Amendment	Potential Impact
Schedule A – Table 1 (Authorised Mining Activities)	Additional disturbance area for the construction and operation of a wind farm. This disturbance total incorporates: - 27.78 ha for wind farm pads - 32.32 ha for access tracks - 12.78 ha for laydowns - 0.72 ha for powerline poles - 0.99 ha for switchyard 2 - 1.23 ha for meteorological masts	Clearance and construction works may result in temporary impacts to air through the release of nuisance dust from exposed surfaces and increased traffic. The sensitive receptor, the Roseby Homestead, is located upwind of the proposed clearance and construction activities. No impacts are expected during operation of the wind farm. A Construction Management Plan will be developed for the wind farm detailing appropriate mitigation controls.
Schedule A – Table 1 (Authorised Mining Activities)	Construction of a Sewage Treatment Plant (0.18 ha) at 412059, 7760070.	A small (<1 ha) disturbance footprint is required for the new STP. Any emissions from construction will be minor and temporary. The sensitive receptor, the Roseby Homestead, is located 5.6 km upwind of the proposed clearance and construction activities. No impacts are expected during operation of the STP. The STP is an enclosed system that will not release any odour or fugitive emissions.

Condition		Proposed Amendment	Potential Impact
			Existing management controls will continue to be implemented.
New condition within Schedule A – General, Exploration		The holder of the environmental authority must not carry out activities in a category A or B environmentally sensitive area. Activities involving machinery must not be carried out within 1km of a category an environmentally sensitive area or within 50 m of a category B environmentally sensitive area.	The proposed amendment will not result in any change to air quality related to drilling activities. All existing mitigation measures will continue to be implemented.
Schedule A – Table 1 (Authorised Mining Activities)		Addition of Ventilation Shaft 9 at 411466, 7761320 (0.54 ha).	No clearing is required for the ventilation shaft. The proposed amendment will not reduce air quality at the Project.
B14	The buildings and structures in place at the licensed place for the storage, stockpiling and loading of mineral concentrate must be constructed and maintained to withstand a Category 2 cyclone.	Remove condition	The concentrate shed is considered to be a concentrate transfer point; it is not used for storage of concentrate. Concentrate is deposited into the concentrate transfer shed from the processing plant where it is collected by a front-end loader and transferred into two half height shipping containers while the shed is under negative pressure. In the unlikely event that a cyclone did occur in the region, there would be no concentrate stored within the shed, and therefore the risk of loss of concentrate, and release of contaminants is negligible.

Condition		Proposed Amendment	Potential Impact
			The proposed amendment will not increase emissions to air or result in nuisance dust.
B15	The construction and state of the buildings and structures in place at the licensed place for the storage, stockpiling and loading of mineral concentrate must be checked for compliance with condition B14 by an appropriately qualified person at least once every three (3) years.	Remove condition.	The proposed amendment will not increase emissions to air or result in nuisance dust.
Schedule C – Table 2 (Contaminant Release Limits)		Remove cyanide as a monitoring parameter.	The proposed amendment will not increase emissions to air or result in nuisance dust.
Schedule C – Table 5 (Receiving waters trigger levels and contaminant limits)		Remove the contaminant limit for total Aluminium, replace the trigger level and contaminant limit for filterable Aluminium with site specific values.	The proposed amendment will not increase emissions to air or result in nuisance dust.
Schedule C – Table 5 (Receiving waters trigger levels and contaminant limits)		Remove cyanide as a monitoring parameter.	The proposed amendment will not increase emissions to air at the Project.
Schedule C – Table 8 (Groundwater trigger levels and contaminant limits)		Remove cyanide as a monitoring parameter.	The proposed amendment will not increase emissions to air at the Project.
Schedule D – Table 2 (Hydraulic performance criteria for Regulated Dams)		Remove the hydraulic performance criteria for the Stage 2 PAF Run Off Dam. Revise the associated footnotes to reference the most recent consequence category assessment.	The proposed amendment will not increase emissions to air at the Project.

4.4.2. Surrounding Land and Sensitive Receptors

DRM is situated in an unpopulated region with the nearest sensitive receptor being The Roseby Homestead, located approximately 6 km south of DRM. The remaining area is made up of grazing land with some homesteads approximately 30 km from DRM. The nearest major centre is Cloncurry, approximately 65 km south. The predominant wind direction is from the south southeast, away from the nearest sensitive receptor.

4.4.3. Existing Condition

Depositional and ambient dust is monitored at the locations and frequencies outlined in Table 35. The key aim of the monitoring program is to monitor for dust impacts at the sensitive receptor, Roseby Homestead. Dust is monitored using depositional dust gauges and high-volume air samplers (total suspended particulates) and low-volume air samplers (suspended particulate matter <10µm).

A recent external review of air quality (ERM 2019) at DRM identified no residual impacts to the receiving environment from existing activities. No complaints have been received to date.

Table 35. Schedule B – Table 2 (Air Quality Monitoring Program)

Monitoring Location Description	Location (GDA94 MGA z54)		Monitoring Site ID	Monitoring Frequency
	Easting	Northing		
Compliance				
Roseby Homestead	413970	7754962	EA_DG_005	For TSP, PM10, arsenic, cadmium and lead: As required by condition B8. For dust deposition measured as insoluble matter: Monthly For arsenic, cadmium and lead in deposited dust: Monthly
			EA_AQ_005	
Reference				
North of Roseby Homestead and the licensed place	408471	7766889	EA_DG_007	For TSP, PM10, arsenic, cadmium and lead: As required by condition B8. For dust deposition measured as insoluble matter: Monthly For arsenic, cadmium and lead in deposited dust: Monthly
			EA_AQ_007	
	411918	7764933	EA_DG_008	
			EA_AQ_008	
	410576	7762936	EA_DG_009	
South of Roseby Homestead and the licenced place	413110	7752939	EA_DG_006	
			EA_AQ_006	
Between Roseby Homestead and the licenced place	413589	7760259	EA_DG_001	
	412867	7758953	EA_DG_010	

4.4.4. Fugitive emissions

The proposed amendment will not result in any changes to the storage, handling or processing of material. Appropriate dust mitigation techniques will continue to be implemented, as described below. All clearing works will be conducted on undisturbed land; there will be no disturbance to any mineral storage or disposal areas and no risk of release of mineral contaminants to the atmosphere.

4.4.5. Construction Impacts

Approximately 86 ha is proposed to be cleared for the wind farm and ancillary infrastructure and 2 ha for the other proposed amendments. Clearance and construction works may result in temporary impacts to air from exposed surfaces and increased traffic. The potential impacts to air described in Table 34. Appropriate controls will be implemented as described below.

4.4.6. Management of Air Impacts

Further air impacts are not envisaged from the proposed amendment and management will continue in accordance with DRMs Air Quality, Noise and Vibration Management Plan. Management controls are summarised as following:

- Conduct air quality monitoring to include meteorological monitoring, dust depositional sampling and volumetric monitoring;
- Maintain sealed roadways;
- Plan dust minimisation activities on disturbed surfaces where practicable, for example: timely rehabilitation; seeding of soil stockpiles; and soil binders;
- Cover and containment of potential odour sources; and
- Record community air emission complaints/grievances.

In addition to the existing Air Quality, Noise and Vibration Management Plan, a Construction Management Plan will be developed prior to works commencing on the wind farm. Appropriate stakeholders, including the Roseby Homestead, will be consulted prior to works commencing to address any specific concerns and mitigation measures.

The Construction Management Plan will include the following:

- Description and locations of sensitive land uses that may be affected by noise, vibration and dust emissions from construction.
- Description of the activities and equipment likely to generate noise, vibration, and dust emissions.
- Description of the noise, vibration and dust impact control measures to be implemented to minimise noise, vibration and dust impacts at sensitive receptors.
- Description of the methods to be used to monitoring performance and receive, record, and respond to complaints.

4.4.7. Contingency Measures

If monitoring or visual assessment detects significant emissions to air, works will cease until appropriate controls are implemented and emissions are reduced.

4.4.8. Summary of Air Impacts

Clearance and construction works may result in temporary impacts to air through the release of nuisance dust caused by exposed surfaces and increased traffic. The nearest sensitive receptor is located approximately 5.7 km upwind of the proposed disturbance. Any impacts from construction, will be minimal and temporary and releases of contaminants to the will be managed to prevent or minimise adverse effects on environmental values.

The proposed amendment is low risk to air.

4.5. Noise Impacts

In preparing this application, consideration has been given to guideline *ESR/2015/1838 – Application requirements for activities with noise impacts* (DES, 2017d). DES is required to assess the application against the requirements stated in the *Environmental Protection Act 1994*, EP Regulation and the Environmental Protection (Noise) Policy 2019 (EPP Noise) to meet the environmental objective and performance outcomes described below:

Environmental Objective

'The activity will be operated in a way that protects the environmental values of the acoustic environment.'

Performance Outcome

- Sound from the activity is not audible at a sensitive receptor, or
- The release of sound to the environment from the activity is managed so that adverse effects on environmental values, including health and wellbeing and sensitive ecosystems, are prevented or minimised.

RISK OF ENVIRONMENTAL IMPACT: LOW

4.5.1. Overview of Noise Impacts

The potential noise impacts from the proposed amendments are discussed in Table 36. A Noise Impact Assessment (AECOM, 2023) has been completed for the construction and operation of the windfarm. The results of the assessment are discussed further below.

Table 36. Noise Impacts

Condition	Proposed Amendment	Potential Impact and Mitigation Measures
Schedule A – Table 1 (Authorised Mining Activities)	Additional disturbance area for the construction and operation of a wind farm. This disturbance total incorporates: - 27.78 ha for wind farm pads - 32.32 ha for access tracks - 12.78 ha for laydowns - 0.72 ha for powerline poles - 0.99 ha for switchyard 2 - 1.23 ha for meteorological masts	A noise model has been completed for the construction and operation of the wind farm. The modelling demonstrates that the wind farm achieves compliance with noise guidelines under both the State Code 23 and EPP (Noise). A Construction Management Plan will be implemented to mitigate potential noise impacts during construction. The DRM Air Quality, Noise and Vibration Management Plan will continue to be implemented. Noise monitoring will be conducted during BBUS and PNRW monitoring programs to identify potential correlations between noise levels and

Condition	Proposed Amendment	Potential Impact and Mitigation Measures
		species presence and/or abundance.
Schedule A – Table 1 (Authorised Mining Activities)	Construction of a Sewage Treatment Plant at 412059, 7760070.	A small (<1 ha) disturbance footprint is required for the new STP. Any increase in noise from construction will be minor and temporary. The operation of the STP will not increase noise from DRM. The nearest sensitive receptor, the Roseby Homestead, is located 6.5 km, upwind of the proposed STP. Existing noise management controls will continue to be implemented.
New condition within Schedule A – General, Exploration	The holder of the environmental authority must not carry out activities in a category A or B environmentally sensitive area. Activities involving machinery must not be carried out within 1km of a category an environmentally sensitive area or within 50 m of a category B environmentally sensitive area.	The proposed amendment will not result in any change to noise emission related to drilling activities. All existing noise mitigation measures will

Condition		Proposed Amendment	Potential Impact and Mitigation Measures
			continue to be implemented.
Schedule A – Table 1 (Authorised Mining Activities)		Addition of Ventilation Shaft 9 at 411466, 7761320 (0.54 ha).	The proposed amendment will not increase noise emissions at the Project. Existing noise management controls will continue to be implemented.
B14	The buildings and structures in place at the licensed place for the storage, stockpiling and loading of mineral concentrate must be constructed and maintained to withstand a Category 2 cyclone.	Remove condition	The proposed amendment will not increase noise emissions at the Project.
B15	The construction and state of the buildings and structures in place at the licensed place for the storage, stockpiling and loading of mineral concentrate must be checked for compliance with condition B14 by an appropriately qualified person at least once every three (3) years.	Remove condition.	The proposed amendment will not increase noise emissions at the Project.
Schedule C – Table 2 (Contaminant Release Limits)		Remove cyanide as a monitoring parameter.	The proposed amendment will not increase noise emissions at the Project.

Condition	Proposed Amendment	Potential Impact and Mitigation Measures
Schedule C – Table 5 (Receiving waters trigger levels and contaminant limits)	Remove the contaminant limit for total Aluminium, replace the trigger level and contaminant limit for filterable Aluminium with site specific values.	The proposed amendment will not increase noise emissions at the Project.
Schedule C – Table 5 (Receiving waters trigger levels and contaminant limits)	Remove cyanide as a monitoring parameter.	The proposed amendment will not increase noise emissions at the Project.
Schedule C – Table 8 (Groundwater trigger levels and contaminant limits)	Remove cyanide as a monitoring parameter.	The proposed amendment will not increase noise emissions at the Project.
Schedule D – Table 2 (Hydraulic performance criteria for Regulated Dams)	Remove the hydraulic performance criteria for the Stage 2 PAF Run Off Dam. Revise the associated footnotes to reference the most recent consequence category assessment.	The proposed amendment will not increase noise emissions at the Project.

4.5.2. Baseline Study

Studies completed for the DRM Environmental Impact Statement by AustralAsian Resource Consultants Pty Ltd (AARC) describe background levels for the area prior to the DRM development as being typical of quiet rural areas with the median background noise levels measured as during the day – 23 dB(A), evening – 21 dB(A) and night-time -16 dB(A) (AARC 2010b).

Predicted noise level impacts modelled for the Roseby Homestead were found to be predominately below the limits of the EA. Table 37 compares the predicted with measured values from a 2016 noise review conducted by Wood & Grieve Engineers. To date, MMG has received no noise complaints.

Table 37. Predicted (AARC 2010b) and Actual (WGE 2016) Noise Levels for DRM (AARC 2010b).

Noise level dB(A) as $L_{Aeq,adj,T}$	Day	**Evening**	Night
EA guideline	40	35	30
Background (2010)	23	21	26
Predicted max impact (2010)	31	31	31

4.5.3. Wind Farm Noise Assessment

A noise assessment was conducted in accordance with the *State Code 23: Wind farm development (State Code 23)* of the State Development Assessment Provisions (SDAP), version 3.0, effective 18 February 2022 and the *State Code 23 Wind Farm Development Planning Guidelines (Planning Guideline*), dated February 2022. The State Code 23 considers the noise generating characteristics of wind farms, specifically, and is considered to be the most relevant guidance for the construction and operation of the wind farm.

The results of the assessment are summarised below, and provided in full in Appendix P.

4.5.3.1. Acoustic Amenity

Under the Environmental Protection (Noise) Policy 2019 (EPP Noise), there is only one defined sensitive receptor for the Project, the Roseby Homestead, located approximately 5.7 km from the nearest wind turbine. The Planning Regulation 2017 identifies non-resident workforce accommodation as being a sensitive land use. The noise assessment has considered both definitions of sensitive receptor/land use and identified three locations of interest for the model. These are the Roseby Homestead, the accommodation village and the temporary exploration camp.

State Code 23 defines performance outcomes and acceptable outcomes for wind farms, as described in Table 38. State Code 23 is not directly assessable for the Project, however, has been referenced for technical guidance.

The acceptable outcome of a separation distance, greater than 1500 m, is achieved at all turbine locations.

Table 38. Extract from Table 23.1 of State Code 23

Performance Outcomes	Acceptable Outcomes	Project Outcome
PO10 Development is sited and designed to protect the amenity of existing or approved sensitive land uses on non-host lots from acoustic impacts.	A10.1 A separation distance of at least 1500 metres is achieved between wind turbines and existing or approved sensitive land uses on non-host lots. OR A10.2 Where wind turbines are proposed within 1500 metres of existing or approved sensitive land uses on non-host lots, written agreements (deeds of release) from all affected non-host lot owners are provided accepting the reduced setback.	The nearest sensitive receptor on a non-host lot is 5,732 metres from the closest turbine.

4.5.3.2. Operational Noise Limits

State Code 23 provides acoustic criteria to be achieved at both host and non-host lots. The State Code 23 acoustic level criteria are provided in Table 39.

The EPP Noise describes the following environmental values to be protected under the policy:

- the qualities of the acoustic environment that are conducive to protecting the health and biodiversity of ecosystems;
- the qualities of the acoustic environment that are conducive to human health and wellbeing; and
- the qualities of the acoustic environment that are conducive to protecting the amenity of the community.

The current EA provides noise limits for mining activities, derived from the EPP Noise, presented in Table 40.

Table 39. Operational Noise Limits and Predictions

Noise Description	Acoustic level does not exceed
Host lot	
The outdoor (free-field) night-time (10pm to 6am) A-weighted equivalent acoustic level (LAeq), assessed at all noise affected existing approved sensitive land uses	1. 45dB(A), or 2. The background noise (LA90) by more than 5dB(A); whichever is the greater, for wind speed from cut-in to rated power of the wind turbine and each integer wind speed in between referenced to hub height.
Non-host lot	
The outdoor (free-field) night-time (10pm to 6am) A-weighted equivalent acoustic level (LAeq), assessed at all noise affected existing or approved sensitive land uses.	1. 35dB(A); 2. the background noise (LA90) by more than 5dB(A); whichever is the greater, for wind speed from cut-in to rated power of the wind turbine and each integer wind speed in between referenced to hub height.
The outdoor (free-field) day-time (6am to 10pm) A-weighted equivalent acoustic level (Laeq), assessed at all noise affected existing or approved sensitive land uses.	1. 37dB(A), or 2. The background noise (LA90) by more than 5dB(A); whichever is the greater, for wind speed from cut-in to rated power of the wind turbine and each integer wind speed in between referenced to hub height.

Table 40. Noise Limits (EA Schedule F - Table 1)

Noise Level dB(A) Measured as:	7 days per week		
	7am to 6pm	6pm to 10pm	10pm to 7am
LAeq, adj, T Note: T = 15 minutes	40	35	30

4.5.3.3. Predicted Noise

Predicted noise was modelled, considering three scenarios, being:

- Scenario 1: Construction earthworks;
- Scenario 2: Construction turbine construction; and
- Scenario 3: Operation.

Noise levels associated with the decommissioning phase of the Project are assumed to be equivalent to the noise levels associated with construction scenario 2 (turbine installation).

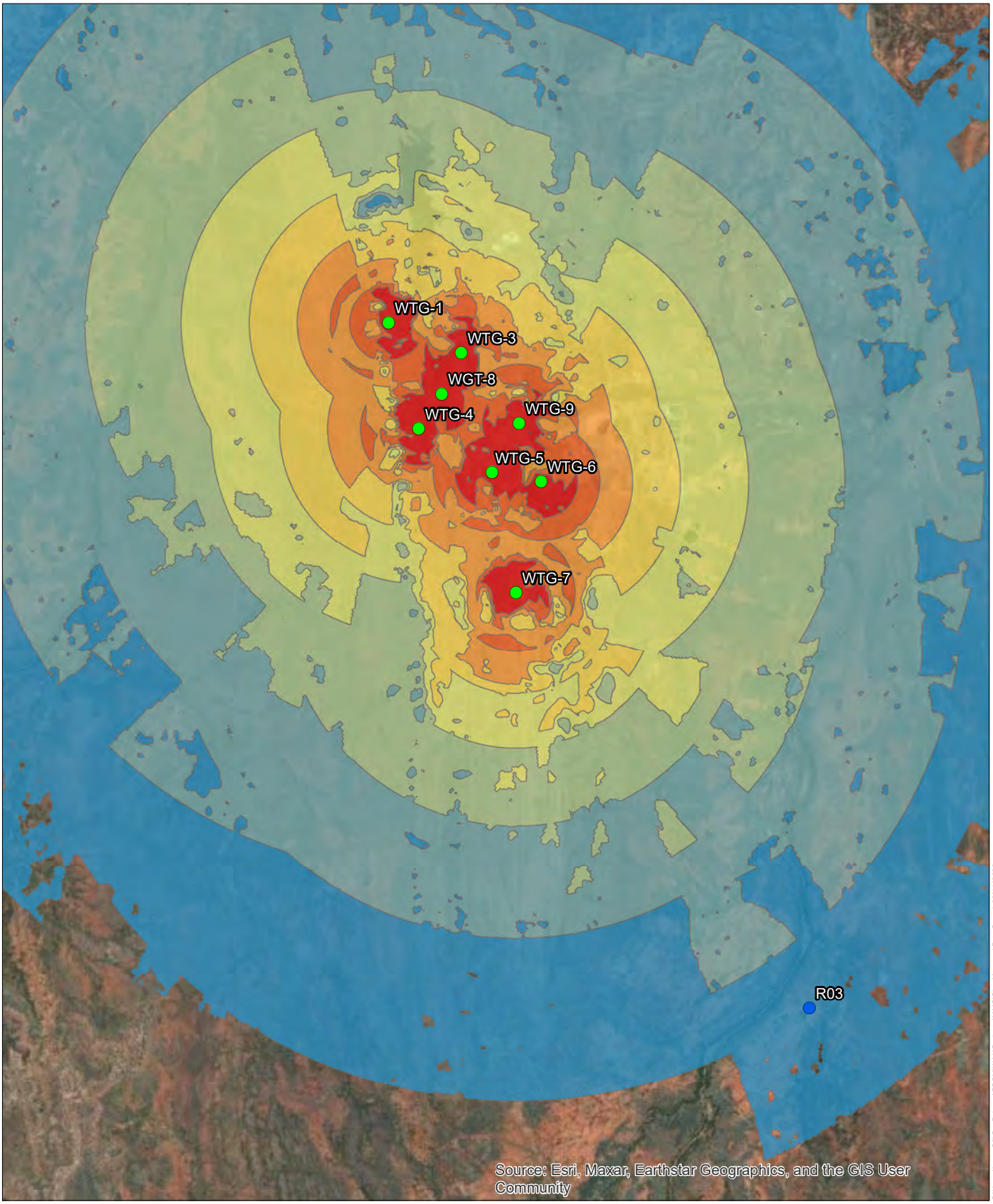
Based on the results of the modelled noise predictions, the noise emissions from the Project are expected to comply with the requirements of State Code 23 at all host and non-host sensitive receptors throughout construction, operation and decommissioning. The noise assessment has concluded that the predicted wind farm noise levels comply with the EPP noise criteria, and therefore EA limits, at each sensitive receptor.

Noise contours for both construction and operation of the wind farm are provided in Figure 20 to Figure 22.

4.5.3.4. Fauna Impact

The ongoing noise pressure and vibrations from the operation of the windfarm have the potential to impact upon fauna distribution throughout the Knapdale Range. Due to the small footprint of the windfarm, compared to available undisturbed area of the Knapdale Range, it is considered unlikely that noise would adversely affect available habitat for fauna. The current PNRW monitoring program has not identified a decline in population numbers since the commencement of mining and processing activities, indicating that the PNRW has a certain tolerance to industrial noise and human activity.

Noise monitoring will be undertaken annually, in conjunction with PNRW monitoring and BBUS monitoring to identify any correlation between noise levels and presence of species. This dataset will be utilised to determine any additional control measures required, as well as evaluate the success of deterrent systems should they be implemented in future.



Dugald River Wind Farm - Construction Scenario 1 - L_{Aeq}

N 0 1 2 km

AECOM

- Noise Sensitive Receptor
- Turbine Locations

Sound Pressure Level, L_{Aeq} dB(A)

20 25 30 35 40 45 50 55

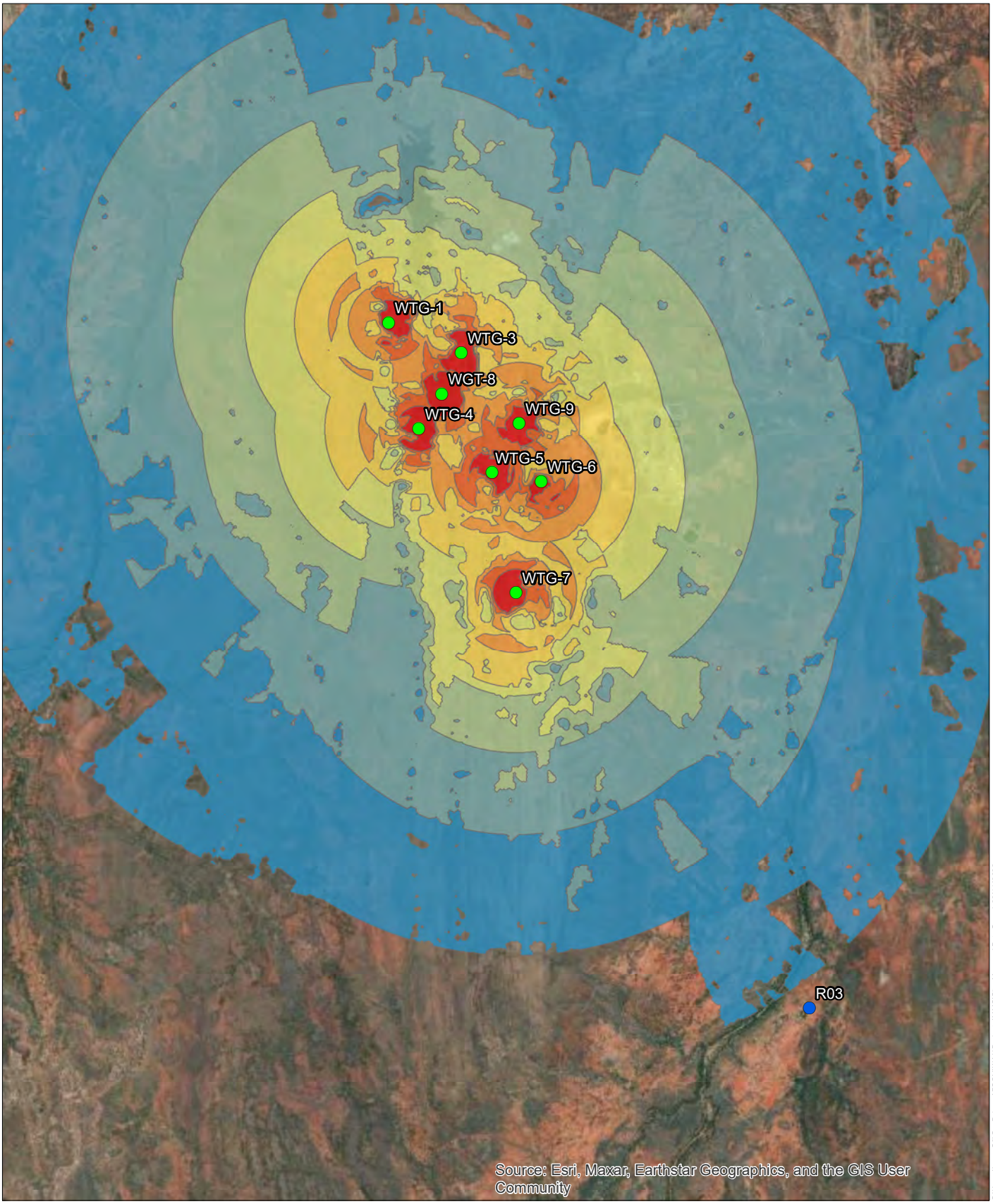
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Dugald River Wind Farm - Construction Scenario 2 - L_{Aeq}

N 0 1 2 km

AECOM

- Noise Sensitive Receptor
- Turbine Locations

Sound Pressure Level, L_{Aeq} dB(A)

20 25 30 35 40 45 50 55

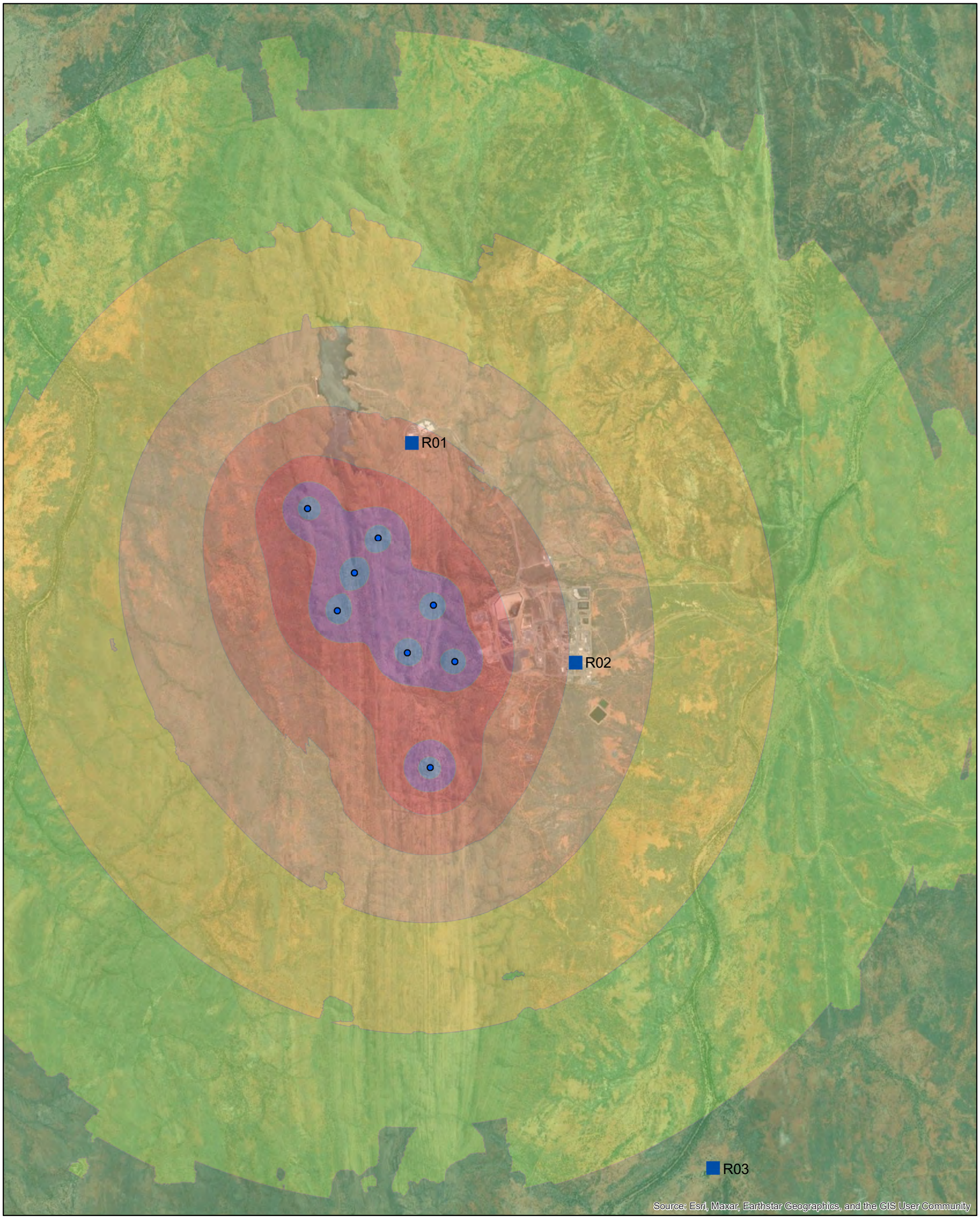
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www.aecom.com

N

DATUM GDA 1994, PROJECTION MGA ZONE 54

0 550 1,100 2,200

metres

1:40,000 (when printed at A3)

Legend

Grid Noise Contours

$L_{Aeq\ 10min}$ dB(A) Noise Levels at 4m above ground

- 0 - 25
- 25 - 30
- 30 - 35
- 35 - 40
- 40 - 45
- 45 - 50
- 50 - 55
- 55 - 60

- Sensitive Receptor
- Wind Turbine (primary)

DISCLAIMER: Map is to be read in conjunction with the Report 60663430-AC-LR-001

Dugald River Wind Farm
Primary Wind Turbines Only
$L_{Aeq\ 10min}$ Noise Contour Map
(Reference Winds Speed: 12m/s at Hub Height)

PROJECT ID	60698169
CREATED BY	OB
LAST MODIFIED	OB - 03 Jul 2023
VERSION:	01

Figure

Appendix C - 01

Filename: C:\Users\AlBusaidiO\OneDrive - AECOM\Dugald River\20230623\04. ArcMap\07 - MXD files\2022 11 03 Overview\02 20230623 Noise Contours 12m_s at 4m Height.mxd

A3 size

4.5.3.5. Cumulative Impacts

No other new or proposed wind farm developments have been identified within the vicinity of the Project that are likely to result in combined or successive noise impacts with the Project (AECOM, 2023).

4.5.4. Noise Management

Noise modelling has predicted that the proposed wind farm will comply with existing EA noise limits as well as the acoustic criteria defined in State Code 23. MMG will continue to implement the DRM Air Quality, Noise and Vibration Management Plan throughout the operation of the wind farm and works related to the other proposed amendments. The current control measures include:

- Conducting routine maintenance on mobile and stationary assets to ensure optimal efficiency;
- Conducting noise monitoring at the sensitive receptors as specified in the EA Schedule F;
- Calibrating, maintaining and servicing noise monitoring equipment and recording all calibration reports; and
- Recording community noise complaints/grievances.

In addition to the existing Air Quality, Noise and Vibration Management Plan, a Construction Management Plan will be developed prior to works commencing on the wind farm. Appropriate stakeholders, including the Roseby Homestead, will be consulted prior to works commencing to address any specific concerns and mitigation measures.

The Construction Management Plan will include the following:

- Description and locations of sensitive land uses that may be affected by noise, vibration and dust emissions from construction.
- Description of the activities and equipment likely to generate noise, vibration, and dust emissions.
- Description of the noise, vibration and dust impact control measures to be implemented to minimise noise, vibration and dust impacts at sensitive receptors.
- Description of the methods to be used to monitoring performance and receive, record, and respond to complaints.

4.5.5. Summary of Noise Impacts

Modelling has predicted that the proposed wind farm will comply with all relevant noise limits and will not result in an environmental nuisance at sensitive receptors. The additional proposed amendments (i.e. vent shaft, groundwater infrastructure, STP etc.) require minimal disturbance and therefore are not expected to result in an environmental nuisance at sensitive receptors. The proposed amendment is low risk to noise.

5. Environmental Risk Assessment

5.1. Overview

An environmental risk assessment has been prepared in relation to the proposed amendment. The risk methodology utilised has been developed based on the Australia and New Zealand Standard AS/NZS for Risk Management – Principles and Guidelines (ISO 31000:2018).

The risk management process involves the systematic application of policies, procedures, and practices to the activities of communicating and consulting, establishing the context and assessing, treating, monitoring, reviewing, recording, and reporting risk (Figure 23).

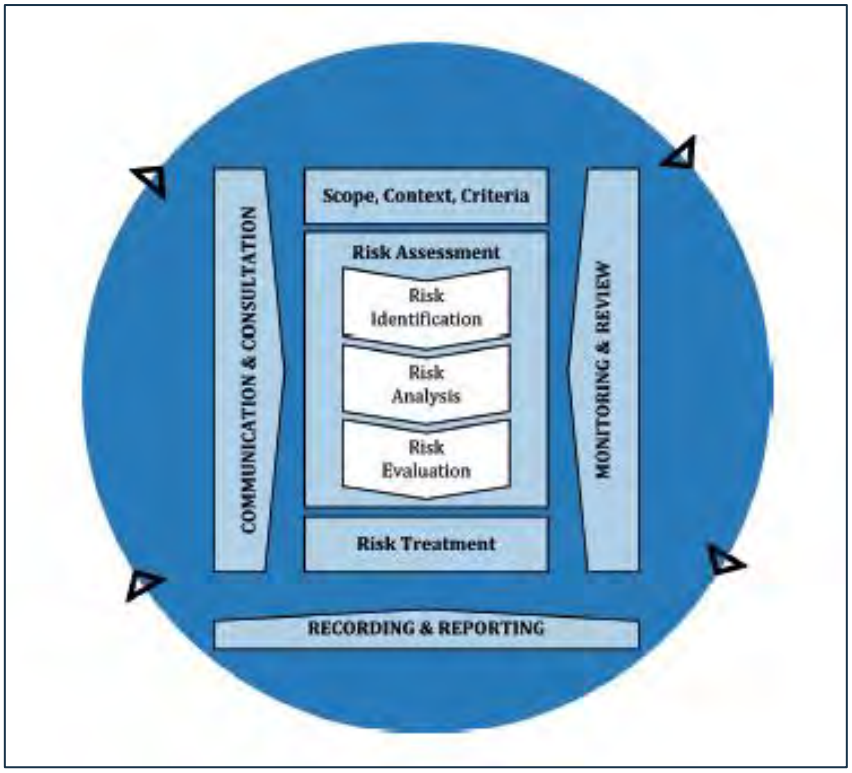


Figure 23. ISO 31000: 2018 Risk management process

5.1.1. Risk Identification

The purpose of risk identification is to find, recognise and describe risks that might help or prevent an organisation achieving its objectives. Relevant, appropriate and up-to-date information is important in identifying risks (Standards Australia 2018).

The following factors and the relationships among these factors have been considered by this risk assessment:

- Tangible and intangible sources of risk;
- Causes and events;

- Threats and opportunities;
- Vulnerabilities and capabilities;
- Changes in the external and internal context;
- Indicators or emerging risks;
- The nature and value of assets and resources;
- Consequences and their impacts on objectives;
- Limitations of knowledge and reliability of information;
- Time-related factors; and
- Biases, assumptions, and beliefs of those involved.

5.1.2. Risk Analysis and Evaluation

The purpose of risk analysis is to comprehend the nature of risk and its characteristics, including, where appropriate, the level of risk. Risk analysis can be undertaken with varying degrees of detail and complexity, depending on the purpose of the analysis, the availability and reliability of information and the resources available. Risk analysis techniques can be qualitative, quantitative or a combination of these and should include:

- The likelihood of events and consequences;
- The nature and magnitude of consequences;
- Complexity and connectivity;
- Time-related factors and volatility;
- The effectiveness of existing controls; and
- Sensitivity and confidence levels.

A likelihood of occurrence and severity of consequence rating has been assigned to each identified risk in accordance with the risk matrix detailed in Table 41. Control measures have been developed following the identification of risks to achieve a level of risk that is considered to be an acceptable level, as described in Table 42.

Table 41. Risk matrix

Likelihood of Occurrence	Severity of Consequence				
	Catastrophic (5)	Major (4)	Moderate (3)	Minor (2)	Insignificant (1)
Almost certain (5)	10	9	8	7	6
Likely (4)	9	8	7	6	5
Possible (3)	8	7	6	5	4
Unlikely (2)	7	6	5	4	3
Rare (1)	6	5	4	3	2

Table 42. Risk scores

Risk Score	Risk Rating	Actions Required
9 – 10	Extreme	Requires immediate action to reduce risk score.
7 – 8	High	Requires an action plan approved by senior management.
5 – 6	Moderate	Specific monitoring and procedures required.
2 – 4	Low	Management through routine procedures and protocols.

5.1.3. Risk Assessment Results

Risks identified were assessed using the methodology described above. Thirteen risks were identified with ten rated as ‘Low’, and three rated as ‘Moderate’. All risks considered the existing and proposed controls to reduce the level of risk to as low as reasonably practicable. Control strategies are reflected in Table 43.

Table 43. Risk assessment

Aspect	Potential Impact	Risk Rating			Risk Controls	Residual Risk Rating			Treatment	Comments
		L	C	R		L	C	R		
Land	Excessive clearing of vegetation and/or PNRW habitat	3	4	7	Provide work crews with accurate mapping of activities, access routes and designed disturbance area. Survey and peg disturbance areas prior to works commencing. Regular visual inspection of disturbance area to ensure clearing has been minimised. Minimise open disturbed areas to the smallest practical areas when conducting clearance works. Construct wind farm as per proposed design, that limits surface disturbance to the smallest possible footprint.	2	4	6	Conduct activities in accordance with DRM Land Clearance and Disturbance Permitting Procedure	SRI has determined unlikely impact to PNRW from clearing.
	Impact to terrestrial fauna through operation of the wind turbines.	3	3	6	Construct wind farm as per proposed design, that limits surface disturbance to the smallest possible footprint. Continue to implement the PNRM Monitoring Program. Complete annual noise monitoring.	1	3	4		

Aspect	Potential Impact	Risk Rating			Risk Controls	Residual Risk Rating			Treatment	Comments
		L	C	R		L	C	R		
					Transport to site limited to the proposed roads. Steep slopes prevent vehicles travelling at high speeds. Maintain clearance around turbines to limit regrowth and potential foraging habitat for fauna. Develop an Adaptive Management Framework that describes the triggers and measures to be taken if a residual impact is observed.					
	Impact to aerial fauna via direct strike, barotrauma or noise and vibration.	4	3	7	Construct wind farm as per proposed design, that limits RSA to the smallest possible footprint. Continue with biannual BBUS monitoring and reporting. Conduct carrion monitoring in accordance with bird and bat management plan. Remove carcasses to prevent predator attraction. Maintain clearance around turbines to limit regrowth and potential foraging habitat for fauna.	2	4	6		

Aspect	Potential Impact	Risk Rating			Risk Controls	Residual Risk Rating			Treatment	Comments
		L	C	R		L	C	R		
					Develop an Adaptive Management Framework that describes the triggers and measures to be taken if a residual impact is observed. Investigate acoustic deterrents if triggered by adaptive management plan.					
	Introduction of spread of invasive flora	3	3	6	Conduct weed surveys of the disturbance areas prior to commencement. Continue to implement the DRM Weed and Pest Management Plan. New equipment deliveries and construction personnel to ensure weed hygiene procedures are implemented. Weed hygiene declarations to be completed and provided with each vehicle accessing DRM.	1	3	4	Conduct activities in accordance with DRM Weed and Pest Management Plan.	
	Impact to Category B ESA by reducing buffer from 500 m to 50 m	3	3	6	Conduct ground truthing surveys ESA before commencing work within 50 – 500 m of a mapped ESA.	1	3	4	Conduct activities in accordance with DRM Land Clearance and	The only ESA on DRM is RE 1.3.7. This RE is allocated a Biodiversity Status of endangered due

Aspect	Potential Impact	Risk Rating			Risk Controls	Residual Risk Rating			Treatment	Comments
		L	C	R		L	C	R		
					Provide work crews with accurate mapping of activities, access routes and designed disturbance area. Survey and peg disturbance areas prior to works commencing. Regular visual inspection of disturbance area to ensure clearing has been minimised.				Disturbance Permitting Procedure	to its importance as seasonal water bird habitat and a regional corridor for fauna. Exploration activities will not affect the RE in relation to its provision as a season water bird habitat and corridor for fauna.
	Release of contaminants to land from sewage effluent	2	3	5	Treat sewage to Class A standard prior to use in dust suppression or transfer to STP dams. Continue watering practices in a manner that prevents ponding. Continue to operate STP dams in a manner than prevents release to environment eg. maintaining additional capacity in STP dam 1. Continue to implement inspection and maintenance program on STP, pipelines and bunding. Conduct water release and monitoring processes in accordance with the EA	1	3	4	Conduct activities in accordance with the DRM Sewage Management Plan.	

Aspect	Potential Impact	Risk Rating			Risk Controls	Residual Risk Rating			Treatment	Comments
		L	C	R		L	C	R		
Water	Increased erosion. Surface water runoff from disturbance areas discharging into the receiving environment resulting in release of contaminants.	3	3	6	Conduct construction works during the dry season where possible. Ensure topsoil resources stockpiled are placed away from drainage areas. Trap sediment laden water prior to discharging into the receiving environment.	2	2	4	Conduct activities in accordance DRM Erosion and Sediment Control Plan. Develop a Construction Management Plan prior to works commencing on the wind farm.	
	Disturbance to drainage lines from access roads. Increased erosion.	3	3	6	Construct wind farm as per proposed design, that limits surface disturbance to the smallest possible footprint. Construct bed level crossings across drainage line. Implement erosion and sediment control measures. Continue monitoring at REMP locations.	1	3	4	Conduct activities in accordance DRM Erosion and Sediment Control Plan. Develop a Construction Management Plan prior to works commencing on the wind farm. Construct and maintain crossings in accordance with the *Accepted development requirements for operational work that is constructing or raising waterway barrier work*	

Aspect	Potential Impact	Risk Rating			Risk Controls	Residual Risk Rating			Treatment	Comments
		L	C	R		L	C	R		
									(Department of Agriculture and Fisheries, 2018).	
	Release of contaminants from effluent to waterways	3	3	6	Treat sewage to Class A standard prior to use in dust suppression or transfer to STP dams. Continue watering practices in a manner that prevents ponding. Continue to operate STP dams in a manner than prevents release to environment eg. maintaining additional capacity in STP dam 1. Continue to implement inspection and maintenance program on STP, pipelines and bunding. Conduct water release and monitoring processes in accordance with the EA.	1	3	4		
	Aluminium concentrations, resulting in environmental harm to receiving waters.	3	3	6	Continue monitoring for aluminium. Conduct data analysis to review trends in aluminium concentrations.	1	3	4		Historical monitoring indicates little difference in aluminium concentrations

Aspect	Potential Impact	Risk Rating			Risk Controls	Residual Risk Rating			Treatment	Comments
		L	C	R		L	C	R		
					Continue to investigate and report on exceedances of proposed aluminium triggers and limits.					downstream of DRM, compared to upstream.
	Undetected cyanide in waters, resulting in environmental harm.	1	1	2	Continue to conduct processing activities, without cyanide. If cyanide is to be introduced to DRM, reinstate cyanide monitoring.	1	1	2		
Waste	Incorrect storage or disposal of waste leading to contamination.	2	2	4	Continue waste storage, transport and disposal as per existing waste management procedures. Consult manufacturers specifications and technical guidance from third party contractors to identify recycling options and correct waste disposal. Monitoring frequency of waste servicing and increase as required. Provide appropriate waste receptables for any maintenance works or shutdowns as required.	1	2	3		
Air	Emissions to air resulting in nuisance at a sensitive receptor.	3	2	5	Maintain clearance areas to as small as practicable. Conduct routine air quality monitoring.	2	2	4	Conduct activities in accordance DRM Air Quality, Noise and	

Aspect	Potential Impact	Risk Rating			Risk Controls	Residual Risk Rating			Treatment	Comments
		L	C	R		L	C	R		
					Maintain unsealed roads using relevant dust suppression methods. Timely rehabilitation of disturbed surfaces. Develop a Construction Management Plan prior to works commencing on the wind farm. Maintain open communication with the Roseby Homestead.				Vibration Management Plan.	
Noise	Increase in noise at sensitive receptor.	2	2	4	Conduct routine maintenance on mobile and stationary assets to ensure optimal efficiency. Record and investigate community noise complaints/grievance. Conduct noise monitoring as required. Maintain open communication with the Roseby Homestead.	1	3	3	Conduct activities in accordance DRM Air Quality, Noise and Vibration Management Plan.	Noise modelling has determined that all noise guidelines will be achieved.

6. Conclusions and Recommendations

This report is submitted to the DES in support of MMG Dugald River Pty Ltd.'s application for a major EA amendment to EA EPML00731213 for the Dugald River Mine and provides a detailed response to the following guidelines:

- *Approval processes for Environmental Authorities* (DES 2019b).
- *Application requirements for activities with impacts to air* (DES 2017a).
- *Application requirements for activities with impacts to land* (DES 2017b).
- *Application requirements for activities with impacts to water* (DES 2017c).
- *Application requirements for activities with noise impacts* (DES 2017d).
- *Application requirements for activities with waste impacts* (DES 2019a).

Risks were assessed in accordance with ISO 31000:2018. Thirteen risks were identified with ten rated as 'Low', and three rated as 'Moderate'. All risks considered the existing and proposed controls to reduce the level of risk to as low as reasonably practicable. Control strategies are reflected in supporting information contained within this document.

It is recommended that this application for the major amendment for EA EPML00731213 be accepted with appropriate and reasonable conditions.

7. References

AARC 2010a, *Dugald River Project Soil and Land Suitability Assessment*, Prepared for MMG Limited, AustralAsian Resource Consultants.

AARC 2010b, *Dugald River Environmental Impact Assessment*, Prepared for MMG Limited, AustralAsian Resource Consultants.

AECOM 2023, *Dugald River Mine Wind Farm - Construction, Operational and Decommissioning Predicted Noise Levels*, Prepared for MMG Dugald River Mine Pty Ltd

ATC Williams 2021, *Dugald River Tailings Storage Facility Operation Plan*, Ref:108003.24-PL01, dated 7 May 2021.

ATC Williams 2022, *Dugald River Mine Tailings Storage Facility Design Storage Allowance Review*, Ref:108003.60.R01_a, dated 15 November 2021.

Australian National Committee on Large Dams (ANCOLD) 2019, *Guidelines on Tailings Dams – Planning, Design, Construction, Operation and Closure*, Rev. 1, July 2019.

Brett Lane & Associates Pty Ltd. (2005). *Wind Farms and Birds: Interim Standards For Risk Assessment.* Carlton North: Australian Wind Energy Association.

Bureau of Meteorology (BOM) 2023, Climate Statistics for Australian locations – Cloncurry Airport (029141), viewed 10 January 2023, <http://www.bom.gov.au/climate/averages/tables/cw_029141.shtml>

CDM Smith 2019, *Dugald River Mine Biennial Groundwater Review*, Prepared for MMG Limited, CDM Smith.

CDM Smith 2021, *Dugald River Mine Biennial Review of Groundwater Monitoring Data: 2019-2020*, Prepared for MMG Limited, CDM Smith.

Department of Agriculture Water and the Environment (DAWE) 2022, Protected Matters Search Tool, viewed 13 January 2023 <https://www.environment.gov.au/epbc/protected-matters-search-tool>.

Department of Environment and Science (DES) 2017a, *Application requirements for activities with impacts to air*, 4.03 ed.

Department of Environment and Science (DES) 2017b, *Application requirements for activities with impacts to land*, 4.02 ed.

Department of Environment and Science (DES) 2017c, *Application requirements for activities with impacts to water*, 4.02 ed.

Department of Environment and Science (DES) 2017d, *Application requirements for activities with noise impacts*, 3.04 ed.

Department of Environment and Science (DES) 2019a, *Application requirements for activities with waste impacts*, 5.01 ed.

Department of Environment and Science (DES) 2022, 'Environmental Authority EPML00731213' MMG Dugald River Pty Ltd, dated 19 December 2022.

Department of Environment and Science (DES) 2019b. Approval processes for environmental authorities. 5.00 ed.

Isbell, R 2021, *The Australian Soil Classification*, National Committee on Soil and Terrain.

EGI 2011, *Dugald River Project QLD Assessment of the Geochemical Characterisitics and ARD Potential of Waste Rock for the Dugald River Zinc, Lead and Silver Deposit*, prepared fo Rmmg Dugald River Pty Ltd, Environmental Geochemistry International Pty Ltd.

Environmental Protection Act 1994 (Qld) (a), *Manual for assessing consequence categories and hydraulic performance of structures*, Effective 29 March 2016

Environmental Protection Act 1994 (Qld) (b), *Environmental Protection (Water and Wetland Biodiversity) Policy 2019*, Curent as at 1 September 2019.

ERM 2019, *MMG Dugald River Mine – Air Monitoring Locations review*, Prepared for MMG Dugald.

River Pty Ltd.

Queensland Government 2023, Queensland Globe, viewed 17 January 2023 <https://qldglobe.information.qld.gov.au/>

SGM 2021, *Progressive Rehabilitation and Closure Plan Dugald River Mine*, Prepared for MMG Dugald River Pty Limited, SGM Environmental Pty Limited.

Standards Australia 2018, *Risk management – Guidelines* (ISO31000: 2018), Retrieved from SAI Global.

Threatened Species Scientific Committee 2019, *Listing Advice – Pseudantechinus mimulus – Carpentarian Antechinus*, viewed 17 January 2023 <chrome-extension://efaidnbmnnnibpcajpcglclefindmkaj/http://www.environment.gov.au/biodiversity/threatened/species/pubs/59283-listing-advice-22022019.pdf>.

WRM 2010, *Dugald River Project Surface Water Assessment*, WRM Water & Environment Pty Ltd.

Wulguru Technical Services Pty Ltd 2021, *Dugald River Mine – Environmental Authority Amendment – Supporting Information*, Prepared by Wulguru Technical Services Pty Ltd for MMG Dugald River Pty Ltd.

Wulguru Technical Services, 2023, *MMG - Dugald River Windfarm Ecological Assessment Report*, Prepared by Wulguru Technical Services Pty Ltd for MMG Dugald River Pty Ltd.

APPENDIX A: Proposed Environmental Authority EPML00731213

Permit

Environmental Protection Act 1994

Environmental authority EPML00731213

This environmental authority is issued by the administering authority under Chapter 5 of the Environmental Protection Act 1994.

Environmental authority number: EPML00731213

Environmental authority takes effect on 19 December 2022.

Environmental authority holder(s)

Name(s)	Registered address
MMG Dugald River Pty Ltd	Level 23, 28 Freshwater Place SOUTHBANK VIC 3006.

Environmentally relevant activity and location details

Environmentally relevant activity/activities	Location(s)		
8-(1) Chemical storage >50t class 1 or 2 8-(3) Chemical storage >500m^3 class C1 or C2 8-(4) Chemical storage >200t solids or gases 15-Fuel burning >500kg per hr 16-(2c) Extractive >1,000,000t per yr 16-(3c) Screening >1,000,000t per yr 31-(2b) Mineral processing >100,000t per yr 33-Crushing, milling, grinding or screening >5,000t per yr 63-(1b)(i) Sewage treatment >100 to 1500EP - IT or IR 63-(1b)(ii) Sewage treatment >100 to 1500EP - no IT or IR Mining - ML gold ore - 16, Site Specific Mining - ML copper ore - 17, Site Specific Mining - ML lead, silver or zinc - 18, Site Specific	MDL79 ML2467 ML2468 ML2469 ML2470 ML2471 ML2477 ML2478 ML2479 ML2480 ML2481 ML2482 ML2496 ML2497 ML2498 ML2499 ML2500 ML2501	ML2502 ML2556 ML2557 ML2558 ML2559 ML2596 ML2599 ML2601 ML2638 ML2684 ML2685 ML7496 ML90047 ML90049 ML90050 ML90051 ML90211 ML90212	ML90213 ML90218 ML90220 ML90230 ML90237

Additional information for applicants

Environmentally relevant activities

The description of any environmentally relevant activity (ERA) for which an environmental authority (EA) is issued is a restatement of the ERA as defined by legislation at the time the EA is issued. Where there is any inconsistency between that description of an ERA and the conditions stated by an EA as to the scale, intensity or manner of carrying out an ERA, the conditions prevail to the extent of the inconsistency.

An EA authorises the carrying out of an ERA and does not authorise any environmental harm unless a condition stated by the EA specifically authorises environmental harm.

A person carrying out an ERA must also be a registered suitable operator under the *Environmental Protection Act 1994* (EP Act).

Contaminated land

It is a requirement of the EP Act that an owner or occupier of contaminated land give written notice to the administering authority if they become aware of the following:

- the happening of an event involving a hazardous contaminant on the contaminated land (notice must be given within 24 hours); or
- a change in the condition of the contaminated land (notice must be given within 24 hours); or
- a notifiable activity (as defined in Schedule 3) having been carried out, or is being carried out, on the contaminated land (notice must be given within 20 business days)

that is causing, or is reasonably likely to cause, serious or material environmental harm.

For further information, including the form for giving written notice, refer to the Queensland Government website www.qld.gov.au, using the search term 'duty to notify'.

Take effect

Please note that, in accordance with section 200 of the EP Act, an EA has effect:

a) if the authority is for a prescribed ERA and it states that it takes effect on the day nominated by the holder of the authority in a written notice given to the administering authority-on the nominated day; or

b) if the authority states a day or an event for it to take effect-on the stated day or when the stated event happens; or

c) otherwise- one the day the authority is issued.

However, if the EA is authorising an activity that requires an additional authorisation (a relevant tenure for a resource activity, a development permit under the *Planning Act 2016* or an SDA Approval under the *State Development and Public Works Organisation Act 1971*), this EA will not take effect until the additional authorisation has taken effect.

If this EA takes effect when the additional authorisation takes effect, you must provide the administering authority written notice within 5 business days of receiving notification of the related additional authorisation taking effect.

If you have incorrectly claimed that an additional authorisation is not required, carrying out the ERA without the additional authorisation is not legal and could result in your prosecution for providing false or misleading information or operating without a valid environmental authority.

	19/12/2022
Signature	Date

Rebecca McAuley
Department of Environment and Science
Delegate of the administering authority
Environmental Protection Act 1994

Enquiries:
Mineral Business Centre
PO Box 7230, Cairns QLD 4870
Phone: (07) 4222 5352
Email: ESCairns@des.qld.gov.au

Obligations under the *Environmental Protection Act 1994*

In addition to the requirements found in the conditions of this environmental authority, the holder must also meet their obligations under the EP Act, and the regulations made under the EP Act. For example, the holder must comply with the following provisions of the Act:

- general environmental duty (section 319)
- duty to notify environmental harm (section 320-320G)
- offence of causing serious or material environmental harm (sections 437-439)
- offence of causing environmental nuisance (section 440)
- offence of depositing prescribed water contaminants in waters and related matters (section 440ZG)
- offence to place contaminant where serious or material environmental harm may be caused (section 443)
- offence to place contaminant where environmental nuisance may be caused (section 443A)

Other permits required

This permit only provides an approval under the *Environmental Protection Act 1994*. In order to lawfully operate you may also require permits / approvals from your local government authority, other business units within the department and other State Government agencies prior to commencing any activity at the site. For example, this may include permits / approvals with your local Council (for planning approval), the Department of Transport and Main Roads (to access state controlled roads), the Department of Natural Resources and Mines (to clear vegetation), and the Department of Agriculture and Fisheries (to clear marine plants or to obtain a quarry material allocation).

Obligations under the *Mining and Quarrying Safety and Health Act 1999*

If you are operating a quarry, other than a sand and gravel quarry where there is no crushing capability, you will be required to comply with the *Mining and Quarrying Safety and Health Act 1999*. For more information on your obligations under this legislation contact Mine Safety and Health at www.dnrm.qld.gov.au, or phone 13 QGOV (13 74 68) or your local Mines Inspectorate Office.

Conditions of environmental authority

This **environmental authority** incorporates the following schedules:

Schedule A - General
Schedule B - Air
Schedule C - Water
Schedule D - Regulated Structures
Schedule E - Sewage Treatment
Schedule F - Noise and Vibration
Schedule G - Non-Mineral Waste
Schedule H - Mineral Waste
Schedule I - Land and Rehabilitation
Schedule J - Definitions
Schedule K - Figures

Schedule A – General

Activity

A1 This environmental authority authorises environmental harm referred to in the conditions. Where there is no condition or this environmental authority is silent on a matter, the lack of a condition or silence does not authorise environmental harm.

A2 In carrying out the mining activity the holder of this environmental authority must comply with Schedule A – Table 1 (Authorised Mining Activities) and Schedule K – Figure 1a (Project Infrastructure Layout – Mine Infrastructure Area), Schedule K – Figure 1b (Project Infrastructure Layout – TSF and Accommodation Village) and Schedule K - Figure 1c (Project Infrastructure Layout – Support Infrastructure).

Schedule A – Table 1 (Authorised Mining Activities)

Mine Domain	Mine Feature Name	Location (GDA94 MGA z54)		Maximum Disturbance Area (hectares)	Constraints
		Easting	Northing		
Ancillary Infrastructure and Services	Accommodation Village and sewage treatment plant	410282	7762986	24.3	
	Pipeline and Accommodation Village Road	-	-	6	
	Communications tower	410265	7762672	0.06	
	Powerline	-	-	675	
	Raw water pipeline	-	-	12.7	
	Roads and Tracks	-	-	66.4	
	Groundwater infrastructure	-	-	0.54	
Borrow Pits & Stockpiles	Borrow Pit/Topsoil Stockpile, Borrow Pit A, and Topsoil Stockpile A	411283	7759760	16.98	
	Borrow Pit B	411092	7760669	2.5	
	Borrow Pit C1	411171	7761447	1.1	
	Borrow Pit C2	411154	7761268	1.8	
	Access Road Borrow Pit(s)	-	-	5	
	TSF Borrow Pit A	408393	7762874	8.3	
	TSF Borrow Pit B	408405	7763128		
	TSF Stockpile	408448	7762900		
	Topsoil Stockpile B	412073	7761399	9.7	
	Spoil Stockpile 1	411945	7760871	0.65	
	Spoil Stockpile 2	411873	7761152	1.5	
Dams and Diversion Structures	Diversion Drains	-	-	2	
	Stage 1 PAF PAD Run Off Dam	411483	7760727	2.25	Dam constructed in accordance with conditions specified in Schedule D of this environmental authority.
	Stage 2 PAF PAD Run Off Dam	411271	7760924	11.7	
	Underground Mine Water Collection Dam	411632	7760659	0.65	

Mine Domain	Mine Feature Name	Location (GDA94 MGA z54)		Maximum Disturbance Area (hectares)	Constraints
		Easting	Northing		
	STP Dam Stage 1	412389	7759783	0.9	
	STP Dam Stage 2	412328	7759645	4	
	ROM Area Run Off Dam	412175	7761066	3.7	
	Raw Water Dam	412153	7760929	1.8	
	Sediment Dam A	412172	7760845	1.1	
	Process Plant Run Off Dam	412176	7760751	1.5	
	Containment Dam	412091	7760745	0.6	
	Mine Workshop Run Off Dam	411989	7760058	0.6	
	Sediment Dam C	412224	7750313	4.5	
	Sediment Dam D	412336	7759989	3.5	
	Sediment Dam F	411592	7760144	1.4	
	Sediment Dam G	411459	7761074	1.4	
Exploration	Drill Pads	-	-	10	Exploration activities must be consistent with conditions A33 and A34 of this environmental authority ~~and the current Plan of Operations~~.
Mineralised Waste	NAF waste rock dump	411393	7760288	8	Maximum disturbance area relates to the disturbance authorised during the operation of the mine. Only non-acid forming waste rock is authorised to be placed in NAF waste rock dump. Where possible non-acid forming waste rock will be used in rehabilitation and only in accordance with the conditions of this environmental authority. Maximum disturbance area relates to the disturbance authorised during the operation of the mine. All potentially acid forming rock must be returned to the void at the end of mine life.
	NAF waste rock dump bund	-	-		
	PAF waste rock dump (Stage 1)	411492	7760604	1.6	
	PAF waste rock dump (Stage 1 Extension)	411270	7760598	1.1	
	PAF waste rock dump (Stage 2)	411512	7760518	9.5	
Mining and Processing Area	West Laydown Area	411157	7760276	10.3	
	Waste Transfer Station	411476	7759611	0.25	
	Explosives magazine	411554	7759189	0.6	
	Fuel Storage	411958	7760396	0.2	
	Temporary Waste Laydown	412193	7759618	1	
	Construction Laydown, Warehouse, Mobile Equipment Laydown and Core Shed	-	-	6.8	
	North decline	411699	7760952	1	
	South decline	411813	7760628	1	
	Ventilation shaft 1	411582	7761135	0.05	
	Ventilation shaft 2	411532	7761107	0.05	

Mine Domain	Mine Feature Name	Location (GDA94 MGA z54)		Maximum Disturbance Area (hectares)	Constraints
		Easting	Northing		
	Ventilation shaft 3	411590	7761068	0.05	
	Ventilation shaft 4	411775	7760549	0.05	
	Ventilation shaft 5	411801	7760484	0.05	
	Ventilation shaft 6	411866	7760294	0.05	
	Ventilation shaft 7	411834	7760290	0.05	
	Ventilation shaft 8	411878	7760205	0.05	
	Ventilation shaft 9	411466	7761320	0.549 5	
	Run of Mine (ROM) Pad	411882	7760964	3.8	
	ROM Haul Roads	-	-	3.6	
	Processing Plant and Conveyor Area	411986	7760590	14.3	
	Switchyard 1	412170	7760656	1.04	
	Switchyard 2	411878	7760073	1.00.9 9	
	Exploration camp, Sewage Treatment Plant and Camp Expansion Works	412173	7760344	3	
	Sewage Treatment Plants	412060	7760070	0.38	
	Workshop, Vehicle Washdown and Maintenance Area	411963	7760191	3.8	
	Office & Administration Buildings	412232	7760234	3.6	
	Laydown	411582	7760535	6.56.47	
Tailings Storage Facility (TSF)	TSF and Seepage Collection Pond	409197	7763517	207	Dam constructed in accordance with conditions specified in Schedule D of this environmental authority
	TSF Pipelines and Roads	-	-	5.7	
Renewables	Wind farm and ancillary infrastructure	-	-	29.73	
	Laydown West		-	6.30	
	Access Roads	-	-	32.32	

A3 Notwithstanding condition A2, infrastructure that has the potential to contaminate groundwater must not be constructed within fifty (50) metres of Silvermine Creek or North Creek.

A4 Access to the licensed place via land authorised for that purpose by the *Mineral Resources Act 1989* is subject to the conditions of this environmental authority.

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Maintenance of Measures, Plant and Equipment

A5 The holder of this environmental authority must:

(a) install all measures, plant and equipment necessary to ensure compliance with the conditions of this environmental authority;

(b) maintain such measures, plant and equipment in a proper condition; and

(c) operate such measures, plant and equipment in a proper manner.

A6 No change, replacement or alteration of any plant or equipment is permitted if the change, replacement or alteration increases, or is likely to increase, the risk of environmental harm.

Monitoring and Reporting

A7 Any management or monitoring plans, systems, programs or reports required to be developed and implemented by a condition of this environmental authority must be reviewed for effectiveness in minimising the likelihood of environmental harm every 3 years and amended immediately if required. The review must be documented and completed by an appropriately qualified person.

A8 Monitoring records or reports required under this environmental authority must be maintained and be readily accessible at the licensed place or at another location agreed to in writing by the administering authority for a period of not less than seven (7) years.

A9 The holder of this environmental authority must upon request from the administering authority, supply monitoring records, plans and reports in the form and by the means requested by the administering authority within five (5) business days.

A10 All monitoring referred to in this environmental authority must be undertaken by an appropriately qualified person using monitoring equipment that is accurately calibrated and maintained in accordance with the manufacturer's specifications.

A11 All analyses and tests required to be conducted under this environmental authority must be carried out by a laboratory that has NATA accreditation for such analyses and tests, except as otherwise authorised by the administering authority.

A12 The holder of this environmental authority must make reasonable efforts to provide safe and all-weather access to all monitoring locations required under this environmental authority where practicable and safe to do so. This includes:

(a) providing appropriate site infrastructure to gain safe all-weather access to monitoring locations during reasonably foreseeable events, where practicable and safe to do so; and

(b) developing and implementing contingency plans to facilitate sampling during extreme events where provision of site infrastructure is not safe or practical.

Risk Management

A13 The holder of this environmental authority must develop and implement a risk management system for mining activities which conforms to the latest edition of the Australian Standard for Risk Management.

Emergency Response / Contingency

A14 The holder of this environmental authority must implement and maintain an emergency response/contingency plan to respond to any emergency event or incident.

A15 The emergency response/contingency plan required under condition ~~A17~~ A14 must address the following matters as a minimum:

(a) response procedures to be implemented to prevent or minimise the risk of environmental harm arising from any emergency event or incident;

(b) response procedures to minimise the extent and duration of environmental harm caused by any emergency event or incident;

(c) the practices and procedures to be employed to restore the environment or mitigate any environmental harm caused by any emergency event or incident;

(d) the resources to be used in response to any emergency event or incident;

(e) procedures to investigate the cause of any emergency event or incident and where necessary, implement remedial actions to reduce the likelihood of recurrence of similar emergency event or incident;

(f) the provision and availability of documented procedures to staff attending any emergency event or incident to enable them to effectively respond;

(g) training of staff that will be called upon to respond to any emergency event or incident to enable them to effectively respond;

(h) timely and accurate reporting of the circumstance and nature of any emergency event or incident to the administering authority in accordance with conditions of this environmental authority;

(i) procedures for accessing monitoring points during any emergency event or incident; and

(j) procedures to notify any potentially impacted stakeholder who may be affected by the emergency event or incident.

Notification of Incidents, Exceedances and Releases

A16 The holder of this environmental authority must notify the administering authority by written notification within 24 hours, after becoming aware of any emergency or incident which results in the release of contaminants not in accordance, or reasonably expected to be not in accordance with, the conditions of this environmental authority.

A17 The notification in condition A16 must include, but not be limited to, the following:

(a) the environmental authority number and name of the holder of this environmental authority;

(b) the name and telephone number of the designated contact person;

(c) the location of the incident, exceedance or release;

(d) the date and time of the incident, exceedance or release;

(e) the time the holder of this environmental authority became aware of the incident, release or exceedance;

(f) where known:

(a) the estimated quantity and type of substances involved in the incident, exceedance or release;

(b) the actual or potential cause of the incident, release or exceedance; and

(c) a description of the nature and effects of the incident, exceedance or release including environmental risks and any risks to public health or livestock.

(g) any sampling conducted or proposed, relevant to the incident, exceedance or release;

(h) immediate actions taken to prevent or mitigate any further environmental harm caused by the incident, exceedance or release; and

(i) what notification of stakeholders who may be affected by the incident, exceedance or release has occurred/is being undertaken.

A18 The holder of this environmental authority must notify the occupiers or registered owners of affected land and any other potentially impacted stakeholder as soon as reasonably practicable after becoming aware of any incident, exceedance or release that has the potential to impact on environmental values or breaches any condition of this environmental authority concerning releases of contaminants to the environment.

A19 The notification in condition A18 must include the following:

(a) the location of the incident, exceedance or release;

(b) the date and time of the incident, exceedance or release;

(c) the estimated quantity and type of any substances involved in the incident, exceedance or release;

(d) the potential impacts to environmental values caused by the incident, exceedance or release; and

(e) where there is potential impact on livestock or human health, precautionary measures that will be taken.

A20 Within ten (10) business days following the initial notification of an incident, exceedance or release, or receipt of monitoring results, whichever is the latter, further written advice must be provided to the administering authority, including the following:

(a) results and interpretation by an appropriately qualified person of any samples taken and analysed;

(b) outcomes of actions taken at the time of the incident, release or exceedance to prevent or minimise unlawful environmental harm; and

(c) outcomes of actions to prevent a recurrence of the incident, exceedance or release.

Complaints

A21 The holder of this environmental authority must record all environmental complaints received about the mining activity including the following details:

(a) name, address and contact number for complainant;

(b) time and date of complaint;

(c) reasons for the complaint;

(d) investigations undertaken;

(e) conclusions formed;

(f) actions taken to resolve complaint;

(g) any abatement measures implemented; and

(h) person responsible for resolving the complaint.

A22 The holder of this environmental authority must, when requested by the administering authority, undertake relevant specified monitoring within a reasonable timeframe nominated or agreed to by the administering authority to investigate any complaint of environmental harm. The results of the investigation (including an analysis and interpretation of the monitoring results) and abatement measures, where implemented must be provided to the administering authority within 10 business days of completion of the investigation, or no later than 10 business days after the end of the timeframe nominated by the administering authority to undertake the investigation.

Community

A23 The holder of this environmental authority must establish, promote and maintain easily accessible lines of communication between residents, stakeholders and land owners, reasonably expected to be affected by the mining activity to ensure that environmental impacts are identified and managed. This must include but not be limited to the following:

(a) regular meetings with all residents, stakeholders and land owners, at intervals of not more than six (6) months; and

(b) the establishment of a consultative committee with representation open for all residents, stakeholders and land owners, that meets at regular intervals as determined by the committee.

Third Party Auditing

A24 The holder of this environmental authority must:

(a) By 1 June 2023, obtain from an appropriately qualified person a report on compliance with the conditions of this environmental authority

(b) obtain further such reports at regular intervals, not exceeding three yearly, from the completion of the report referred to above

(c) provide each report to the administering authority within 90 days of its completion.

Exploration

A25 All exploration activities carried out at the licensed place must comply with each of the Standard Environmental Conditions contained in the most recent version of the *Eligibility criteria and standard conditions for exploration and mineral development projects.* ~~*Code of Environmental Compliance for exploration and mineral development projects.*~~

A26 Disturbance due to exploration activities in areas not scheduled to be mined within twelve (12) months must be rehabilitated in accordance with the provisions detailed in the administering authority's *Eligibility criteria and standard conditions for exploration and mineral development projects.* ~~*Code of Environmental Compliance for Exploration and Mineral Development Projects.*~~

A27 Where a condition of this environmental authority refers to a matter addressed in the *Eligibility criteria and standard conditions for exploration and mineral development projects.* ~~*Code of Environmental Compliance for Exploration and Mineral Development Projects,*~~ the condition of this environmental authority prevails.

NEW The holder of the environmental authority must not carry out activities in a category A or B environmentally sensitive area. Activities involving machinery must not be carried out within 1km of a category an environmentally sensitive area or within 50 m of a category B environmentally sensitive area.

Transition to New Standards

A28 Where a condition of this environmental authority requires compliance with a standard, guideline or relevant legislation published externally to this environmental authority and the standard, guideline or relevant legislation is amended or changed subsequent to the issues of this environmental authority the holder of this environmental authority, unless otherwise agreed to by the administrating authority, must:

(a) comply with the amended or changed standard, guideline or relevant legislation within twelve (12) months of the amendment or change being made, unless a different period is specified in the amended standard, guideline or relevant legislation; and

(b) continue to remain in compliance with the previous standard, guideline or relevant legislation until compliance with the amended or changed standard or guideline is achieved.

Regard for Comment

A29 Where comments are provided by the administering authority with respect to any plans, systems or programs required to be developed by a condition of this environmental authority then the holder of this environmental authority must have due regard to these comments.

END OF CONDITIONS FOR SCHEDULE A

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Schedule B – Air

General

B1 Unless authorised by this environmental authority, the release of noxious or offensive odour, dust or any other airborne contaminant resulting from the mining activity must not cause environmental harm.

Bulk Material Handling Management

B2 The holder of this environmental authority must ensure that vehicles used for transporting bulk materials on or from the licensed place, have appropriate load preparation to prevent the spillage and/or loss of particulate matter and/or windblown dust during transport.

Air Quality – Particulate Matter

B3 The mining activity must not cause particulate matter to exceed the following levels when measured at any sensitive place or commercial place:

(a) a concentration of particulate matter with an aerodynamic diameter of less than 10 micrometres (PM_{10}) suspended in the atmosphere of 50 micrograms per cubic metre over a 24 hour averaging time monitored in accordance with:

(i) the most recent version of Australian Standard AS3580.9.6 *Determination of suspended particulate matter – PM(sub) 10(/sub) high volume sampler with size-selective inlet – Gravimetric method*; or

(ii) an alternate method of monitoring PM_{10} which complies with the performance specifications detailed in another Australian Standard for PM_{10} and agreed to in writing by the administering authority.

(b) a concentration of particulate matter suspended in the atmosphere of 90 micrograms per cubic metre over a one (1) year averaging time, when monitored in accordance with the most recent version of AS/NZS3580.9.3:2003 *Determination of suspended particulate matter – Total suspended particulate matter (TSP) – High volume sampler gravimetric method*;

(c) a concentration of arsenic with an aerodynamic diameter of less than 10 micrometres (PM_{10}) suspended in the atmosphere of 0.006 micrograms per cubic metre over a one (1) year averaging time monitored in accordance with:

(i) the most recent version of Australian Standard AS3580.9.6 *Determination of suspended particulate matter – PM(sub) 10(/sub) high volume sampler with size-selective inlet – Gravimetric method*; or

(ii) an alternate method of monitoring PM_{10} which complies with the performance specifications detailed in another Australian Standard for PM_{10} and agreed to in writing by the administering authority.

(d) a concentration of cadmium with an aerodynamic diameter of less than 10 micrometres (PM_{10}) suspended in the atmosphere of 0.005 micrograms per cubic metre over a one (1) year averaging time monitored in accordance with:

(i) the most recent version of Australian Standard AS3580.9.6 *Determination of suspended particulate matter – PM(sub) 10(/sub) high volume sampler with size-selective inlet – Gravimetric method*; or

(ii) an alternate method of monitoring PM_{10} which complies with the performance specifications detailed in another Australian Standard for PM_{10} and agreed to in writing by the administering authority.

(e) a concentration of lead suspended in the atmosphere of 0.5 micrograms per cubic metre over a one (1) year averaging time monitored in accordance with:

(i) the most recent version of Australian Standard AS/NZS3580.9.3:2003 Determination of suspended particulate matter – Total suspended particulate matter (TSP) – High volume sampler gravimetric method; or

(ii) an alternate method of monitoring TSP which complies with the performance specifications detailed in another Australian Standard for TSP and agreed to in writing by the administering authority.

Note: The holder of this environmental authority may elect to monitor the concentration of arsenic and cadmium as the total metal content in total suspended particulates (TSP) when measured in accordance with the most recent version of AS/NZS3580.9.3:2003 Determination of suspended particulate matter – Total suspended particulate matter (TSP) – High volume sampler gravimetric method and meet the same limit as specified in condition B3.

Air Quality – Dust Deposition

B4 The holder of this environmental authority must conduct the mining activity in such a manner so as not to cause any exceedance of limits identified in Schedule B – Table 1 (Dust Deposition Trigger Levels and Limits) at any sensitive place or commercial place.

Schedule B – Table 1 (Dust Deposition Trigger Levels and Limits)

Air Quality Indicator	Measurement Period	Trigger Level ($\mu g/m^2$/day)	Limit ($\mu g/m^2$/day unless specified otherwise)
Arsenic and its compounds as arsenic[4]	Annual average	4[1]	-
Cadmium and its compounds as cadmium[4]	Annual average	2[1]	-
Lead and its compounds as lead[4]	Annual average	100[1]	250[2]
Total insoluble matter (insoluble analysis and particulate matter deposition rate)[3]	Monthly average	-	$4g/m^2$/month[5,6]

1. Trigger levels based on First General Administrative Regulation Pertaining to the *Federal Emission Control Act* (Technical Instructions on Air Quality Control – TA Luft) (Table 6 page 29).
2. Air quality limit derived from World Health Organisation – Air Quality Guidelines for Europe Second Edition, 2000 (Chapter 6 page 152).
3. Monitored in accordance with the most recent version of Australian Standard AS3580.10.1 *Methods for sampling and analysis of ambient air – Determination of particulate matter – Deposited matter – Gravimetric method.*
4. Metals analysis is to be carried out in accordance with a methodology, sufficient to produce representative results capable of comparison against the respective limits and trigger levels.
5. Based on the New Zealand Ministry for Environment Good Practice Guide for Assessing and Managing for Environmental Effects of Dust Emissions (Table 7.1).
6. The dust deposition limit is calculated over a nominal month as per AS/NZS3580.10.1 of 2003 (or more recent editions).

B5 If monitoring indicates the maximum concentrations in condition B3 or the limits in Schedule B – Table 1 (Dust Deposition Trigger Levels and Limits) have been exceeded at a sensitive place or commercial place as a result of the mining activity, then the holder of this environmental authority must immediately implement dust abatement measures to ensure that dust emissions generated by the mining activity no longer exceed the levels specified in condition B3 and Schedule B – Table 1 (Dust Deposition Trigger Levels and Limits).

Note: If the holder of the environmental authority can demonstrate to the administering authority that it is not the cause of the exceedance of concentrations in condition B3 or the limits in Schedule B – Table 1 (Dust Deposition Trigger Levels and Limits) then this condition does not apply.

B6 In the event of monitoring results showing an exceedance of any of the trigger levels or limits specified in Schedule B – Table 1 (Dust Deposition Trigger Levels and Limits) at a sensitive place or commercial place, the holder of this environmental authority must:

(a) complete an investigation to identify the cause of the exceedance;

(b) if the investigation shows that the exceedance is not attributable to the mining activity, then no further action is required and this must be advised to the administering authority; or

(c) if the investigation shows that the exceedance is attributable to the mining activity provide a written report to the administering authority within one (1) month of the date of the monitoring results showing an exceedance, outlining:

(i) details of the investigations carried out;

(ii) details of the environmental impacts observed; and

(iii) actions taken to prevent environmental harm.

Air Quality Monitoring Program

B7 The holder of this environmental authority must implement and maintain an air quality monitoring program for the air quality indicators specified in condition B3 and Schedule B – Table 1 (Dust Deposition Trigger Levels and Limits) at the monitoring locations and specified in Schedule B – Table 2 (Air Quality Monitoring Program) and Schedule K – Figure 2 (Air Quality Monitoring Program Monitoring Locations).

Schedule B – Table 2 (Air Quality Monitoring Program)

Monitoring Location Description	Location (GDA94 MGA z54)		Monitoring Site ID	Monitoring Frequency
	Easting	Northing		
Compliance				
Roseby Homestead	413970	7754962	EA_DG_005	For TSP, PM_{10}, arsenic, cadmium and lead: As required by condition B8. For dust deposition measured as insoluble matter: Monthly
			EA_AQ_005	For arsenic, cadmium and lead in deposited dust: Monthly
Reference				
North of Roseby Homestead and the licensed place[1]	408471	7766889	EA_DG_007	For TSP, PM_{10}, arsenic, cadmium and lead: As required by condition B8. For dust deposition measured as insoluble matter: Monthly For arsenic, cadmium and lead in deposited dust: Monthly
			EA_AQ_007	
	411918	7764933	EA_DG_008	
			EA_AQ_008	
	410576	7762936	EA_DG_009	
South of Roseby Homestead and the licenced place[1]	413110	7752939	EA_DG_006	
			EA_AQ_006	
Between Roseby Homestead and the licenced place	413589	7760259	EA_DG_001	
	412867	7758953	EA_DG_010	

1. Upwind sites must be located upwind of Roseby Homestead and the licensed place at the time of monitoring.

Note: Monitoring sites must comply with Australian Standard 3580.1.1:2007 Methods for the sampling and analysis of ambient air – Guide to siting air monitoring equipment.

B8 Air quality monitoring for TSP, PM_{10}, arsenic, cadmium and lead must be carried out on a campaign basis for at least seven (7) consecutive days on four (4) separate occasions in May, July, September and November each year.

B9 Notwithstanding condition B7, the holder of this environmental authority must implement and maintain a dust deposition monitoring program to monitor the deposition and airborne concentrations of contaminants in dust generated by the mining activity in the receiving environment and the actual and potential environmental impacts as a result. At a minimum, the program must include:

(a) a description of the sources, locations and predicted quantity of contaminants in air emissions generated by each mining activity carried out at the licensed place;

(b) suitable monitoring locations, nominated by an appropriately qualified person, for monitoring of dust deposition and heavy metals in dust, associated with dust generating mining activities as specified in Schedule B – Table 3 (Air Quality Monitoring Program – Dust Deposition);

(c) collection of contaminants in dust deposition samples at the monitoring locations and at the frequency specified in Schedule B – Table 3 (Air Quality Monitoring Program – Dust Deposition;

(d) annual assessment of the environmental harm caused by dust deposition on the receiving environment and performance against air quality trigger levels and limits specified in Schedule B – Table 1 (Dust Deposition Trigger Levels and Limits); and

(e) a sufficient number of impact monitoring and reference locations, constructed in accordance with Australian Standard 3580.1.1:2007 *Methods for the sampling and analysis of ambient air – Guide to siting air monitoring equipment*, to enable scientifically justifiable conclusions on the level of impact from mining activity.

Schedule B – Table 3 (Air Quality Monitoring Program – Dust Deposition)

Monitoring Location Description	Monitoring Site ID	Location (GDA94 MGA z54)		Monitoring Frequency
		Easting	Northing	
1km east of the site, along the main access road	EA_DG_001	413589	7760259	Monthly
Approximately 700m NE of the Roseby Homestead	EA_DG_005	413970	7754962	Monthly
Approximately 1.5km SE of the Roseby Homestead	EA_DG_006	413110	7752939	Monthly
Far northern end of the lease, at the northern end of the Knapdale Range	EA_DG_007	408471	7766889	Monthly
North-eastern corner of the mining lease area	EA_DG_008	411918	7764933	Monthly
Between the mine site and the permanent accommodation village	EA_DG_009	410576	7762936	Monthly
Approximately 2km SE of the mine site.	EA_DG_010	412867	7758953	Monthly

1. The holder of this environmental authority must provide monitoring location description and location information to the administering authority as part of the dust monitoring program required by condition B9.
2. Monitoring sites must comply with Australian Standard 3580.1.1:2007 *Methods for the sampling and analysis of ambient air – Guide to siting air monitoring equipment*

Air Quality Monitoring Requirements

B10 Samples taken for air quality monitoring specified in this environmental authority must be collected and analysed in accordance with the requirements of the administering authority's latest edition of the *Air Quality Sampling Manual*, or more recent editions or supplements to that document as are published by the administering authority, unless otherwise agreed by the administering authority in writing.

Concentrate Management

B11 All mineral concentrate must be stored, stockpiled and loaded in fully enclosed buildings.

B12 Buildings or structures used for the storage, stockpiling and loading of mineral concentrate must incorporate the following dust control measures as a minimum:

(a) all necessary openings and vents in the buildings or structures (other than doorways and access ways) must be covered with filter media or other equivalent dust control measures;

(b) cladding of the buildings or structures must be securely affixed and free of any unnecessary holes;

(c) all doorways and access ways in the buildings or structures must be fitted with doors;

(d) all doors in the buildings or structures must remain closed except when being used for access or egress;

(e) all doors, doorways and access ways in the buildings or structures must be maintained in such a condition that doors, when closed, provide a seal against the release of mineral concentrate to the receiving environment;

(f) transfer of mineral concentrate to vehicles and containers must be carried out in a manner that minimises the likelihood of any release of mineral concentrate to the atmosphere and waters; and

(g) transfer of mineral concentrate along conveyor belts must be designed and operated in a manner that minimises, using best practice technology and design, the release of mineral concentrate to the atmosphere and waters.

B13 The interior of all mineral concentrate storage, stockpiling and loading buildings must be maintained under negative air pressure sufficient to minimise, using best practice technology and design, the release of concentrate from the buildings or structures.

B14 ~~The buildings and structures in place at the licensed place for the storage, stockpiling and loading of mineral concentrate must be constructed and maintained to withstand a Category 2 cyclone~~.

B15 ~~The construction and state of the buildings and structures in place at the licensed place for the storage, stockpiling and loading of mineral concentrate must be checked for compliance with condition B14 by an appropriately qualified person at least once every three (3) years.~~

B16 ~~A wash bay for mobile equipment must be installed as part of the mineral concentrate storage facility, for cleaning machinery before exit from the area and to prevent the movement of mineral concentrate outside the building.~~

House-keeping Procedure

B17 A whole of site housekeeping procedure must be developed and implemented which must include, but not be limited to:

(a) the completion of periodic inspections of the licensed place including all structures, plant, equipment and trafficked surfaces to identify and remove exposed mineral concentrate that may be mobilised by wind, water or equipment movement; and

(b) an ongoing cleaning and maintenance schedule to minimise any potential release of mineral concentrate and to ensure there is no build-up of mineral concentrates over time in areas where it may be mobilised.

Weather Station

B18 The holder of this environmental authority must establish and maintain a permanent meteorological station to continuously measure and record wind speed, wind direction, temperature and daily rainfall volume.

B19 The permanent meteorological station must be installed in accordance with the latest edition of the Bureau of Meteorology guideline *Observation Specifications No.2013.1 – Guidelines for the positioning and exposure of meteorological instruments and observing facilities*.

B20 The holder of this environmental authority must record, compile, evaluate and keep all monitoring records obtained from the permanent automatic meteorological station.

END OF CONDITIONS FOR SCHEDULE B

Schedule C – Water

General

C1 Contaminants that will, or have the potential to cause environmental harm, must not be released directly or indirectly to any waters except as permitted under the conditions of this environmental authority.

C2 The maintenance and cleaning of vehicles and any other equipment or plant must not be carried out in areas from which contaminants can be released into any waters, roadside gutter or stormwater drainage system.

C3 Any spillage of wastes, contaminants or other materials must be cleaned up as quickly as practicable to minimise the release of wastes, contaminants or materials to any stormwater drainage system or receiving waters.

C4 All determinations of water quality/sample analysis required under a condition of this environmental authority must be:

(a) made in accordance with methods prescribed in the latest edition of the latest edition of the administering authority's *Water Quality Sampling Manual*;

(b) collected from the monitoring locations identified within this environmental authority, within two (2) hours of each other where possible; and

(c) carried out on representative samples.

C5 The release of contaminants directly or indirectly to waters must not produce any slick or other visible or odorous evidence of oil, grease or petrochemicals nor contain visible floating oil, grease, scum, or litter.

C6 The following information must be recorded in relation to all water monitoring required under the conditions of this environmental authority and submitted to the administering authority in the specified format when requested:

(a) the date and time when the sample was taken;

(b) the monitoring point where the sample was taken;

(c) the measured or estimated daily quantity of the contaminants released from all release points;

(d) the release flow rate at the time of sampling for each release point; and

(e) the results of all monitoring and details of any exceedances of the conditions of this environmental authority.

Contaminant Release to Waters

C7 The release of contaminants to waters must only occur from the release points specified in Schedule C – Table 1 (Release Points) and depicted in Schedule K – Figure 3 (Release Points and Water Storage Monitoring Locations).

Schedule C – Table 1 (Release Points)

Release Point	Location (GDA94 MGA z54)		Contaminant Source, Location and Description of Release Point	Receiving Waters Description
	Easting	Northing		
Sediment Dam C	412210	7760305	Stormwater runoff from the existing construction camp, the change house and car park, the administration building and data centre, the sewerage treatment plan, water treatment plant and the vehicle wash bay – from the Sediment Dam C spillway ~~and controlled release pipe~~.	Unnamed tributary of Silvermine Creek
Sediment Dam D	412346	7759965	Stormwater runoff from the site services lay-down and storage area, Gatehouse and security, emergency services, temporary generators, core yard and core shed, and laydown area – from the Sediment Dam D spillway ~~and controlled release pipe~~.	Silvermine Creek
Sediment Dam F	411642	7760116	Stormwater runoff from the NAF Waste Rock Dump and stormwater runoff from the clean water catchment between mine workshop area and the NAF waste rock dump – from the Sediment Dam F spillway	Silvermine Creek
Sediment Dam G	411491	7761147	Stormwater runoff from the ~~PAF waste rock dumps, Stages 1 and 2, and the~~ clean water catchments adjacent to the PAF waste rock dumps – from the Sediment Dam G spillway	North Creek
Stage 2 PAF Pad Run Off Dam	411198	7761055	Stormwater runoff from the PAF waste rock dump – from the PAF Pad Run Off Dam spillway	North Creek
STP Dam Stage 1	412426	7759746	Treated effluent from the project STPs – from the STP Dam spillway	Silvermine Creek
STP Dam Stage 2	412403	7759586	Treated effluent from the project STPs – from the STP Dam Stage 2 spillway	Silvermine Creek
ROM Area Run Off Dam	412223	7761099	Stormwater runoff from ROM Pad, crusher and conveyor – from the ROM Area Run Off Dam spillway	North Creek
Process Plant Run Off Dam	412201	7760797	Stormwater from processing plant and reagent shed (roofed and bunded), as well as the warehouse and reagent storage – from the Process Plant Run Off Dam spillway	North Creek
Mine Workshop Run Off Dam	411980	7760028	Stormwater from workshop, fuel depot, go-line and light vehicle parking area – from the Mine Workshop Run Off Dam spillway	Silvermine Creek
Raw Water Dam	412220	7760903	Raw water from Lake Julius – from the Raw Water Dam spillway	North Creek
Sediment Dam A	412191	7760848	Stormwater runoff from the clean water catchment between the process plant area and the PAF waste rock dump	North Creek
Tailings Storage Facility (TSF)	408976	7763597	Water release from the TSF	Cabbage Tree Creek
Seepage Collection Pond	408920	7763507	Release from the TSF	Cabbage Tree Creek

C8 The release of contaminants to waters from the authorised release points must be monitored at the locations specified in Schedule C – Table 1 (Release Points) for each quality characteristic and at the frequency specified in Schedule C – Table 2 (Contaminant Release Limits).

C9 The release of contaminants to waters must not exceed the contaminant limits stated in Schedule C – Table 2 (Contaminant Release Limits).

Schedule C – Table 2 (Contaminant Release Limits)

Quality Characteristic[1]	Unit	Contaminant Limit	Monitoring Frequency
Hardness	mg/L	For interpretation purposes only	Event based sampling of release events: • One sample must be taken within twelve (12) hours of a release event commencing. A second sample must be taken between twelve (12) and twenty four (24) hours after the release event commences. • Where a release event has a duration of twenty four (24) hours or greater, samples must be taken daily for one • (1) week, and once a week thereafter until release event ceases.
pH	pH unit	5.5[2] (minimum) 9.0[9] (maximum)	
EC	µS/cm	1000	
Total Suspended Solids	mg/L	Reference[3] value plus 10%[4]	
Aluminium	mg/L	5[5]	
Arsenic[6]	mg/L	0.5[5]	
~~Cyanide[8]~~	~~mg/L~~	~~0.5[7]~~	
Sulphate	mg/L	1000[5]	
Fluoride	mg/L	2[5]	
Cadmium	mg/L	0.01[5]	
Copper	mg/L	1[5]	
Lead	mg/L	0.1[5]	
Manganese	mg/L	Reference[3] value plus 10%[4]	
Nickel	mg/L	1[5]	
Zinc	mg/L	20[5]	

[1] All metals and metalloids must be measured as total (unfiltered) and dissolved (filtered) concentrations.
[2] Based on Environmental Management Plan for the Dugald River Project dated February 2012.
[3] Reference sites defined in Schedule C – Table 4 (Receiving Water and Stream Sediment Reference Sites and Downstream Monitoring Points).
[4] Contaminant limit based on quality of upstream reference site sampled at the time of release plus 10%.
[5] Contaminant limit based on ANZECC (2000) stock water quality guidelines.
[6] Speciated arsenic concentrations for As (III) and As (V) only required if 13 µg/L is exceeded - note that the sample bottle requirements for As (total species) and As (speciated) may differ.
[7] International Cyanide Management Code discharge limit, International Cyanide Management Institute, June 2011.
[8] Cyanide as un-ionised hydrogen cyanide from ANZECC (2000)
[9] Based on TropWATER Technical Memo – Recommended amendments to Dugald River Mine Environmental Authority EPML00731213 dated January 2020.

NOTES:

(a) Where release(s) or flow event(s) occur simultaneously only one (1) set of samples are required to be taken.
(b) All dissolved (filtered) samples must be obtained from field filtered grab samples.
(c) Grab sampling is the preferred method for sample collection.

Stream Flow Monitoring

C10 The holder of this environmental authority must install, operate and maintain a stream flow gauging station to determine and record stream flows at the locations upstream of each release point, as specified in Schedule C – Table 3 (Contaminant Release during Flow Events) and Schedule K – Figure 4 (Stream Flow Gauge, Receiving Waters and Stream Sediment Monitoring Locations) for any receiving water into which a release occurs.

C11 Notwithstanding any other condition of this environmental authority, the release of contaminants to waters must only take place during periods of natural flow specified as minimum flow in Schedule C – Table 3 (Contaminant Release during Flow Events) and at the contaminant release point(s) specified in Schedule C – Table 1 (Release Points) and shown in Schedule K – Figure 4 (Stream Flow Gauge, Receiving Waters and Stream Sediment Monitoring Locations).

Schedule C – Table 3 (Contaminant Release during Flow Events)

Receiving Water Description	Release point	Gauging station description[1]	Location (GDA94 MGA zone 54)		Minimum Flow in Receiving Water Required for a Release Event	Flow Recording Frequency
			Easting	Northing		
Silvermine Creek	Sediment Dam F	SC-29 (MS5)	411465	7760021	As specified in condition C12	Continuous (minimum daily)
	Mine Workshop Run Off Dam					
	Sediment Dam D					
	Sediment Dam C					
	STP Dam Stage 1					
	STP Dam Stage 2					
North Creek	Stage 2 PAF Pad Run Off Dam	SN-15 (MS8)	411282	7761188	As specified in condition C12	
	Sediment Dam A					
	ROM Area Run Off Dam					
	Process Plant Run Off Dam					
	Sediment Dam G					
	Raw Water Dam					

[1] Codes in parentheses are provided for consistency with the Receiving Environment Monitoring Program and the Dugald River Project Baseline Limnological Data Report (2012-2014).

Note: The volume of flow can be determined by height of water or flow. The actual flow must be a quantifiable measure, e.g.: ≥5m³/sec

C12 At the time of release from the authorised release points specified in Schedule C – Table 3 (Contaminant Release during Flow Events) there must be natural flow in the respective receiving water at a sufficient volume to allow for dilution of the release to comply with the contaminant limits associated with the respective receiving waters.

C13 The daily quantity of water and contaminant load released from each release point specified in Schedule C – Table 1 (Release Points) must be measured and recorded.

Onsite Water Storages

C14 Onsite water storages must be monitored in accordance with the Receiving Environment Monitoring Program required by condition C23.

C15 The holder of this environmental authority must implement measures to prevent access to the following dams by livestock and minimise access by native fauna: Sediment Dam A, Sediment Dam F, Sediment Dam G, Stage 1 PAF PAD Run Off Dam, Stage 2 PAF PAD Run Off Dam, Underground Mine Water Collection Dam, ROM Area Run Off Dam, Raw Water Dam, Process Plant Run Off Dam, Containment Dam, Mine Workshop Run Off Dam and STP Dam Stages 1 and 2.

Receiving Waters Monitoring

C16 Waters at the monitoring points specified in Schedule C – Table 4 (Receiving Water and Stream Sediment Reference Sites and Downstream Monitoring Points) and Schedule K – Figure 4 (Stream

Flow Gauge, Receiving Waters and Stream Sediment Monitoring Locations) must be monitored for each quality characteristic and at the frequency stated in Schedule C – Table 5 (Receiving waters trigger levels and contaminant limits).

Schedule C – Table 4 (Receiving Water and Stream Sediment Reference Sites and Downstream Monitoring Points)

Monitoring Point[1]	Description	Location (GDA94 MGA Zone 54)	
		Easting	Northing
Interpretative Sites			
SC-08 (MS5 Ref)	Silvermine Creek – upstream of processing plant area	410892	7759982
SN-05 (MS8 Ref)	North Creek – upstream of processing plant area	410893	7761256
CT3-08 (MS2)	Un-named tributary of Cabbage Tree Creek – West of Knapdale Ranges on the northwest boundary, downstream of the tailings storage facility (TSF)	408063	7763376
MS5 (SC-29)	Un-named tributary of Silvermine Creek – South of processing plant area, east of the Knapdale Ranges, downstream of the processing plant area	412689	7760035
UT1-06 (MS6 Ref)	Un-named tributary of Dugald River - East of the Knapdale Ranges on the south eastern boundary	412495	7758628
SN-15 (MS8)	North Creek – Downstream of processing plant on the boundary of the mining lease	412043	7761203
SN-23 (MS9)	North Creek – Downstream of processing plant, and upstream of confluence with Silvermine Creek	413842	7761258
SC-38 (MS10)	Un-named tributary of Silvermine Creek – East of processing plant area, downstream of the Process Plant Run off Dam overflows and within access road easement	413453	7760754
Reference Sites[2, 3]			
DR-10	Dugald River upstream of unnamed tributary (REMP waterway designation UT1)	414144	7759328
DR-14	Dugald River mine site access bridge, downstream of UT1 and upstream of Silvermine Creek confluence	414431	7760405
CC-05	Cabbage Tree Creek, upstream of the tributary which drains the TSF (REMP waterway designation CT3)	406375	7763485
Downstream Monitoring Points			
DR-18 (Downstream compliance site for DR-10 and DR14)	Dugald River downstream of Silvermine Creek (the upstream end of Longamundi Waterhole, possibly within the mixing zone associated with Silvermine Creek)	414660	7761171
DR-22 (Downstream compliance site for DR-10 and DR14)	Dugald River downstream of Silvermine Creek (the downstream end of Longamundi waterhole, and likely downstream of the Silvermine Creek mixing zone)	415275	7762341
CC-15 (Downstream compliance site for CC-05)	Cabbage Tree Creek downstream of the TSF (the closest waterhole to the TSF that retains water long enough to sustain seasonal aquatic communities, and the only accessible point on the creek during wet weather).	407593	7768969

[1] Codes in parentheses are provided for consistency with historical site names.
[2] Reference sites must:

(a) be from the same bio-geographic and climatic region;
(b) have similar geology, soil types and topography;
(c) contain a range of habitats similar to those at the test sites;
(d) have a similar flow regime;
(e) not be so close to the test sites that any disturbance at the test site also results in a change at the reference site; and
(f) the data from upstream reference monitoring points must not be used where they are affected by releases from other mines.

[3] Reference sites must comply with the criteria specified in ANZECC 2000.

Schedule C – Table 5 (Receiving waters trigger levels and contaminant limits)

Quality Characteristic[1]	Unit	Trigger Level[1,10]	Contaminant Limit[1,10,12]	Monitoring Frequency
Hardness ($CaCO_3$)	mg/L	For interpretation purposes		
pH	pH units	6.0 (minimum) 8.6[13] (maximum)	5.5 (minimum) 9.0[13] (maximum)	
Electrical conductivity	µS/cm	435 or 80th percentile of reference whichever is higher	1000	
Total Suspended Solids	mg/L	For interpretation purposes		Sites on tributaries of Dugald River: Sample daily for the first two days when releases or stream flows commence at interpretative sites. If releases or flows at interpretative sites persist, sample weekly until flow ceases. Dugald River Sites: Sample Dugald River sites daily while there is flows at DR-14, and daily for one week after cessation of flows at SC-38 and SN-23. Sample monthly if flows are present in Dugald River during the wet season. Cabbage Tree Creek sites: Sample CT3-08, CC-05 and CC-15 daily when flows are present at CT3-08 and sample CC-05 and CC-15 daily for two days after flows at CT3-08 cease. Sample CC-05 and CC-15 weekly if flows are present.
Sulfate	mg/L	77 [MMG Dugald River] or 80th percentile of reference whichever is higher	400[4]	
Fluoride	mg/L	80th percentile of reference	2[3] or 95th percentile of reference[10] whichever is lower	
Aluminium (dissolved)	mg/L	~~0.055~~[2] TBC or 80th percentile of reference whichever is higher	95th percentile of reference[10]	
Aluminium (total)	mg/L	-	TBC~~0.2~~[4]	
Arsenic[8] (dissolved)	mg/L	0.013[2] or 80th percentile of reference whichever is higher	95th percentile of reference[10]	
Arsenic (total)	mg/L	-	0.5[3]	
Cadmium (dissolved)	mg/L	0.0002[2] or 80th percentile of reference whichever is higher	95th percentile of reference[10]	
Cadmium (total)	mg/L	-	0.005[4]	
Copper (dissolved)	mg/L	0.0014[2] or 80th percentile of reference whichever is higher	95th percentile of reference[10]	
Copper (total)	mg/L	-	1[4]	
Cyanide[5] Free	mg/L	0.007[6] or 80th percentile of reference whichever is higher	0.022[6]	
Cyanide WAD	mg/L	-	0.1[4]	

Quality Characteristic[1]	Unit	Trigger Level[1,10]	Contaminant Limit[1,10,12]	Monitoring Frequency
Lead (dissolved)	mg/L	0.0034[2] or 80th percentile of reference whichever is higher	95th percentile of reference[10]	
Lead (total)	mg/L	-	0.05[4]	
Manganese (dissolved)	mg/L	1.9[2] or 80th percentile of reference whichever is higher	95th percentile of reference[10]	
Manganese (total)	mg/L	For interpretation purposes.		
Nickel (dissolved)	mg/L	0.011[2] or 80th percentile of reference whichever is higher	95th percentile of reference[.10]	
Nickel (total)	mg/L	-	1[3]	
Zinc (dissolved)	mg/L	0.008[2] or 80th percentile of reference whichever is higher	95th percentile of reference[10]	
Zinc (total)	mg/L	-	20[3]	

[1] All metals and metalloids must be measured as both 'total' (from analysis of an unfiltered sample) and 'dissolved' (from analysis of a field filtered sample). All trigger levels are based on dissolved metal concentrations.
- Metals concentrations may be adjusted to the site-specific hardness in accordance with ANZECC 2000 (Section 3.4.3 and Table 3.4.3) as appropriate.
- If a filterable result exceeds the applicable trigger value, further analysis may be performed to quantify the dissolved component of the filtrate.

[2] Based on ANZG (2018).
[3] Based on ANZECC/ARMCANZ (2000) Table 4.3.2 for livestock drinking water.
[4] Based on ANZECC/ARMCANZ (2000) Table 5.2.3 for recreational purposes.
[5] The requirement to monitor for cyanide is deferred until the time cyanide is introduced into the mining process.
[6] Cyanide as un-ionised HCN, measured as [CN] - based on ANZECC/ARMCANZ (2000) Table 3.4.1, refer also Section 8.3.7.2.
[7] Free Cyanide - based on International Cyanide Management Institute (2009) Implementation Guidance - Standard of Practice 4.5 - receiving surface waterbody guideline value)
[8] Speciated arsenic concentrations for As (III) and As (V) only required if 13 mg/L is exceeded - note that the sample bottle requirements for As (total species) and As (speciated) may differ.
[9] Site-specific trigger levels and contaminant limits for water quality (80th and 95th percentile of reference site concentration) must be calculated in accordance with QWQG (2009) and ANZECC (2000) methodology if sufficient monitoring data is available. The environmental authority holder must maintain a database documenting all relevant water quality monitoring data and calculation of 80th/95th percentiles adopted as water quality trigger levels and contaminant limits.
[10] The contaminant limit '95th percentile of reference' is not applicable where the 95th percentile of reference site concentration is below the specified trigger level for the respective Quality Characteristic.
[11] Reference site concentration determined from reference sites specified in Schedule C – Table 6 (Receiving Water and Stream Sediment Reference Sites and Downstream Monitoring Points).
[12] Compliance at DR-18 and DR-22 is assessed when surface flows are present at either interpretive site SC-38 or SN-23
[13] Based on TropWATER Technical Memo – Recommended amendments to Dugald River Mine Environmental Authority EPML00731213 dated January 2020.

Note: The method of sampling of waters must comply with the latest edition of the administering authority's Water Quality Sampling Manual.

C17 If quality characteristics of the receiving water at the downstream monitoring points exceed any of the trigger levels specified in Schedule C – Table 5 (Receiving waters trigger levels and contaminant limits) the holder of this environmental authority must compare the downstream results to the reference site results in the receiving waters and:

(a) where the downstream result is the same or a lower value than the reference site value for the quality characteristic during the monitoring event then no action is to be taken; or

(b) where the downstream results exceed the reference site complete an investigation in accordance with the ANZECC and ARMCANZ 2000 methodology, into the potential for environmental harm and provide a written report to the administering authority within three (3) months, outlining:

(i) details of the investigations carried out;

(ii) details of the environmental impacts observed; and

(iii) actions taken to prevent environmental harm.

Note: Where an exceedance of a trigger level has occurred and is being investigated, in accordance with clause (b) of this condition, then no further reporting is required for subsequent trigger events for that quality characteristic within the three (3) month investigation period.

C18 The release of contaminants must not result in an exceedance of contaminant limits stated in Schedule C – Table 5 (Receiving waters trigger levels and contaminant limits) at the downstream monitoring points specified in Schedule C – Table 4 (Receiving Water and Stream Sediment Reference Sites and Downstream Monitoring Points). Where the downstream result is the same or a lower value than the reference site value for the quality characteristic during the monitoring event then no action is to be taken.

Stream Sediment

C19 Sediment quality of receiving waters and reference waters must be monitored twice a year (once at the end of the wet season and once at the end of the dry season) at the monitoring locations defined in Schedule C – Table 4 (Receiving Water Reference Sites and Downstream Monitoring Points) and identified on Schedule K – Figure 4 (Stream Flow Gauge, Receiving Waters and Stream Sediment Monitoring Locations) and for the parameters defined in Schedule C – Table 6 (Stream Sediment Trigger Levels and Contaminant Limits).

Schedule C – Table 6 (Stream Sediment Trigger Levels and Contaminant Limits)

Parameter[1]	Trigger Level	Contaminant Limit
Arsenic (mg/kg)	20[3] or reference[2], whichever is higher	70[4] or 3 times the reference[2], whichever is higher
Cadmium (mg/kg)	1.5[3] or reference[2], whichever is higher	10[4] or 3 times the reference[2], whichever is higher
Copper (mg/kg)	65[3] or reference[2], whichever is higher	270[4] or 3 times the reference[2], whichever is higher
Lead (mg/kg)	50[3] or reference[2], whichever is higher	220[4] or 3 times the reference[2], whichever is higher
Manganese (mg/kg)	For interpretation purposes	
Nickel (mg/kg)	21[3] or reference[2], whichever is higher	52[4] or 3 times the reference[2], whichever is higher
Zinc (mg/kg)	200[3] or reference[2], whichever is higher	410[4] or 3 times the reference[2] whichever is higher
Particle size distribution	For interpretation purposes	

[1] All samples must be sieved to the sand fraction (63 – 2000µm) prior to analysis.
[2] Reference sites as specified in Schedule C – Table 4 (Receiving Water and Stream Sediment Reference Sites and Down Stream Monitoring Points).
[3] ANZECC (2000) Interim Sediment Quality Guidelines – low values based on total sediments.
[4] ANZECC (2000) Interim Sediment Quality Guidelines – high values based on total sediments.
[5] Analysis for metals/metalloids concentrations in sediment must be conducted on the <2mm fraction of the sample and measured as a dilute acid extractable concentration in a manner consistent with the Revision of the ANZECC/ARMCANZ Sediment Quality Guidelines, CSIRO (May 2013). Metals and metalloids concentrations in the <63um fraction must be performed for interpretative purposes.

Note: Where compliance monitoring results are compared with reference site monitoring results, data must be normalised to account for any difference in particle size distribution.

C20 Releases of contaminants from the mine must not result in an exceedance of sediment contaminant limits stated in Schedule C – Table 6 (Stream Sediment Trigger Levels and Contaminant Limits).

C21 If quality characteristics of the sediments exceed any of the trigger levels specified in Schedule C – Table 6 (Stream Sediment Trigger Levels and Contaminant Limits), the holder of this environmental authority must compare the results of the downstream site to the data from reference monitoring sites and:

(a) if the level of contaminants at the downstream site does not exceed the reference monitoring site data, then no action is to be taken; or

(b) if the level of contaminants at the downstream site is greater than the reference monitoring site data, complete an investigation in accordance with the ANZECC and ARMCANZ 2000 methodology, into the potential for environmental harm and provide a written report to the administering authority within three (3) months, outlining:

(i) details of the investigations carried out;

(ii) details of the environmental impacts observed; and

(iii) actions taken to prevent environmental harm.

Note: Where an exceedance of a trigger level has occurred and is being investigated, in accordance with clause (b) of this condition, then no further reporting is required for subsequent trigger events for that quality characteristic within the three (3) month investigation period.

C22 All stream sediment sampling and analysis must be undertaken using the methods documented in the MMG Dugald River Project Baseline Limnological Data Report (2012-2014).

Receiving Environment Monitoring Program

C23 The environmental authority holder must develop and implement a Receiving Environment Monitoring Program to monitor, identify and describe any adverse impacts to surface water environmental values, quality and flows due to the authorised mining activity. This must include monitoring the effects of the mine on the receiving environment periodically (under natural flow conditions) and while mine affected water is being discharged from the site. For the purposes of the Receiving Environment Monitoring Program, the receiving environment is the waters of Cabbage Tree Creek, Silvermine Creek, Silvermine Creek Tributary B, North Creek, Dugald River and connected waterways potentially influenced by the tailings storage facility. The Receiving Environment Monitoring Program should encompass any sensitive receiving waters or environmental values downstream of the authorised mining activity that will potentially be directly affected by an authorised release of mine affected water.

C24 A Receiving Environment Monitoring Program Design Document that addresses the requirements of the Receiving Environment Monitoring Program must be prepared and made available to the administering authority upon request.

NOTE: the Receiving Environment Monitoring Program Design Document sets out, for the next monitoring period, the location, frequency and parameters to be monitored under the Receiving Environment Monitoring Program.

C25 A report outlining the findings of the Receiving Environment Monitoring Program (REMP), including all monitoring results and interpretations must be prepared annually and made available on request to the Administering Authority. This must include an assessment of background reference water quality, the condition of downstream water quality compared against water quality objectives, and the suitability of current discharge limits to protect downstream environmental values.

Water Management Plan

C26 A water management plan that provides for the proper and effective management of the actual and potential environmental impacts resulting from the mining activity and to ensure compliance with the conditions of this environmental authority must be implemented and maintained.

C27 The water management plan must be developed by an appropriately qualified person and must include at least the following components:

(a) contaminant source study;
(b) site water balance and model;
(c) water management system;
(d) saline drainage prevention and management measures;
(e) acid rock drainage prevention and management measures;
(f) emergency and contingency planning; and
(g) monitoring and review.

~~C28 The holder of this environmental authority must undertake a review of the water management plan before 1 November each year to ensure that proper and effective measures, practices or procedures are in place so that the mine is operated in accordance with the conditions of this environmental authority and that environmental harm is prevented or minimised.~~

Site Water Balance

C29 The holder of this environmental authority must develop a site specific operational site water balance model.

C30 The water balance model must be run for a simulation period for the following:

(a) weekly during the period November to March;
(b) monthly during other periods;
(c) promptly after each rainfall event greater than fifty (50) millimetres within a twenty four (24) hour period within the relevant surface water containment area;

(d) with documentation of inputs and outputs from each run being stored and retrievable for a minimum period of one (1) year.

(e) performance in response to rainfall must be undertaken by an appropriately qualified person and

(f) assessments using the operational simulation water balance model must use a minimum of 100 years of historical rainfall data.

Saline, Acid and Metalliferous Drainage

C31 The holder of this environmental authority must ensure proper and effective measures are taken to avoid or otherwise minimise the generation and/or release of saline, acid and/or metalliferous mine drainage as a result of the mining activity.

Erosion and Sediment Control

C32 An Erosion and Sediment Control Plan must be maintained by an appropriately qualified person and implemented for all stages of the mining activity on the licensed place to prevent or minimise erosion and the release of sediment to receiving waters and contamination of storm water.

C33 The erosion and sediment control plan must provide for at least the following functions:

(a) prevent or minimise the contamination of receiving waters and stormwater;

(b) diverting uncontaminated stormwater run-off around areas disturbed by the mining activity or where contaminants or wastes are stored or handled;

(c) contaminated stormwater runoff, incident rainfall and leachate is collected; and treated, reused, or released in accordance with the conditions of this environmental authority;

(d) roofing or minimising the size of areas where contaminants or wastes are stored or handled;

(e) erosion and sediment control structures are placed to minimise erosion of disturbed areas and prevent the contamination of any waters;

(f) procedures to ensure that erosion and sediment control structures are maintained and adequate storage is available in sediment dams in accordance with design criteria; and

(g) training of staff that will be responsible for maintenance and operations of sediment and erosion control structures.

C34 Releases to waters must be undertaken so as not to cause erosion of the bed and banks of the receiving waters, or cause a material build-up of sediment in such waters.

Groundwater

C35 Groundwater quality and level must be monitored at the locations and frequencies defined in Schedule C – Table 7 (Groundwater Monitoring Locations and Frequency) and Schedule K – Figure 5 (Groundwater Bore Monitoring Locations) for quality characteristics identified in Schedule C – Table 8 (Groundwater Trigger Levels and Contaminant Limits)

Schedule C – Table 7 (Groundwater Monitoring Locations and Frequency)

Monitoring Point	Location (GDA94 MGA zone 54)		Monitoring frequency
	Easting	Northing	
Interpretation Bores – Depth[1]			
GWBFAB	411395	7761383	Quarterly
MB1AB	411199	7761205	
MB2AB	412187	7761185	
MB3AB	411421	7760107	
MB4AB	412744	7760042	
SHALL6AB	410983	7760929	
Compliance Bores – Depth[1] and quality			
MB2	412191	7761189	Quarterly
MB4	412749	7760041	
MB5	408537	7763364	
MB6	408287	7763224	
MB9D	408723	7763433	
MB9S	408724	7763433	
Background Bores[2] – Depth[1] and quality			
MB1	411301	7761214	Quarterly
MB3	411931	7760127	

[1] RL must be measured to the nearest 5cm from the top of the bore casing.

[2] Reference sites must:

(a) have similar flow regime;

(b) be from the same bio-geographic and climatic region;

(c) have similar geology, soil types and topography; and

(d) not be so close to the test sites that any disturbance at the test site also results in a change at the reference site.

~~[3] To be monitored when landholder access allows.~~

Schedule C – Table 8 (Groundwater Trigger Levels and Contaminant Limits)

Quality Characteristic[1]	Unit	Trigger Level[1]	Contaminant limit[2]
pH	pH unit	6.0 (minimum) 8.0 (maximum	6.0 (minimum) 9.0 (maximum)
Electrical Conductivity	µS/cm	1500[6]	2000[6]
Hardness (as $CaCO_3$)	mg/L	For interpretation purposes	
Total Dissolved Solids (TDS)	mg/L	For interpretation purposes	
Major ions (Na, Ca, K, Mg, Cl, bicarbonate, total alkalinity)	mg/L	For interpretation purposes	
Sulphate (mg/L)	mg/L	150[6]	1000[5]
Fluoride (mg/L)	mg/L	-	2[4]
Aluminium	mg/L	0.055[3,11]	5[4]
Arsenic[7]	mg/L	0.013[3,11]	0.5[4]
Cadmium (mg/L)	mg/L	0.0002[3,11]	0.01[4]
Copper (mg/L)	mg/L	0.0014[3]	1[4]
~~Cyanide[8]~~	~~mg/L~~	~~0.007[9]~~	~~0.022[10]~~
Lead (mg/L)	mg/L	0.0034[3,11]	0.1[4]
Manganese (mg/L)	mg/L	1.9[3,11]	-
Nickel (mg/L)	mg/L	0.011[3,11]	1[4]
Zinc (mg/L)	mg/L	0.008[3,11]	20[4]

[1] All metals and metalloids must be measured as filtered with the exception of fluoride.
[2] All metals and metalloids must be measured as total (unfiltered).
[3] Based on ANZG (2018)..
[4] Based on ANZECC/ARMCANZ (2000) Table 4.3.2 for livestock drinking water.
[5] Based on ANZECC/ARMCANZ (2000) Section 4.3.3.4;
[6] MMG Dugald River - site specific value
[7] Speciated arsenic concentrations for As (III) and As (V) only required if 13 mg/L is exceeded - note that the sample bottle requirements for As (total species) and As (speciated) may differ.
[8] The requirement to monitor for cyanide is deferred until the time cyanide is introduced into the mining process.
[9] Cyanide as un-ionised HCN, measured as [CN] - based on ANZECC/ARMCANZ (2000) Table 3.4.1, refer also Section 8.3.7.2.
[10] Free Cyanide - based on International Cyanide Management Institute (2009) Implementation Guidance - Standard of Practice 4.5 - receiving surface waterbody guideline value)
[11] Where appropriate, the default trigger values may be hardness adjusted in accordance with ANZG (2018).

C36 If quality characteristics of groundwater from compliance bores identified in Schedule C – Table 7 (Groundwater Monitoring Locations and Frequency) exceed any of the trigger levels stated in Schedule C – Table 8 (Groundwater Trigger Levels and Contaminant Limits), the holder of this environmental authority must compare the compliance monitoring bore results to the reference bore results and:

(a) if the level of contaminants at the compliance monitoring bore does not exceed the reference bore results, then no action is to be taken; and

(b) if the level of contaminants at the compliance monitoring bore is greater than the reference bore results, complete an investigation in accordance with the ANZECC and ARMCANZ 2000, into the potential for environmental harm and provide a written report to the administering authority within three (3) months, outlining:

(i) details of the investigations carried out;

(ii) details of environmental impacts observed; and

(iii) actions taken to prevent environmental harm.

Note: Where an exceedance of a trigger level has occurred and is being investigated, in accordance with clause (b) of this condition, then no further reporting is required for subsequent trigger events for that quality characteristic within the three month investigation period.

C37 Results of monitoring of groundwater from compliance bores identified in Schedule C – Table 7 (Groundwater Monitoring Locations and Frequency), must not exceed any of the contaminant limits defined in Schedule C – Table 8 (Groundwater Trigger Levels and Contaminant Limits).

Monitoring Bore Construction, Maintenance and Decommissioning

C38 The construction, maintenance and management of groundwater bores (including groundwater monitoring bores) must be undertaken in a manner that prevents or minimises impacts to the environment and ensures the integrity of the bores to obtain accurate monitoring.

Reporting

C39 A report on groundwater monitoring, including monitoring results and interpretations, must be prepared by a relevantly qualified and suitable person on a biennial (two yearly) basis and be made available to the administering authority on request. The report must include:

(a) An assessment of groundwater monitoring results against the objectives of the MMG Dugald River Mine Groundwater Monitoring Program.

(b) A review of groundwater compliance against requirements specified in the environmental authority.

(c) Any proposed refinement or update to the groundwater monitoring program or environmental authority, with respect to monitoring locations, frequency, parameters, specified trigger values and/or specified contaminant limits, that may be applicable on review of the collected data or other relevant information.

END OF CONDITIONS FOR SCHEDULE C

Schedule D – Regulated Structures

Assessment of Consequence Category

D1 The consequence category of any structure must be assessed by a suitably qualified and experienced person in accordance with the *Manual for Assessing Consequence Categories and Hydraulic Performance of Structures (ESR/2016/1933)* at the following times:

(a) prior to the design and construction of the structure, if it is not an existing structure; or

(b) prior to any change in its purpose or the nature of its stored contents.

D2 A consequence assessment report and certification must be prepared for each structure assessed and the report may include a consequence assessment for more than one structure.

D3 Certification must be provided by the suitably qualified and experienced person who undertook the assessment, in the form set out in the *Manual for Assessing Consequence Categories and Hydraulic Performance of Structures (ESR/2016/1933)*.

Notification of affected persons

D4 All affected persons must be provided with a copy of the emergency action plan in place for each regulated structure

(a) for existing structures that are regulated structures, within 10 business days of this condition taking effect;

(b) prior to the operation of the new regulated structure; and

(c) if the emergency action plan is amended, within 5 business days of it being amended.

Operation of a Regulated Structure

D5 Operation of a regulated structure, except for an existing structure, is prohibited unless the holder has submitted to the administering authority, all of the following:

(a) one paper copy and one electronic copy of the design plan and certification of the 'design plan' in accordance with condition D6;

(b) a set of 'as constructed' drawings and specifications;

(c) certification of those 'as constructed drawings and specifications' in accordance with condition D9;

(d) where the regulated structure is to be managed as part of an integrated containment system for the purpose of sharing the DSA volume across the system, a copy of the certified system design plan;

(e) the requirements of this authority relating to the construction of the regulated structure have been met;

(f) the holder has entered the details required under this authority, into a Register of Regulated Structures; and,

(g) there is a current operational plan for the regulated structure.

D6 For existing structures that are regulated structures:

(a) where the existing structure that is a regulated structure is to be managed as part of an integrated containment system for the purpose of sharing the DSA volume across the system, the holder must submit to the administering authority within 12 months of the commencement of this condition a copy of the certified system design plan including that structure; and

(b) there must be a current operational plan for the existing structures.

D7 Each regulated structure must be maintained and operated, for the duration of its operational life until decommissioned and rehabilitated, in compliance with the current operational plan and, if applicable, the current design plan and associated certified 'as constructed' drawings.

Mandatory Reporting Level

D8 Conditions D15 to D16 inclusive only apply to Regulated Structures which have not been certified as low consequence category for 'failure to contain – overtopping'.

D9 The Mandatory Reporting Level (the MRL) must be marked on a regulated dam in such a way that during routine inspections of that dam, it is clearly observable.

D10 The holder must, as soon as practicable but within forty-eight (48) hours of becoming aware, notify the administering authority when the level of the contents of a regulated dam reaches the MRL.

D11 The holder must, immediately on becoming aware that the MRL has been reached, act to prevent the occurrence of any unauthorised discharge from the regulated dam.

D12 The holder must record any changes to the MRL in the Register of Regulated Structures.

Design Storage Allowance

D13 The holder must assess the performance of each regulated dam or linked containment system over the preceding November to May period based on actual observations of the available storage in each regulated dam or linked containment system taken prior to 1 July of each year.

D14 By 1 November of each year, storage capacity must be available in each regulated dam (or network of linked containment systems with a shared DSA volume), to meet the Design Storage Allowance (DSA) volume for the dam (or network of linked containment systems).

D15 The holder of this environmental authority must, as soon as possible and within forty-eight (48) hours of becoming aware that the regulated dam (or network of linked containment systems) will not have the available storage to meet the DSA volume on 1 November of any year, notify the administering authority.

D16 The holder must, immediately on becoming aware that a regulated dam (or network of linked containment systems) will not have the available storage to meet the DSA volume on 1 November of any year, act to prevent the occurrence of any unauthorised discharge from the regulated dam or linked containment systems.

Annual Inspection Report

D17 Each regulated structure must be inspected each calendar year by a suitably qualified and experienced person.

D18 At each annual inspection, the condition and adequacy of all components of the regulated structure must be assessed and a suitably qualified and experienced person must prepare an annual inspection report containing details of the assessment and include a recommendations section, with any recommended actions to ensure the integrity of the regulated structure or a positive statement that no recommendations are required.

D19 The suitably qualified and experienced person who prepared the annual inspection report must certify the report in accordance with the *Manual for Assessing Consequence Categories and Hydraulic Performance of Structures (ESR/2016/1933)*.

D20 The holder of this environmental authority must:

(a) within twenty (20) business days of receipt of the annual inspection report, provide to the administering authority:
    (i) the recommendation section of the annual inspection report; and,
    (ii) if applicable, any actions being taken in response to those recommendations; and
(b) If, following receipt of the recommendations and (if applicable) recommended actions, the administering authority requests a copy of the annual inspection report from the holder, provide this to the administering authority within 10 business days of receipt of the request.

Transfer Arrangements

D21 The holder must provide a copy of any reports, documentation and certifications prepared under this authority, including but not limited to any Register of Regulated Structures, consequence assessment, design plan and other supporting documentation, to a new holder on transfer of this authority.

Decommissioning and Rehabilitation

D22 Regulated structures must not be abandoned but be either:

(a) decommissioned and rehabilitated to achieve compliance with condition D23; or
(b) be left in-situ for a use by the landholder provided that:
    (i) it no longer contains contaminants that will migrate into the environment; and
    (ii) it contains water of a quality that is demonstrated to be suitable for its intended use(s); and
(c) the holder of the environmental authority and the landholder agree in writing that the;
    (i) dam will be used by the landholder following the cessation of the environmentally relevant activity(ies); and
    (ii) landholder is responsible for the dam, on and from an agreed date.

D23 Before surrendering this environmental authority the site must be rehabilitated to achieve a safe, stable, non-polluting landform.

Register of Regulated Dams

D24 A Register of Regulated Structures must be established and maintained by the holder for each regulated structure.

D25 The holder must provisionally enter the required information in the Register of Regulated Structures when a design plan for a regulated dam is submitted to the administering authority.

D26 The holder must make a final entry of the required information in the Register of Regulated Structures once compliance with condition D11 and D12 has been achieved.

D27 The holder must ensure that the information contained in the Register of Regulated Structures is current and complete on any given day.

D28 All entries in the Register of Regulated Structures must be approved by the chief executive officer for the holder of this authority, or their delegate, as being accurate and correct.

D29 The holder must, at the same time as providing the annual return, supply to the administering authority a copy of the records contained in the Register of Regulated Structures, in the electronic format required by the administering authority.

Transitional arrangements

D30 All existing regulated structures must subsequently comply with the timetable for any further assessments in accordance with the Manual specified in Schedule D - Table 1 (Transitional hydraulic performance requirements for existing structures), depending on the consequence category for each existing structure assessed in the most recent previous certification for that structure.

D31 Schedule D - Table 1 (Transitional hydraulic performance requirements for existing structures) ceases to apply for a structure once any of the following events has occurred:

(a) it has been brought into compliance with the hydraulic performance criteria applicable to the structure under the Manual; or

(b) it has been decommissioned; or

(c) it has been certified as no longer being assessed as a regulated structure.

D32 Certification of the transitional assessment required by D30 (as applicable) must be provided to the administering authority within 6 months of amendment of the authority adopting this schedule.

Schedule D – Table 1 (Transitional hydraulic performance requirements for existing structures)

Transition period required for existing structures to achieve the requirements of the *Manual for Assessing Consequence Categories and Hydraulic Performance of Dams*			
Compliance with criteria	**High**	**Significant**	**Low**
>90% and a history of good compliance performance in last 5 years	No transition required	No transition required	No transitional conditions apply. Review consequence assessment every 7 years.
>70%-≤90%	Within 7 years, unless otherwise agreed with the administering authority, based on no history of unauthorised releases.	Within 10 years, unless otherwise agreed with the administering authority, based on no history of unauthorised releases.	No transitional conditions apply. Review consequence assessment every 7 years.
>50-≤70%	Within 5 years unless otherwise agreed with the administering authority, based on no history of unauthorised releases.	Within 7 years unless otherwise agreed with the administering authority, based on no history of unauthorised releases.	Review consequence assessment every 7 years.
≤50%	Within 5 years or as per compliance requirements (e.g. TEP timing)	Within 5 years or as per compliance requirements (e.g. TEP timing)	Review consequence assessment every 5 years.
Regulated levee designed to prevent the ingress of clean flood water <100% compliant7	Within 5 years unless otherwise agreed with the administering authority.		

Hydraulic performance of regulated dams

D33 Regulated dams must meet the hydraulic performance criteria specified in Schedule D - Table 2 (Hydraulic performance criteria for Regulated Dams).

Schedule D - Table 2 (Hydraulic performance criteria for Regulated Dams)

Name of dam	Consequence category	Hydraulic performance criteria	
		Design Storage Allowance (DSA)	Mandatory Reporting Level (MRL)
Stage 2 PAF Pad Run Off Dam	Significant[1]	~~RL 207.65m~~[2]	~~RL 208.60m~~[2]
Tailings Storage Facility	High[3]	RL 236.2m[4]	RL 239.6m[4]

[1] Consequence category assessed in ATC Williams (1 May 2015) report titled "MMG Dugald River - Consequence Category Assessment - 2015 Review: Stage 1 & 2 PAF Pad Runoff Dams, STP Evaporation Dam, NAF Pad Runoff Dam, Underground Mine Water Collection Dam and ROM Area Runoff Dam: May 2015: Doc. No. 108003.19-R01", which includes certification by Mark Dillon (RPEQ 8690).

[2] DSA and MRL details as recorded in ATC Williams (22 December 2014) report titled "MMG Dugald River - Dugald River Mine Regulated Dams Operation Plan: December 2014, ATCW Doc No: 108003.12-R04, Version No: 2".

[3] Consequence category assessed in ATC Williams (24 May 2016) report titled ""MMG Dugald River Tailings Storage Facility: May 2016, ATCW Doc No: 108003.18-R03", which includes certification by Mark Dillon (RPEQ 8690).

[4] DSA and MRL details as recorded in ATC Williams (October 2019) report titled "MMG Dugald River - Dugald River Mine - Regulated Structures – Annual Inspection Report – 2019. ATCW Doc No: 1080033.37-R01, Revision No: 0".

Tailings Disposal

D34 Upon disposal of tailings into the tailings storage facility, the holder of this environmental authority must inspect the tailings storage facility weekly to identify and register any fauna mortalities. This information will be made available to the administering authority upon request within and forty eight (48) hours of the discovery of any fauna mortalities. Details of mortalities will include but not be limited to:

(a) animal species of the discovery of any fauna mortality;
(b) number of animals;
(c) location; and
(d) likely cause of death.

D35 If in the opinion of the administering authority, the mortality rate referred to in condition D34 is unacceptable, the holder of this environmental authority will be required to develop and implement an action plan to reduce the mortality rate and provide the action plan to the administering authority within one (1) month of the plan being required.

END OF CONDITIONS FOR SCHEDULE D

Schedule E – Sewage

Sewage Treatment Management Plan

E1 A Sewage Treatment Management Plan that provides for the proper and effective management of actual and potential environmental impacts resulting from the operation of sewage treatment plants and to ensure compliance with the conditions of the environmental authority must be implemented and maintained.

E2 The Sewage Treatment Management Plan must include but no be limited to:

(a) topographical map of suitable scale clearly showing the licensed place and surrounding land likely to be affected by the sewage treatment plants along with the location of any sensitive receptors;

(b) a site plan including the Q100 flood level in conjunction with licensed place boundaries and infrastructure and buffer zones;

(c) detail any potential impact on groundwater and surface water from the discharge of effluent; and

(d) strategies for managing and minimising the impact on surface water and groundwater; and

Alarms

E3 Sewage treatment infrastructure must be fitted with stand-by pumps and pump-failure alarms as well as high level alarms to warn of imminent overflow. All alarms must be able to operate via telemetry and without mains power.

Sewage Treatment – Effluent Release to Waters

E4 Treated sewage effluent may be released to waters from the STP Dam in accordance with the conditions of this environmental authority.

E5 Notwithstanding the monitoring requirements specified Schedule C of this environmental authority, the release of contaminants to waters from the STP Dam release point must also be monitored at the release point STP Dam and for each quality characteristic and at the frequency specified in Schedule E - Table 1 (Sewage Effluent Contaminant Release Limits).

Schedule E - Table 1 (Sewage Effluent Contaminant Release Limits)

Quality Characteristic	Release Limit	Monitoring Frequency
Total Nitrogen (mg/L)	20	Daily during release (the first sample must be taken within 2 hours of commencement of release)
Total Phosphorous (mg/L)	5	
5 Day Biochemical Oxygen Demand (mg/L)	20	
Faecal Coliforms (cfu/100mL)	1000	
Free Residual Chlorine (mg/L)	1	

E6 The release of contaminants to waters must not exceed the release limits stated in Schedule E - Table 1 (Sewage Effluent Contaminant Release Limits) for each quality characteristic.

END OF CONDITIONS FOR SCHEDULE E

Schedule F – Noise and Vibration

Noise Monitoring

F1 The holder of this environmental authority must ensure that noise generated by the mining activity does not cause a nuisance at a sensitive place or commercial place.

F2 In the event of a complaint made to the administering authority, considered in the opinion of an authorised officer to be neither frivolous or vexatious, about noise generated in carrying out the mining activity and the noise is considered by the administering authority to be an unreasonable noise, the holder of this environmental authority must take action to ensure that it is no longer an unreasonable noise. Noise monitoring and recording must include the following descriptor characteristics and matters:

(a) L_{Aeq}
(b) $L_{AN,T}$ (where N equals the statistical levels of 1, 10 and 90 and T = 15 minutes);
(c) background noise $L_{A90,}$;
(d) the level and frequency of occurrence of impulsive or tonal noise and any adjustment and penalties to statistical levels;
(e) atmospheric conditions including temperature, relative humidity and wind speed and directions;
(f) effects due to any extraneous factors such as traffic noise;
(g) location, date and time of monitoring;
(h) if the complaint concerns low frequency noise, Max $Lp_{LIN,T}$; and
(i) if the complaint concerns low frequency noise, one third octave band measurements in dB(LIN) for centre frequencies in the 10 – 200 Hz range.

F3 In the event of a complaint about noise from the mining activities, noise from the mining activities must not exceed the criteria in Schedule F – Table 1 (Noise Limits).

Schedule F – Table 1 (Noise Limits)

Noise Level dB(A) Measured As:	7 Days per Week		
	7am to 6pm	6pm to 10pm	10pm to 7am
$L_{Aeq, adj, T}$	40	35	30

Note: T = 15 minutes

Air Blast and Ground Vibration

F4 The holder of this environmental authority must ensure that blasting does not cause the limits for peak particle velocity and air blast overpressure in Schedule F – Table 2 (Blasting Noise Limits) to be exceeded at any sensitive place or commercial place.

Schedule F – Table 2 (Blasting Noise Limits)

Blasting Noise Limits	Sensitive or Commercial Place Limits	
	7am to 6pm	6pm to 7am
Airblast overpressure	115 dB (Linear) peak for four (4) out of five (5) consecutive blasts initiated and not greater than 120 dB (Linear) peak at any time	95 dB (Linear) peak
Ground vibration peak particle velocity	5mm/second peak particle velocity for four (4) out of five (5) consecutive blasts and not greater than 10 mm/second peak particle velocity at any time	1mm/second peak particle velocity

F5 The holder of this environmental authority must implement measures to reduce airblast overpressure and ground vibration impacts upon receipt of a complaint such that blasting activities no longer cause environmental harm.

F6 Where blast monitoring detects non-compliance with Schedule F – Table 2 (Blasting Noise Limits) the holder of this environmental authority must:

(a) take steps to ensure compliance is achieved by subsequent blasts; and

(b) continue to monitor all consecutive blasts until at least three (3) successive blasts comply with Schedule F – Table 2 (Blasting Noise Limits).

F7 The method of measurement and reporting of airblast overpressure levels must comply with the most recent Australian standard *Explosives – Storage and use* guidelines.

F8 The method of measurement and reporting of vibration levels must comply with the most recent edition of the administering authority's guideline *Noise and vibration from blasting*.

END OF CONDITIONS FOR SCHEDULE F

Schedule G – Non Mineral Waste

Waste Management Program

G1 A Waste Management Program must be developed and implemented by the environmental authority holder and submitted to the administering authority upon request.

Waste Disposal

G2 All general and regulated waste (other than waste authorised in condition G3) must be removed from the licensed place to a facility that is lawfully able to accept the waste.

G3 The only waste that can be disposed of on the licensed place is waste generated on the licensed place and is limited to:

(a) waste rock;
(b) tailings;
(c) tyres;
(d) plastic; and
(e) SIPEX and Sodium Metabisulphite containers.

G4 Unless otherwise permitted by the conditions of this environmental authority or with prior approval from the administering authority and in accordance with a relevant standard operating procedure, waste must not be burnt.

Regulated Waste

G5 Regulated waste, other than that authorised to be disposed of at the licensed place under this environmental authority, must only be removed and transported from the licensed place by a person who holds a current authority to transport such wastes to a facility that is lawfully able to accept the waste.

G6 Regulated waste generated by the mining activity can be temporarily stored at the licensed place prior to removal provided it is for a period no longer than six (6) months and it is stored in a manner to minimise risk of fire or contamination of land or waters.

G7 Each container of regulated waste stored awaiting movement from the licensed place must be clearly marked to identify the contents.

Tyre Storage and Disposal

G8 Tyres stored awaiting disposal or transport for take-back and recycling or waste-to-energy options – must be stockpiled in volumes less than three (3) metres in height and 200m^2 in area and at least ten (10) metres from any other tyre storage area.

G9 Fire prevention measures must be implemented including the removal of all combustible materials, including grass and vegetation, within a ten (10) metre radius of any tyre storage area.

G10 Subject to demonstrating to the administering authority that no other use higher in the waste hierarchy can be practicably implemented, waste tyres generated from the mining activity may be disposed of at the licensed place in the underground mine workings.

END OF CONDITIONS FOR SCHEDULE G

Schedule H – Mineral Waste

Tailings Disposal

H1 Tailings must be managed in accordance with procedures contained within the Mineral Waste Tailing Disposal Plan. The Mineral Waste Tailing Disposal Plan must be regularly reviewed and updated every three years. These procedures must include provisions for:

(a) containment of tailings in accordance with the approved design plan(s);

(b) the management of seepage and leachates both during operation and post closure;

(c) the control of fugitive emissions to air;

(d) a program of progressive sampling and characterisation to identify acid producing potential and metal concentrations of tailings that must include:

(i) progressive characterisation of all tailings material during disposal for net acid producing potential (NAPP) and the following contaminants: arsenic, cadmium, copper, cyanide, iron, lead, manganese, nickel, silver, zinc, fluoride and sulfate;

(ii) geochemical kinetic testing where the acid producing potential of tailings material has not been conclusively determined to indicate oxidation rates, potential reaction products and effectiveness of control strategies.

(e) management of tailings in order to minimise the potential for environmental harm.

Waste Rock

H2 No waste rock dumps are to remain upon surrender of environmental authority.

H3 All potentially acid forming (PAF) waste material is to be returned to the North or South Decline at end of mine life and must not cause environmental harm.

H4 Non-acid forming waste rock (NAF) may be used in rehabilitation or the construction of temporary or permanent structures within the operational areas if it is characterised as un-reactive (including material that does not cause acid, neutral or saline mine drainage).

H5 A Waste Rock Management Plan must be developed and implemented by the environmental authority holder and submitted to the administering authority upon request.

H6 Waste rock disposal must not occur on the licensed place unless the holder of this environmental authority has submitted to the administering authority a waste rock management plan. The waste rock management plan must be certified by an appropriately qualified person, to ensure the plan has addressed the requirements of this environmental authority in accordance with best practice environmental management.

H7 The waste rock management plan must include:

(a) a detailed design of the waste rock dumps;

(b) characterisation of the waste rock to predict the quality of runoff and seepage generated, including salinity, acidity, alkalinity, dissolved metals, metalloids and non-metallic inorganic substances;

(c) a program of progressive sampling program to validate pre-mine waste rock characterisation. The waste rock sampling program must include validation of salinity, acid and alkali producing potential and metal concentrations including arsenic, cadmium, copper, lead, manganese, nickel, silver, zinc, fluoride and sulfate;

(d) where the acid rock drainage potential / neutral mine drainage potential of waste rock material has not been conclusively determined, geochemical kinetic testing must be conducted to indicate oxidation rates, potential reaction products and effectiveness of control strategies;

(e) records must be maintained of all waste rock characterisation and disposal including contingency planning for the management of acid rock / neutral mine drainage;

(f) a materials balance and disposal plan demonstrating how potentially acid forming and acid forming waste rock will be selectively placed and/or encapsulated to minimise the generation of acid mine drainage;

(g) a materials balance and disposal plan demonstrating how waste rock that has a potential to generate neutral and/or saline mine drainage will be selectively placed and managed to minimise the generation of neutral and/or saline mine drainage;

(h) a sampling program to verify encapsulation and/or placement of potentially acid forming / acid forming waste rock / waste rock that has a potential to generate neutral mine drainage;

(i) how often the performance of the plan will be assessed;

(j) a rehabilitation strategy which meets the rehabilitation objectives specified in Schedule I of this environmental authority; and

(k) monitoring or rehabilitation, research and/or trials to verify the requirements and methods for decommissioning and final rehabilitation of the placed materials, including the prevention and management of acid mine drainage, erosion minimisation and establishment of vegetation cover.

H8 The waste rock dumps must be designed, constructed and operated to minimise the infiltration of incidental rainfall into the waste rock dump.

H9 Any seepage from the waste rock dump must be captured and directed to an appropriately engineered and maintained storage authorised to receive seepage in accordance with Schedule D – Regulated Structures of this environmental authority.

Acid Rock Drainage Management

H10 Subject to the release limits defined in Schedule – C of this environmental authority, all reasonable and practicable measures must be implemented to prevent contaminated water being directly or indirectly released or likely to be released as a result of the mining activity to any waters.

END OF CONDITIONS FOR SCHEDULE H

Schedule I – Land and Rehabilitation

General

I1 Unless authorised by this environmental authority contaminants that will or may cause environmental harm must not be directly or indirectly released to land.

I2 Any spillage of wastes, contaminants or other materials must be cleaned up promptly. Such spillages must be cleaned up using dry methods that minimise the impact of the release of wastes, contaminants or materials to land.

Topsoil

I3 Topsoil and subsoils must be stripped and stockpiled ahead of the areas proposed to be disturbed for the mining activity to a depth determined from soil surveys to ensure that useable soil resources are preserved for rehabilitation.

I4 Topsoil and subsoil stockpiles must be managed to ensure stability and minimise the release of contaminants. Measures must include:

(a) Vegetating stockpiles;

(b) Minimising the height of stockpiles; and

(c) Re-using stockpiles as soon as possible.

I5 A topsoil and subsoil inventory which identifies the soil requirements for the mining activity and availability of suitable soil on the licensed place must be submitted to the administering authority upon request.

Disturbance to Land

I6 When carrying out the mining activity the holder of this environmental authority must:

(a) avoid, minimise or mitigate (in order of preference) any impacts on areas of sensitive vegetation or other areas of ecological value;

(b) minimise the risk of injury, harm, or entrapment to wildlife and stock;

(c) minimise disturbance to land that may otherwise result in land degradation;

(d) prior to carrying out any disturbance activities, make all relevant staff, contractors or agents carrying out those activities, aware of the location of any Category A, B or C Environmentally Sensitive Area (ESA) and the relevant requirements of this environmental authority;

(e) if significant disturbance to land is unavoidable, the holder of this environmental authority must clear vegetation in a way which minimises fragmentation; and

(f) manage cleared vegetation so that it is stockpiled in a manner that facilitates salvage and respreading and does not impede vehicle, stock or wildlife movements.

I7 A registered spotter/catcher is to be engaged to work ahead of site clearing works at the commencement of vegetation clearing to ensure the protection of species that may be of conservation significance.

Note: This environmental authority does not authorise the taking of protected animals or the tampering with an animal breeding place that is being used by a protected animal to incubate or rear the animal's offspring.

I8 In the event of identification of threatened species on the licensed place, a diagrammatic representation of the species occurrence relative to the mining activity together with a management and monitoring strategy for species conservation must be prepared to the satisfaction of the administering authority and submitted with the plan of operations.

Purple-necked Rock-wallaby Monitoring Program *(Petrogale purpureicollis)*

I9 The holder of this environmental authority must take all reasonable and practicable measures to avoid, minimise and mitigate impacts on the Purple-necked Rock-wallaby *(Petrogale purpureicollis)*.

I10 A purple-necked rock-wallaby monitoring program must be implemented by an appropriately qualified person to monitor and record the effects of the mining activity on the purple-necked rock wallaby population. The purple-necked rock-wallaby monitoring program must be implemented and maintained for the life of the environmental authority.

I11 The purple-necked rock-wallaby monitoring program required by condition I10 must be conducted annually in each wet and dry season and must include the following at a minimum:

(a) an estimation of the number of purple-necked rock-wallabies inhabiting the licensed place;

(b) continuation of data collection on suitable purple-necked rock-wallaby shelter sites and foraging areas;

(c) details of the person that undertook the monitoring program and the methods used;

(d) details of when (both date and time of day) and the climatic conditions at the time that the monitoring program was undertaken;

(e) an estimation of the number and type of pest species occurring along the Knapdale Range within the licensed place that may impact on the population of the purple-necked rock-wallaby;

(f) consideration and comparison to previous similar monitoring programs;

(g) support for findings as follows including photos/records of the purple-necked rock-wallaby, scats or other trace material; and

(h) procedures for notification to the administering authority and contingency plans in the event that any significant decline in the purple-necked rock-wallaby population is detected.

I12 A report detailing the results of the purple-necked rock-wallaby monitoring program carried out in accordance with conditions I10 and I11 must be provided to the administering authority, before 1 February each year.

Rehabilitation Objectives

I13 Land disturbed by mining must be rehabilitated in accordance with Schedule I – Table 1 (Dugald River Project Rehabilitation Requirements) and the objectives of the Post Mine Land Use Plan required under condition I18.

~~I14 Rehabilitation must commence progressively as soon as areas become available and in accordance with the plan of operations.~~

~~I15 Within six (6) months of the commencement of tailings disposal in the tailings storage facility, the holder of this environmental authority must commence trials to establish suitable capping systems for infrastructure on the licensed place including but not limited to the tailings storage facility and all waste rock dumps.~~

~~I16 By 1 October 2017 and once every two (2) years thereafter the holder of this environmental authority must submit a report to the administering authority detailing the success and findings from the capping system trials.~~

~~I17 By 2 October 2019 the holder of this environmental authority must submit to the administering authority a report nominating the most appropriate capping system for the tailings storage facility based on the results from trials required by condition I18.~~

Post Mine Land Use Plan

I18 A Post Mine Land Use Plan must be developed and implemented by the authority holder and submitted to the administering authority upon request. The PMLUP must be developed by an appropriately qualified person and include:

(a) schematic representation of final land form inclusive of drainage features;

(b) slope designs;

(c) cover design (not limited to store and release covers);

(d) drainage design;

(e) erosion controls;

(f) description of experimental design for monitoring of analogue and rehabilitated areas inclusive of statistical design;

(g) proposed revegetation methods inclusive of plant species selection, re-profiling, respreading soil, soil ameliorants/amendments, surface preparation and method of propagation;

(h) materials balance including available top soil, and low permeability capping material;

(i) geotechnical, geochemical and hydrological studies;

(j) chemical, physical and biological properties of soil and water; and

(k) a rehabilitation monitoring program as required by condition I20.

Rehabilitation Monitoring Program

I19 A rehabilitation monitoring program must be developed and be implemented on commencement of rehabilitation identified in Schedule I – Table 1 (Dugald River Project Rehabilitation Requirements) by an appropriately qualified person.

I20 The holder of this environmental authority must conduct rehabilitation monitoring in accordance with the program developed in condition (I21) at least once a year including sufficient spatial and temporal replication to enable scientifically justifiable conclusions to be made, as established in the rehabilitation monitoring program.

I21 Verification of rehabilitation success is to be carried for each domain. Monitoring must be carried out for each domain at a minimum sampling intensity of 1:15,000 and must include sufficient replication to enable statistical analysis of results at an acceptable power.

~~Schedule I – Table 1 (Dugald River Project Rehabilitation Requirements)~~

~~Mine Domain~~	~~Mine Feature~~	~~Rehabilitation Goal~~	~~Rehabilitation Objectives~~	~~Indicators~~	~~Completion Criteria~~
~~Ancillary Infrastructure and Services~~	~~Accommodation Village~~	~~Safe, non-polluting, stable and self-sustaining. (All land subject to the mining activity must be rehabilitated to meet the requirements of the administering authorities Guideline Rehabilitation requirements for Mining Projects).~~	~~Class 5 Native Habitat.~~	~~Compliance with condition I19 and the Post Mine Land Use Plan.~~	~~TBA[4]~~
	~~Pipeline and Accommodation Village Road~~				
~~Borrow Pits & Stockpiles~~	~~Topsoil Stockpiles – Mine Infrastructure Area~~	~~Safe, non-polluting, stable and self-sustaining. (All land subject to the mining activity must be rehabilitated to meet the requirements of the administering authority's Guideline Rehabilitation requirements for Mining Projects)~~	~~Class 4 – 5 Low Intensity Grazing / Native Habitat.~~	~~Compliance with condition I19 and the Post Mine Land Use Plan.~~	~~TBA[4]~~
	~~Borrow Pits and Stockpiles~~				
~~Dams and Diversion Structures~~	~~Sediment Dams A, C, D, F and G~~	~~Safe, non-polluting, stable and self-sustaining. (All land subject to the mining activity must be rehabilitated to meet the requirements of the administering authority's Guideline Rehabilitation requirements for Mining Projects).~~	~~Class 4 – 5 Low Intensity Grazing / Native Habitat.~~	~~Compliance with condition I19 and the Post Mine Land Use Plan.~~	~~TBA[4]~~
	~~Containment Dam~~				
	~~Stage 1 PAF Pad Run Off Dam~~				
	~~Stage 2 PAF Pad Run Off Dam~~				
	~~Underground Mine Water Collection Dam~~				
	~~STP Dam Stage 1~~				
	~~STP Dam Stage 2~~				
	~~ROM Area Run Off Dam~~				
	~~Process Plant Run Off Dam~~				
	~~Mine Workshop Run Off Dam~~				
	~~Raw Water Dam~~				
	~~Diversion Drains~~				

Mine Domain	Mine Feature	Rehabilitation Goal	Rehabilitation Objectives	Indicators	Completion Criteria
Mineralised Waste	PAF waste rock dump (Stage 1) PAF waste rock dump (Stage 2) NAF Waste Rock Dump Temporary Ore Stockpile	Safe, non-polluting, stable and self-sustaining. (All land subject to the mining activity must be rehabilitated to meet the requirements of the administering authority's Guideline Rehabilitation requirements for Mining Projects). All potentially acid forming waste rock must be returned to the void at the end of mine life. Only non acid forming waste rock is authorised to be placed in the NAF waste rock dump. Where possible non-acid forming waste rock will be used in rehabilitation and only in accordance with the conditions of the environmental authority.	Class 4 Low Intensity Grazing.	Compliance with condition I19 and the Post Mine Land Use Plan.	TBA[1]
Mining and Processing Area	ROM Pad ROM Haul Roads Processing Plant and Conveyor Area	Safe, non-polluting, stable and self-sustaining. (All land subject to the mining activity must be rehabilitated to meet the requirements of the administering authority's Guideline Rehabilitation requirements for Mining Projects)	Class 4 Low Intensity Grazing.	Compliance with condition I19 and the Post Mine Land Use Plan.	TBA[1]
	Underground Portals and Support Infrastructure Switchyard Existing Camp and Expansion Works Sewage Treatment Plant	Safe, non-polluting, stable and self-sustaining. (All land subject to the mining activity must be rehabilitated to meet the requirements of the administering authority's Guideline Rehabilitation requirements for Mining Projects)	Class 4 – 5 Low Intensity Grazing / Native Habitat.	Compliance with condition I19 and the Post Mine Land Use Plan.	TBA[1]

Mine Domain	Mine Feature	Rehabilitation Goal	Rehabilitation Objectives	Indicators	Completion Criteria
	Workshop, Vehicle Washdown and Maintenance Area				
	Shared Construction Laydown and Warehouse Laydown Area				
	Water Services				
	Shared Mobile Equipment and Construction Laydown Area				
	Mine Infrastructure Area Roads and Parking				
Tailings Storage Facility (TSF)	TSF and Seepage Collection Pond	Safe, non-polluting, stable and self-sustaining. (All land subject to the mining activity must be rehabilitated to meet the requirements of the administering authorities Guideline Rehabilitation requirements for Mining Projects).	Class 5 Native Habitat.	Compliance with condition I19 and the Post Mine Land Use Plan.	TBA[4]
	Topsoil Stockpiles – TSF				
	TSF Pipelines and Roads				

1. Post mine land use, rehabilitation indicators and completion criteria are to be nominated in accordance with condition I18.
2. Table 2 of the Land Suitability Techniques – Technical Guideline for Environmental Management of Exploration and Mining in Queensland (DME 1995).

~~**Post Closure Management Plan**~~

~~I22 A Post Closure Management Plan must be developed and implemented by the authority holder and submitted to the administering authority upon request. The Plan must be implemented for a period of:~~

~~(a) at least thirty (30) years following cessation of the mining activity (excluding rehabilitation) on the licensed place; or~~

~~(b) a shorter period if:~~

~~(i) the licensed place is proven to be geo-technically and geo-chemically stable; and~~

~~(ii) it can be demonstrated to the satisfaction of the administering authority that no release of contaminants from the licensed place will result in environmental harm.~~

~~I23 The Post Closure Management Plan must include the following elements:~~

~~(c) operation and maintenance of:~~

~~(i) contaminated water collection and reticulation systems;~~

~~(ii) contaminated water treatment systems;~~

~~(iii) the groundwater monitoring network;~~

~~(iv) final cover systems; and~~

~~(v) vegetative cover.~~

~~(d) monitoring of:~~

~~(i) surface water;~~

~~(ii) groundwater;~~

~~(iii) seepage rates;~~

~~(iv) erosion rates;~~

~~(v) the integrity and effectiveness of final cover systems; and~~

~~(vi) the health and resilience of vegetative cover.~~

Infrastructure

I24 All buildings, structures, mining equipment and plant erected and/or used for the mining activity must be removed from the licensed place prior to surrender, except where agreed to in writing by the administering authority and the landowner.

Chemicals and Flammable or Combustible Liquids

I25 All explosives, hazardous chemicals, corrosive substances, toxic substances, gases, *flammable or combustible* liquids and dangerous goods must be stored and handled in accordance with the current, relevant Australian Standard where such is applicable.

I26 Notwithstanding the requirements of any applicable Australian Standard, any liquids stored on licensed place that have the potential to cause environmental harm must be stored and serviced by an effective containment system that is impervious to the materials stored and managed to prevent the release of liquids to waters or land.

I27 Where no relevant Australian Standard is available, the following must be applied:

(a) storage tanks must be bunded such that the capacity and construction of the bund is sufficient to contain at least 110% of a single storage tank or 100% of the largest storage tank plus 10% of the second largest storage tank in multiple storage areas; and

(b) drum storages must be bunded such that the capacity and construction of the bund is sufficient to contain at least 25% of the maximum design storage volume within the bund.

I28 All containment systems must be designed to minimise rainfall collection within the system.

Contaminated Land

I29 Prior to making an application for surrender or approval for progressive rehabilitation the holder of this environmental authority must undertake a contaminated land assessment / investigation of the relevant areas of the licensed place in accordance with, but not limited to, the following guidance: National Environment Protection (Assessment of Site Contamination) Amendment Measure, 2013. Other appropriate guidance may also be utilised where appropriate, however, application of any additional guidance must not contradict the requirements of Qld legislation and guidance.

Biodiversity Offsets

I30 The holder of this environmental authority must implement and maintain the *Biodiversity Offset Strategy* and the *Dugald River Project: Offset Area Management Plan*, developed in accordance with the *Queensland Biodiversity Offset Policy*.

END OF CONDITIONS FOR SCHEDULE I

Schedule J – Definitions

Key terms and/or phrases used in this document are defined in this section. Applicants should note that where a term is not defined, the definition in the *Environmental Protection Act 1994*, its regulations or environmental protection policies must be used. If a word remains undefined it has its ordinary meaning.

"acceptance criteria" means the measures by which the actions implemented to rehabilitate the land are deemed to be complete. The acceptance criteria indicate the success of the rehabilitation outcome or remediation of areas which have been significantly been disturbed by the mining activity. Acceptance criteria may include information regarding:

a) vegetation establishment, survival and succession;
b) vegetation productivity, sustained growth and structure development;
c) fauna colonisation and habitat development;
d) ecosystem processes such as soil development and nutrient cycling, and the recolonisation of specific fauna groups such as collembola, mites and termites which are involved in these processes;
e) microbiological studies including recolonisation by mycorrhizal fungi, microbial biomass and respiration;
f) effects of various establishment treatments such as deep ripping, topsoil handling, seeding and fertiliser application on vegetation growth and development;
g) resilience of vegetation to disease, insect attack, drought and fire; and
h) vegetation water use and effects on ground water levels and catchment yields.

"acid mine drainage (AMD)" means any contaminated release emanating from a mining operation formed through a series of chemical and biological reaction, when geological strata is disturbed and exposed to oxygen and moisture as a result of the mining activity.

"acid rock drainage (ARD)" means any contaminated release emanating from a mining activity formed through a series of chemical and biological reactions, when geological strata is disturbed and exposed to oxygen and moisture as a result of the mining activity.

"administering authority" means the chief executive of the agency administering the *Environmental Protection Act 1994.*

"affected land" means land on which an event has caused or threatens serious or material environmental harm.

"affected person" is someone whose drinking water can potentially be impacted as a result of discharges from a dam or their life or property can be put at risk due to dwellings or workplaces being in the path of a dam break flood.

"airblast overpressure" means energy transmitted from the blast site within the atmosphere in the form of pressure waves. The maximum excess pressure in this wave, above ambient pressure is the peak airblast overpressure measured in decibels linear (dBL).

"Annual Exceedance Probability" or **"AEP"** the probability that at least one event in excess of a particular magnitude will occur in any given year.

"annual inspection report" means an assessment prepared by a suitably qualified and experienced person containing details of the assessment against the most recent consequence assessment report and design plan (or system design plan);

a) against recommendations contained in previous annual inspections reports;
b) against recognised dam safety deficiency indicators;
c) for changes in circumstances potentially leading to a change in consequence category;
d) for conformance with the conditions of this authority;
e) for conformance with the 'as constructed' drawings;
f) for the adequacy of the available storage in each regulated dam, based on an actual observation or observations taken after 31 May each year but prior to 1 November of that year, of accumulated sediment, state of the containment barrier and the level of liquids in the dam (or network of linked containment systems);
g) for evidence of conformance with the current operational plan.

"ANZECC 2000" means Australian and New Zealand Environment Conservation Council Marine and Freshwater Quality Guidelines.

"appropriately qualified person" means a person who has professional qualifications, training, skills or experience relevant to the nominated subject matter and can give authoritative assessment, advice and analysis on performance relative to the subject matter using the relevant protocols, standards, methods or literature.

"assessed" or **"assessment"** by a suitably qualified and experienced person in relation to a consequence assessment of a dam, means that a statutory declaration has been made by that person and, when taken together with any attached or appended documents referenced in that declaration, all of the following aspects are addressed and are sufficient to allow an independent audit of the assessment:

a) exactly what has been assessed and the precise nature of that determination;
b) the relevant legislative, regulatory and technical criteria on which the assessment has been based;
c) the relevant data and facts on which the assessment has been based, the source of that material, and the efforts made to obtain all relevant data and facts; and
d) the reasoning on which the assessment has been based using the relevant data and facts, and the relevant criteria.

"associated works" in relation to a dam, means:

a) operations of any kind and all things constructed, erected or installed for that dam; and
b) any land used for those operations.

"authority" means an environmental authority or a development approval.

"environmental authority" means environmental authority under the *Environmental Protection Act 1994*.

"background" means the average of samples taken prior to the commencement of mining from the same waterway that the current sample has been taken.

"blasting" means the use of explosive materials to fracture:

a) rock, coal and other minerals for later recovery; or
b) structural components or other items to facilitate removal from a site or for reuse.

"bunded" means within bunding consistent with Australian Standard 1940.

"certification", "certifying", "certify" or certified" in relation to any assessment or documentation required by the *Manual for Assessing Consequence Categories and Hydraulic Performance of Structures (ESR/2016/1933)*, including design plans, 'as constructed' drawings and specifications, construction, operation or an annual report regarding regulated structures, means assessment and approval must be undertaken by a suitably qualified and experienced person in accordance with the Board of Professional Engineers of Queensland Policy Certification by RPEQs (ID: 1.4 (2A)).

"CFU" means colony forming units.

"chemical" means:

a) an agricultural chemical product or veterinary chemical product within the meaning of the *Agricultural and Veterinary Chemicals Code Act 1994* (Commonwealth); or
b) a dangerous good under the Australian Code for the Transport of Dangerous Goods by Road and Rail approved by the Australian Transport Council; or
c) a lead hazardous substance within the meaning of the *Workplace Health and Safety Regulation 1997*;
d) a drug or poison in the Standard for the Uniform Scheduling of Drugs and Poisons prepared by the Australian Health Ministers' Advisory Council and published by the Commonwealth; or
e) any substance used as, or intended for use as:
    (i) a pesticide, insecticide, fungicide, herbicide, rodenticide, nematocide, miticide, fumigant or related product; or
    (ii) a surface active agent, including, for example, soap or related detergent; or
    (iii) a paint solvent, pigment, dye, printing ink, industrial polish, adhesive, sealant, food additive, bleach, sanitiser, disinfectant, or biocide; or
    (iv) a fertiliser for agricultural, horticultural or garden use; or
    (v) a substance used for, or intended for use for mineral processing or treatment of metal, pulp and paper, textile, timber, water or wastewater; or
    (vi) manufacture of plastic or synthetic rubber.

"climatic season" means summer (1 December to 29 February), autumn (1 March to 31 May), winter (1 June to 31 August) and spring (1 September to 30 November).

"commercial place" means a workplace used as an office or for business or commercial purposes, which is not part of the mining activity and does not include employees accommodation or public roads.

"consequence" in relation to a structure as defined, means the potential for environmental harm resulting from the collapse or failure of the structure to perform its primary purpose of containing, diverting or controlling flowable substances.

"consequence category" means a category, either low, significant or high, into which a dam is assessed as a result of the application of tables and other criteria in the *Manual for Assessing Consequence Categories and Hydraulic Performance of Structures (ESR/2016/1933)*.

"construction" or **"constructed"** in relation to a dam/structure includes building a new dam/structure and modifying or lifting an existing dam/structure, but does not include investigations and testing necessary for the purpose of preparing a design plan.

"contaminant" A contaminant can be a gas, liquid or solid; or an odour; or an organism (whether alive or dead), including a virus; or energy, including noise, heat, radioactivity and electromagnetic radiation; or a combination of contaminants

"contaminated" means the substance has come into contact with a contaminant.

"control measure" means any action or activity that can be used to prevent or eliminate a hazard or reduce it to an acceptable level.

"dam" means a land-based structure or a void that contains, diverts or controls flowable substances, and includes any substances that are thereby contained, diverted or controlled by that land-based structure or void and associated works.

"dam crest volume" means the volume of material (liquids and/or solids) that could be within the walls of a dam at any time when the upper level of that material is at the crest level of that dam. That is, the instantaneous maximum volume within the walls, without regard to flows entering or leaving (for example, via spillway).

"design plan" is a document setting out how all identified consequence scenarios are addressed in the planned design and operation of a regulated structure.

"design storage allowance" or **"DSA"** means an available volume, estimated in accordance with the *Manual for Assessing Consequence Categories and Hydraulic Performance of Structures (ESR/2016/1933)* published by the administering authority, must be provided in a dam as at 1 November each year in order to prevent a discharge from that dam to an annual exceedance probability (AEP) specified in that Manual.

"development approval" means a development approval under the *Integrated Planning Act 1997* or the *Sustainable Planning Act 2009* in relation to a matter that involves an environmentally relevant activity under the *Environmental Protection Act 1994*.

"EC" means electrical conductivity.

"effluent" treated waste water released from sewage treatment plants.

"emergency action plan" means documentation forming part of the operational plan held by the holder of this environmental authority or a nominated responsible officer, that identifies emergency conditions that sets out procedures and actions that will be followed and taken by the dam/structure owner and operating personnel in the event of an emergency. The actions are to minimise the risk and consequences of failure, and ensure timely warning to downstream communities and the implementation of protection measures. The plan must require dam/structure owners to annually update contact details that are part of the plan, and to comprehensively review the plan at least every five years.

"environmentally relevant activity (ERA)" means an environmentally relevant activity as defined under Section 18 of the *Environmental Protection Act 1994* and listed under Schedule 2 of the *Environmental Protection Regulation 2008*.

"existing structure" means a structure that was in existence prior to the adoption of this schedule of conditions under the authority.

"**flare pit**" means containment area where any hydrocarbon that is discovered in an over-pressured reservoir during a drilling operation is diverted to, and combusted. The flare pit is only used during the drilling and work over process on a petroleum well.

"flowable substance" means matter or a mixture of materials which can flow under any conditions potentially affecting that substance. Constituents of a flowable substance can include water, other liquids fluids or solids, or a mixture that includes water and any other liquids fluids or solids either in solution or suspension.

"flow event" means a surface water flow in a drainage feature or watercourse that occurs as a result of rainfall.

"hazard" in relation to a dam/structure as defined, means the potential for environmental harm resulting from the collapse or failure of the dam/structure to perform its primary purpose of containing, diverting or controlling flowable substances.

"hazard category" means a category, either low, significant or high, into which a dam/structure is assessed as a result of the application of tables and other criteria in the *Manual for Assessing Hazard Categories and Hydraulic Performance of Dams*.

"hazardous waste" means a substance, whether liquid, solid or gaseous that, if improperly treated, stored, disposed of or otherwise managed, is likely to cause environmental harm.

"holder of this environmental authority" means any person who is the holder of, or is acting under, that environmental authority.

"hydraulic performance" means the capacity of a regulated dam to contain or safely pass flowable substances based on the design criteria specified for the relevant consequence category in the *Manual for Assessing Consequence Categories and Hydraulic Performance of Structures* (ESR/2016/1933).

"implement" means to put (a plan, proposal, etc.) into effect.

"infrastructure" means water storage dam/structures, roads and tracks, buildings and other structures built for the purpose of the mining activity but does not include facilities required for the long term management of mining impacts or the protection of potential resources. Such facilities include dam/structures containing hazardous waste, waste rock dumps, voids, or ore stockpiles and buildings or other structures whose ownership can be transferred and which have a residual beneficial use for the next owner of the operational land or the background land owner.

"levee" means an embankment that only provides for the containment and diversion of stormwater or flood flows from a contributing catchment, or containment and diversion of flowable materials resulting from releases from other works, during the progress of those stormwater or flood flows or those releases; and does not store any significant volume of water or flowable substances at any other times.

"land" in the "land schedule" of this document means land excluding waters and the atmosphere.

"land suitability" as defined in the DME 1995 Technical Guidelines for the Environmental Management of Exploration and Mining in Queensland.

"land use" term to describe the selected post mining use of the land, which is planned to occur after the cessation of mining operations.

"leachate" means a liquid that has passed through or emerged from, or is likely to have passed through or emerged from, a material stored, processed or disposed of at the operational land which contains soluble, suspended or miscible contaminants likely to have been derived from the said material.

"licensed place" means the mining activities carried out at the mining tenements detailed in Table 3 (page 3) of this environmental authority.

"**low consequence dam**" means any dam that is not a high or significant consequence category as assessed using the Manual for assessing consequence categories and hydraulic performance of structures (ESR/2016/1933).

"m" means metres.

"maintain" to keep in due condition, operation, or force.

"mandatory reporting level" or **"MRL"** means a warning and reporting level determined in accordance with the criteria in the *Manual for Assessing Consequence Categories and Hydraulic Performance of Structures (ESR/2016/1933)* published by the administering authority.

"Manual" means the *Manual for Assessing Consequence Categories and Hydraulic Performance of Structures* (ESR/2016/1933) published by the administering authority.

"measures" includes any measures to prevent or minimise environmental impacts of the mining activity such as bunds, silt fences, diversion drains, capping, and containment systems.

"metalliferous mine drainage" means any waters, contaminated with metals / metalloids or other contaminants as a result of the mining activity.

"mg/L" means milligrams per litre.

"mineral" means a substance which normally occurs naturally as part of the earth's crust or is dissolved or suspended in water within or upon the earth's crust and includes a substance which may be extracted from such a substance, and includes—

a) clay if mined for use for its ceramic properties, kaolin and bentonite;

b) foundry sand;
c) hydrocarbons and other substances or matter occurring in association with shale or coal and necessarily mined, extracted, produced or released by or in connection with mining for shale or coal or for the purpose of enhancing the safety of current or future mining operations for coal or the extraction or production of mineral oil there from;
d) limestone if mined for use for its chemical properties;
e) marble;
f) mineral oil or gas extracted or produced from shale or coal by in situ processes;
g) peat;
h) salt including brine;
i) shale from which mineral oil may be extracted or produced;
j) silica, including silica sand, if mined for use for its chemical properties;
k) rock mined in block or slab form for building or monumental purposes;

but does not include—

l) living matter;
m) petroleum within the meaning of the *Petroleum Act 1923*;
n) soil, sand, gravel or rock (other than rock mined in block or slab form for building or monumental purposes) to be used or to be supplied for use as such, whether intact or in broken form;
o) water.

"ML" means megalitres.

"mL" means millilitres.

"modification" or **"modifying"**(see definition of "construction")

"NAF waste rock" means non-acid forming waste rock.

"NATA" means National Association of Testing Authorities, Australia.

"natural flow" means the flow of water through waters caused by nature.

"non polluting" means having no adverse impacts upon the receiving environment.

"noxious" means harmful or injurious to health or physical well being.

"offensive" means causing reasonable offence or displeasure; is disagreeable to the sense; disgusting, nauseous or repulsive, other than trivial harm.

"operational plan" includes:

a) normal operating procedures and rules (including clear documentation and definition of process inputs in the DSA allowance);
b) contingency and emergency action plans including operating procedures designed to avoid and/or minimise environmental impacts including threats to human life resulting from any overtopping or loss of structural integrity of the regulated structure.

"PAF waste rock" means potentially acid forming waste rock with either a Net Acid Producing Potential of greater than 5 kg of H_2SO_4/tonne or a Net Acid Generation oxidation pH of less than 4.5 (pH unit).

"peak particle velocity (ppv)" means a measure of ground vibration magnitude which is the maximum rate of change of ground displacement with time, usually measured in millimetres/second (mm/s).

"performance" as it relates to site water balance, means the effectiveness of the water balance model to react to certain rainfall conditions.

"process water" means water used or produced during the mineral development activities.

"progressive rehabilitation" means rehabilitation (defined below) undertaken progressively or a staged approach to rehabilitation as mining operations are ongoing.

"protected area" means – a protected area under the *Nature Conservation Act 1992*; or

a) a marine park under the *Marine Parks Act 1992*; or
b) a World Heritage Area.

"receiving environment" means all groundwater, surface water, land, and sediments that are not disturbed areas authorised by this environmental authority.

"receiving waters" means all groundwater and surface water that are not disturbed areas authorised by this environmental authority.

"reference site" (or analogue site) may reflect the original location, adjacent area or another area where rehabilitation success has been completed for a similar biodiversity. Details of the reference site may be as photographs, computer generated images and vegetation models etc.

"Register of Regulated Structures" includes:

a) Date of entry in the register;
b) Name of the structure, its purpose and intended/actual contents;
c) The consequence category of the dam as assessed using the Manual for assessing consequence categories and hydraulic performance of structures (ESR/2016/1933);
d) Dates, names, and reference for the design plan plus dates, names, and reference numbers of all document(s) lodged as part of a design plan for the dam;
e) Name and qualifications of the suitably qualified and experienced person who certified the design plan and 'as constructed' drawings;
f) For the regulated dam, other than in relation to any levees –
   (i) The dimensions (metres) and surface area (hectares) of the dam measured at the footprint of the dam;
   (ii) Coordinates (latitude and longitude in GDA94) within five metres at any point from the outside of the dam including its storage area
   (iii) Dam crest volume (megalitres);
   (iv) Spillway crest level (metres AHD).
   (v) Maximum operating level (metres AHD);
   (vi) Storage rating table of stored volume versus level (metres AHD);
   (vii) Design storage allowance (megalitres) and associated level of the dam (metres AHD);
   (viii) Mandatory reporting level (metres AHD);
g) The design plan title and reference relevant to the dam;
h) The date construction was certified as compliant with the design plan;
i) The name and details of the suitably qualified and experienced person who certified that the constructed dam was compliant with the design plan;
j) Details of the composition and construction of any liner;
k) The system for the detection of any leakage through the floor and sides of the dam;
l) Dates when the regulated dam underwent an annual inspection for structural and operational adequacy, and to ascertain the available storage volume for 1 November of any year;
m) Dates when recommendations and actions arising from the annual inspection were provided to the administering authority;
n) Dam water quality as obtained from any monitoring required under this authority as at 1 November of each year.

"regulated structure" means any structure in the significant or high consequence category as assessed using the Manual for assessing consequence categories and hydraulic performance of structures (ESR/2016/1933) published by the administering authority. A regulated structure does not include:

- a fabricated or manufactured tank or container, designed and constructed to an Australian Standard that deals with strength and structural integrity of that tank or container;
- a sump or earthen pit used to store residual drilling material and drilling fluid only for the duration of drilling and well completion activities;
- a flare pit.

"regulated waste" means non-domestic waste mentioned in schedule 7 of the *Environmental Protection Regulation 1998* (whether or not it has been treated or immobilised), and includes:

a) for an element – any chemical compound containing the element; and
b) anything that has contained the waste.

"rehabilitation" the process of reshaping and revegetating land to restore it to a stable landform and in accordance with the acceptance criteria set out in this environmental authority and, where relevant, includes remediation of contaminated land.

"release event" means a surface water discharge from water storages or contaminated areas on the licensed place.

"representative" means a sample set which covers the variance in monitoring or other data either due to natural changes or operational phases of the mining activity.

"residual drilling material" means waste drilling materials including muds and cuttings or cement returns from well holes and which have been left behind after the drilling fluids are pumped out.

"RL" means reduced level, relative to mean sea level as distinct from depths to water.

"saline mine drainage" The movement of waters, contaminated with salt(s), as a result of the mining activity.

"self sustaining" means an area of land which has been rehabilitated and has maintained the required acceptance criteria without human intervention for a period nominated by the administering authority.

"sensitive place" means;

a) a dwelling, residential allotment, mobile home or caravan park, residential marina or other residential premises; or
b) a motel, hotel or hostel; or
c) an educational institution; or
d) a medical centre or hospital; or
e) a protected area under the *Nature Conservation Act 1992*, the *Marine Parks Act 1992* or a World Heritage Area; or
f) a public park or gardens.

"significant disturbance" – includes land;

a) if it is contaminated land; or
b) it has been disturbed and human intervention is needed to rehabilitate it;
   (i) to a state required under the relevant environmental authority; or
   (ii) if the environmental authority does not require the land to be rehabilitated to a particular state – to its state immediately before the disturbance.

Some examples of disturbed land include:

a) areas where soil has been compacted, removed, covered, exposed or stockpiled;
b) areas where vegetation has been removed or destroyed to an extent where the land has been made susceptible to erosion; (vegetation and topsoil)
c) areas where land use suitability or capability has been diminished;
d) areas within a watercourse, waterway, wetland or lake where the mining activity occur;
e) areas submerged by tailings or hazardous contaminant storage and dam/structure walls in all cases;
f) areas under temporary infrastructure. Temporary infrastructure includes any infrastructure (roads, tracks, bridges, culverts, dam/structures, bores, buildings, fixed machinery, hardstand areas, airstrips, helipads etc) which is to be removed after the mining activity have ceased; or
g) areas where land has been contaminated and a suitability statement has not been issued.

However, the following areas are not included:

a) areas off lease (e.g. roads or tracks which provide access to the mining lease);
b) areas previously significantly disturbed which have achieved the rehabilitation outcomes;
c) by agreement with the administering authority, areas previously significantly disturbed which have not achieved the rehabilitation objective(s) due to circumstances beyond the control of the mine operator (such as climatic conditions);
d) areas under permanent infrastructure. Permanent infrastructure includes any infrastructure (roads, tracks, bridges, culverts, dam/structures, bores, buildings, fixed machinery, hardstand areas, airstrips, helipads etc) which is to be left by agreement with the landowner. The agreement to leave permanent infrastructure must be recorded in the Landowner Agreement and lodged with the administering authority;
e) disturbances that pre-existed the grant of the tenure unless those areas are disturbed during the term of the tenure.

"subsoil", or substrata, is the layer of under the topsoil on the surface of the ground. The subsoil may include substances such as sand, silt and/or clay that has only been partially broken down by air, sunlight, water and wind, to produce true soil.

"spillway" means a weir, channel, conduit, tunnel, gate or other structure designed to permit discharges form the dam, normally under flood conditions or in anticipation of flood conditions.

"spotter/catcher" means a registered spotter catcher operating under a current Rehabilitation Permit as prescribed by the Qld. Nature Conservation Act 1992.

"structure" means dam or levee.

"suitably qualified and experienced person" in relation to regulated structures means a person who is a Registered Professional Engineer of Queensland (RPEQ) under the provisions of the *Professional Engineers Act 2002*, and has demonstrated competency and relevant experience:

a) for regulated dam/structures, an RPEQ who is a civil engineer with the required
   (i) qualifications in dam safety and dam design.
b) for regulated levees, an RPEQ who is a civil engineer with the required
   (i) qualifications in the design of flood protection embankments.

Note: It is permissible that a suitably qualified and experienced person obtain subsidiary certification from an RPEQ who has demonstrated competence and relevant experience in either geomechanics, hydraulic design or engineering hydrology.

"system design plan" means a plan that manages an integrated containment system that shares the required DSA volume across the integrated containment system.

"TBA" means to be advised.

"trivial harm" means environmental harm which is not material or serious environmental harm and will not cause actual or potential loss or damage to property of an amount of, or amounts totalling more than $5,000.

"µS/cm" means micro siemens per centimetre.

"void" means any constructed, open excavation in the ground.

"waste water" means used water from the mining activity, process water or contaminated storm water.

"watercourse" has the meaning in Schedule 4 of the Environmental Protection Act 1994 and means:

1) a river, creek or stream in which water flows permanently or intermittently—
   (a) in a natural channel, whether artificially improved or not; or
   (b) in an artificial channel that has changed the course of the watercourse.
2) Watercourse includes the bed and banks and any other element of a river, creek or stream confining or containing water.

"water quality" means the chemical, physical and biological condition of water.

"waters" includes all or any part of a river, stream, lake, lagoon, pond, swamp, wetland, unconfined surface water, unconfined water in natural or artificial watercourses, bed and banks of a watercourse, dams, non-tidal or tidal waters (including the sea), stormwater channel, stormwater drain, roadside gutter, stormwater run-off, and groundwater.

"wet season" means the time of year, covering one or more months, when most of the average annual rainfall in a region occurs. For the purposes of DSA determination this time of year is deemed to extend from 1 November in one year to 31 May in the following year inclusive.

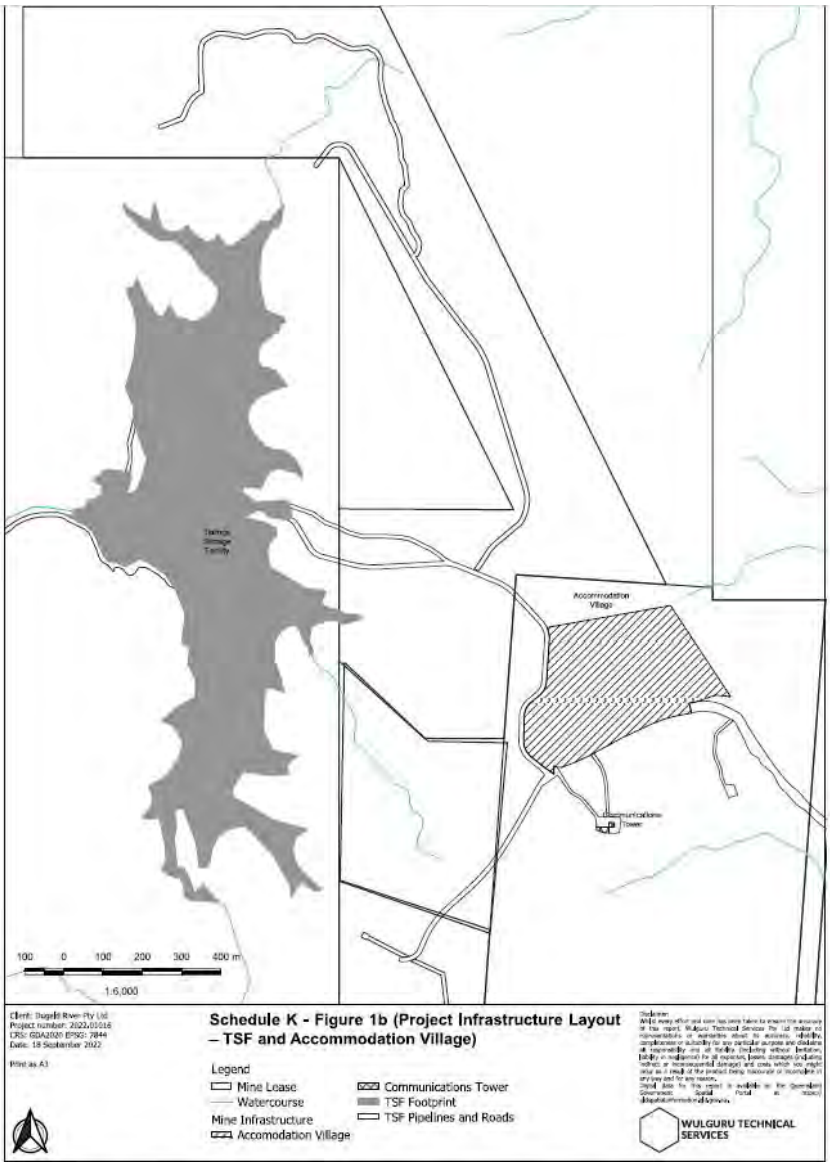
END OF DEFINITIONS FOR SCHEDULE J

Schedule K – Maps/Plans

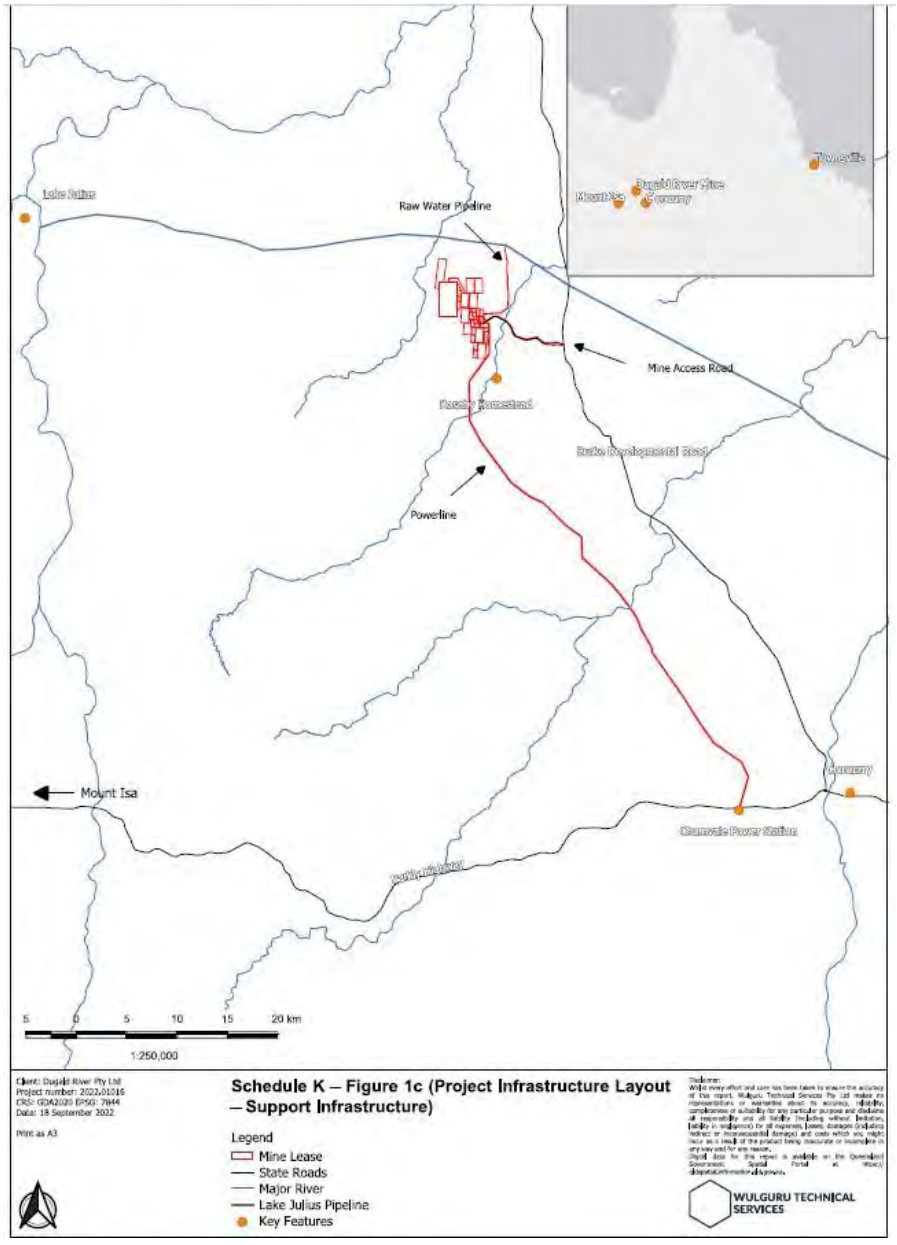
Schedule K – Figure 1a (Project Infrastructure Layout – Mine Infrastructure Area)



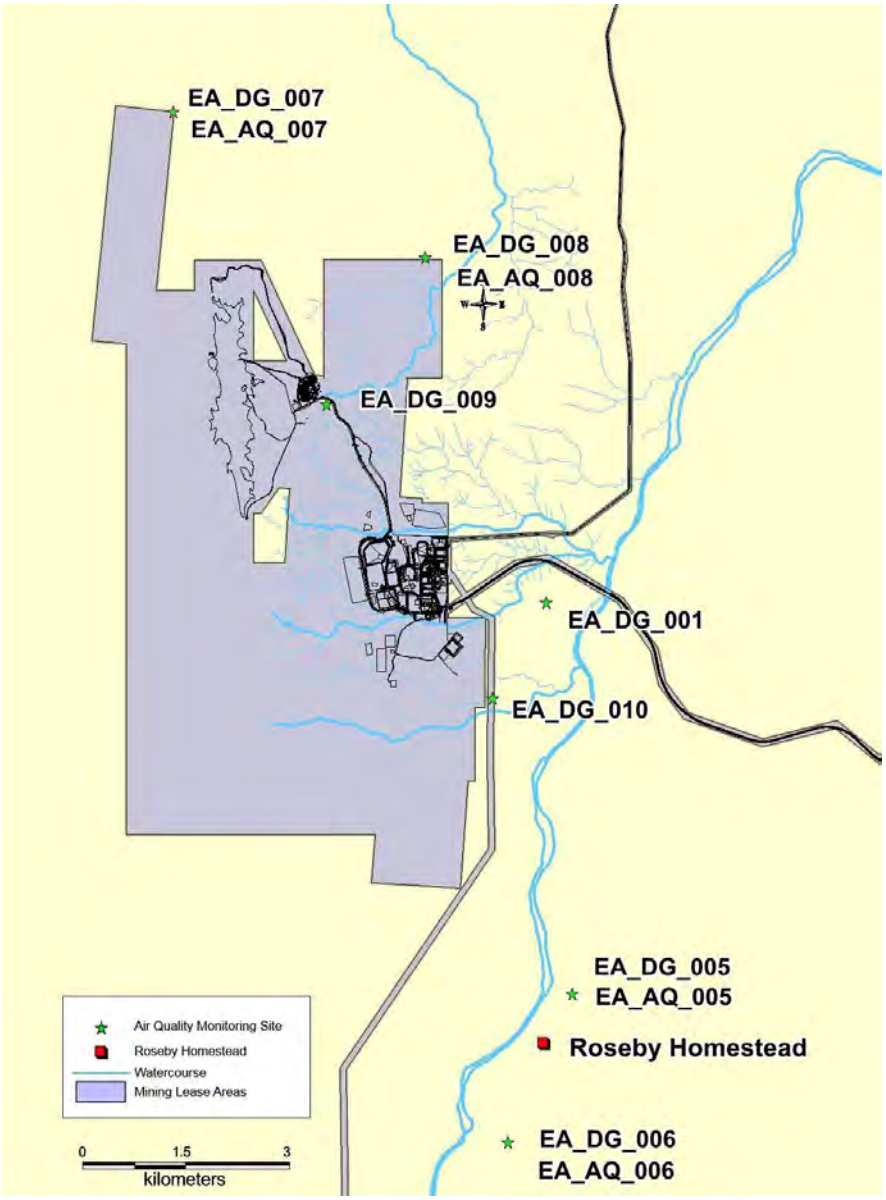
Schedule K – Figure 1b (Project Infrastructure Layout – TSF and Accommodation Village)



Schedule K – Figure 1c (Project Infrastructure Layout – Support Infrastructure)



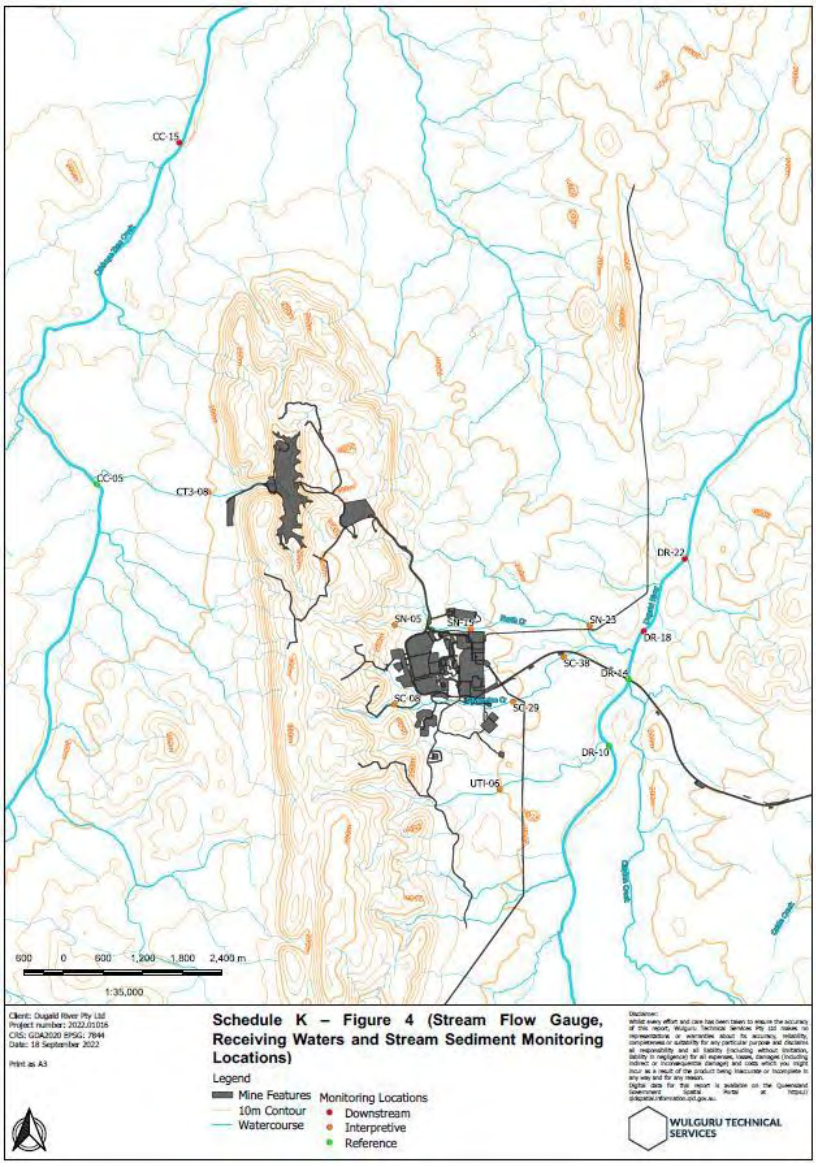
Schedule K – Figure 2 (Air Quality Monitoring Program Monitoring Locations)



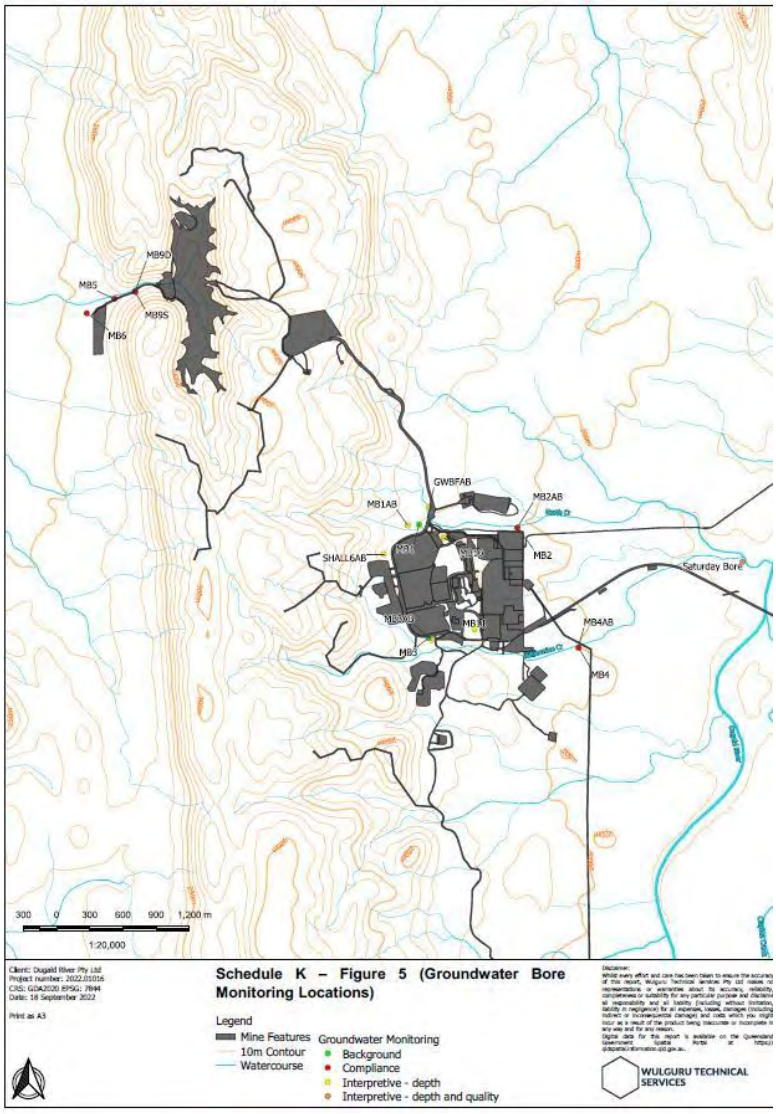
Schedule K – Figure 3 (Release Points and Water Storage Monitoring Locations)



Schedule K – Figure 4 (Stream Flow Gauge, Receiving Waters and Stream Sediment Monitoring Locations)



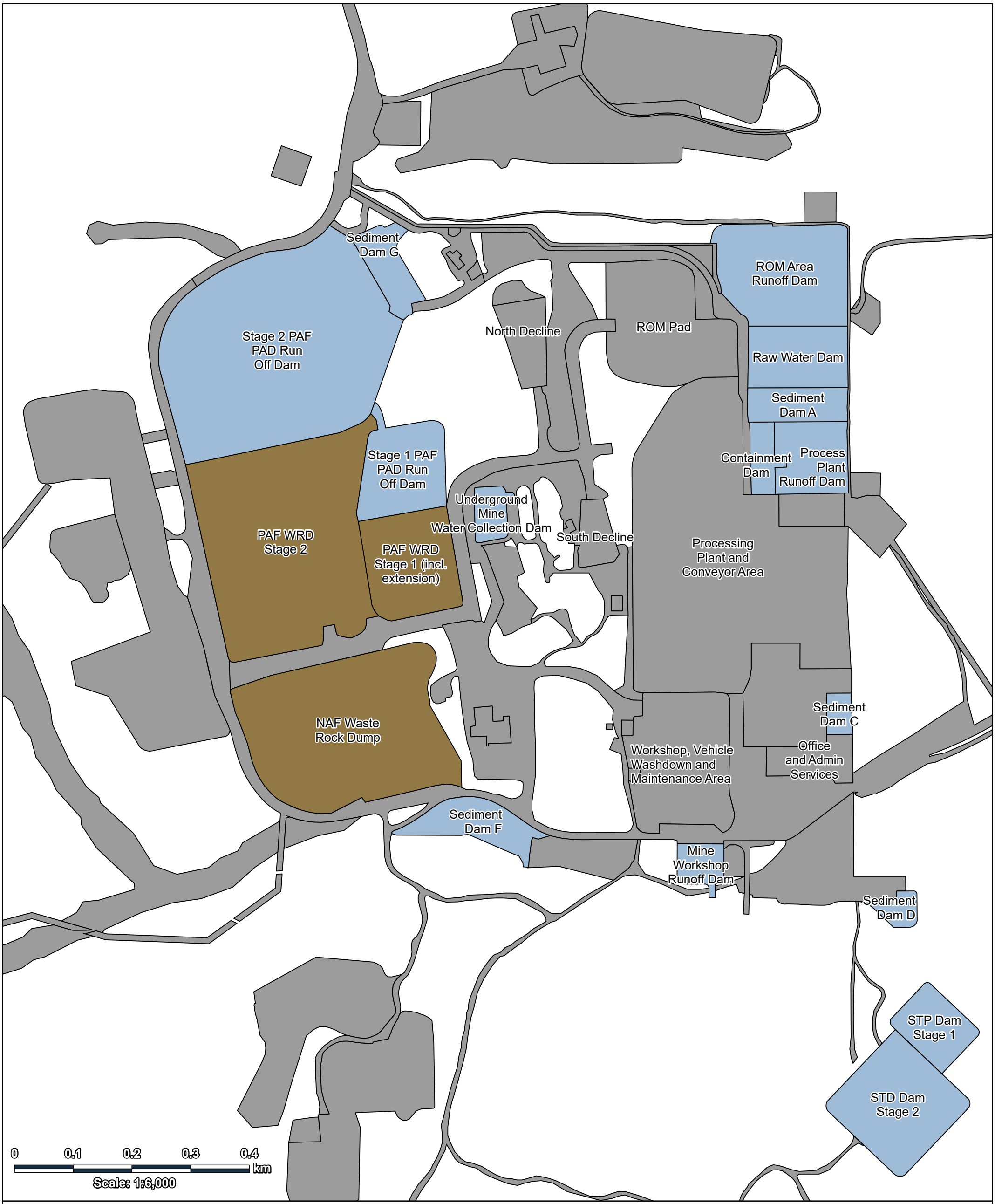
Schedule K – Figure 5 (Groundwater Bore Monitoring Locations)



END OF FIGURES FOR SCHEDULE K

END OF PERMIT

APPENDIX B: Revised Figures for Schedule K – Maps/Plans



Schedule K - Figure 1a (Project Infrastructure Layout - Mine Infrastructure Area)

Client: MMG Dugald River Pty Ltd
Project Number: 2023.03002
Publication Date: 30/11/2023

Spatial Reference
PCS: GDA2020 MGA Zone 54
GCS: GDA2020
Datum: GDA2020

Print on A3

Legend

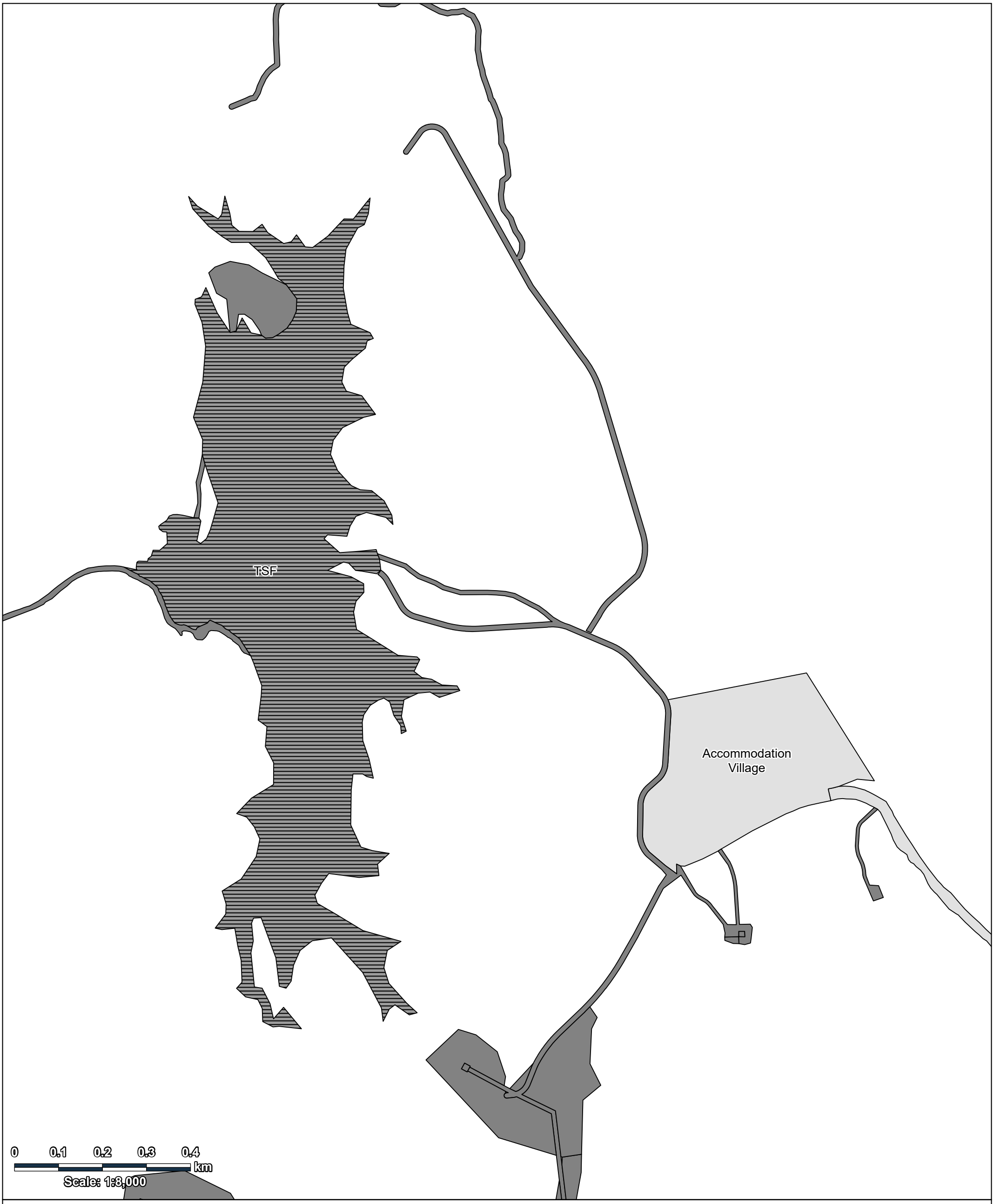
Schedule K Domain

- Mine Infrastructure Area
- Waste
- Water

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W:\2. GIS Projects\2023.03002 -MMG - EA Amendment Wind Farm\21_ArcGIS\SchedK\SchedKmaps.aprx



Schedule K - Figure 1b (Project Infrastructure Layout - TSF and Accommodation Village)

Client: MMG Dugald River Pty Ltd
Project Number: 2023.03002
Publication Date: 30/11/2023

Spatial Reference
PCS: GDA2020 MGA Zone 54
GCS: GDA2020
Datum: GDA2020

Print on A3

Legend

Mine Domain

- TSF
- Accommodation Village
- Mine Infrastructure

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EA_DG_007

EA_DG_008

EA_DG_009

EA_DG_001

EA_DG_010

EA_DG_005

Roseby Homestead

EA_DG_006

0 1 2 3 4 km

Scale: 1:45,000

Schedule K - Figure 2 (Air Quality Monitoring Program)

Client: MMG Dugald River Pty Ltd
Project Number: 2023.03002
Publication Date: 30/11/2023

Spatial Reference
PCS: GDA2020 MGA Zone 54
GCS: GDA2020
Datum: GDA2020

Print on A3

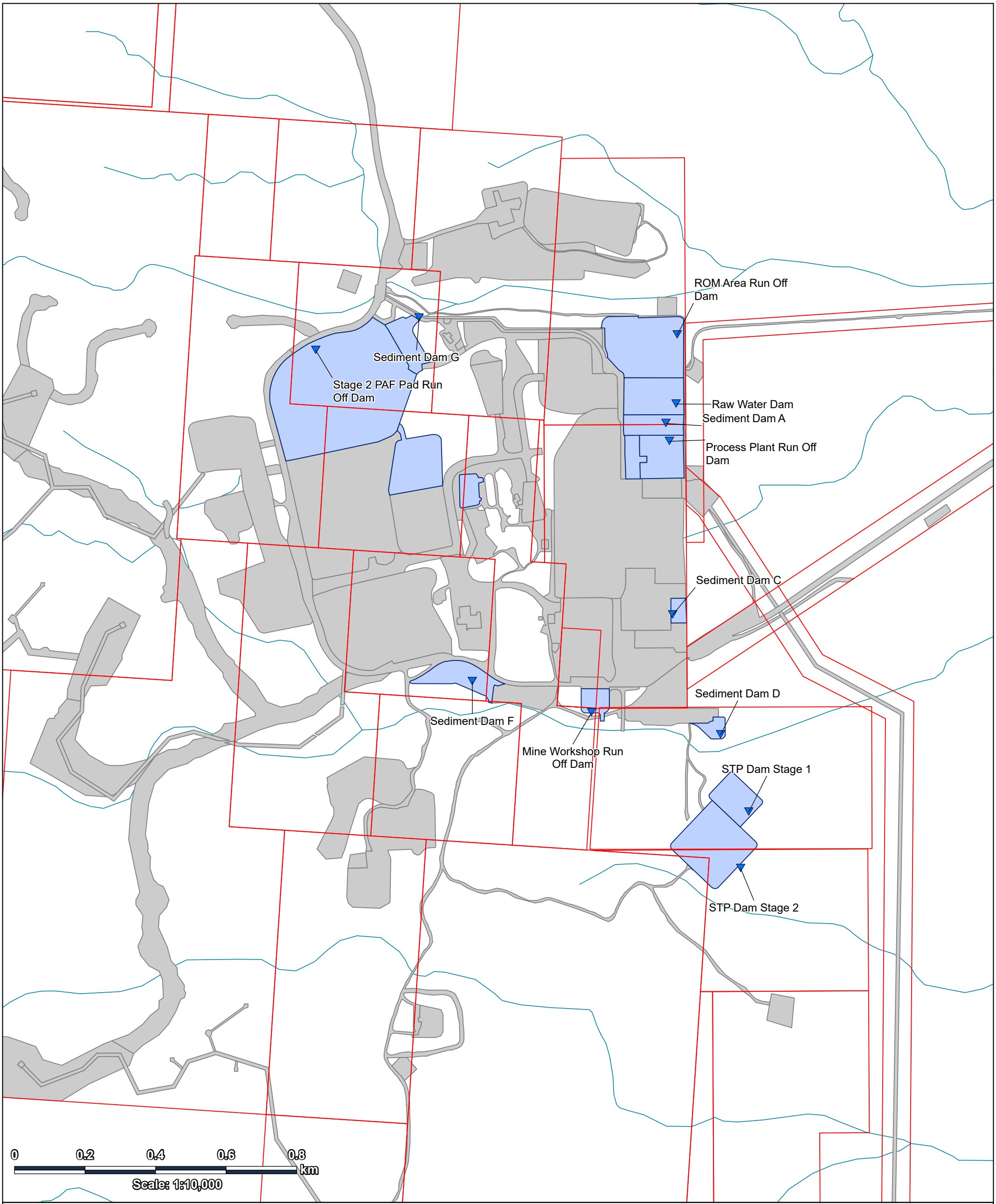
Legend

- Mining Lease
- Sensitive Receptor
- Air Quality
- Mine Footprint

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Schedule K - Figure 2 (Release Points and Water Storage Monitoring Locations)

Client: MMG Dugald River Pty Ltd
Project Number: 2023.03002
Publication Date: 30/11/2023

Spatial Reference
PCS: GDA2020 MGA Zone 54
GCS: GDA2020
Datum: GDA2020

Print on A3

Legend

- Mining Lease
- Mine Footprint
- Water Storage
- Water Storage Release Point
- Watercourse

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Tailings Storage Facility (TSF)

Seepage Collection Pond

ROM Area Run Off Dam

Sediment Dam A

Sediment Dam G

Raw Water Dam

Stage 2 PAF Pad Run Off Dam

Process Plant Run Off Dam

Sediment Dam C

Sediment Dam D

Sediment Dam F

Mine Workshop Run Off Dam

STP Dam Stage 1

STP Dam Stage 2

0 0.5 1 1.5 2 km

Scale: 1:20,000

Schedule K - Figure 2 (Release Points and Water Storage Monitoring Locations)

Client: MMG Dugald River Pty Ltd
Project Number: 2023.03002
Publication Date: 30/11/2023

Spatial Reference
PCS: GDA2020 MGA Zone 54
GCS: GDA2020
Datum: GDA2020

Print on A3

Legend

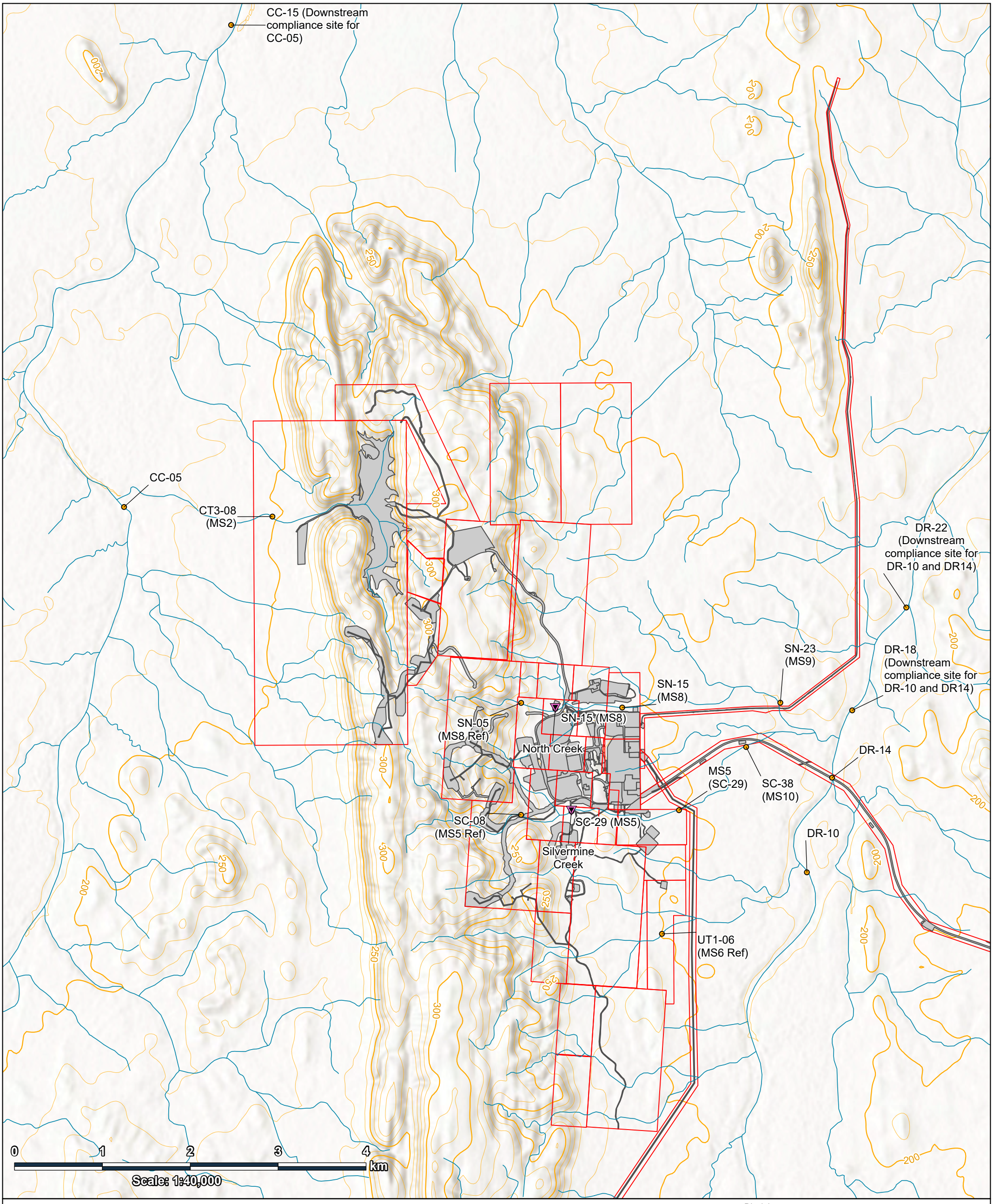
- Mining Lease
- Schedule K Domain
  - Mine Footprint
- Water Storage
- Water Storage Release Point
- Watercourse

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W:\2. GIS Projects\2023.03002 -MMG - EA Amendment Wind Farm\21_ArcGIS\SchedK\SchedKrecover.aprx



Schedule K - Figure 4 (Stream Flow Gauge, Receiving Waters and Stream Sediment)

Client: MMG Dugald River Pty Ltd
Project Number: 2023.03002
Publication Date: 30/11/2023

Spatial Reference
PCS: GDA2020 MGA Zone 54
GCS: GDA2020
Datum: GDA2020

Print on A3

Legend

- Mining Lease
- Mine Footprint
- Flow Gauge
- Surface Water & Sediment Monitoring
- Watercourse
- Contour (10m)

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Esri, Geoscience Australia, NASA, NGA, USGS

311 m
323 m
216 m
MB5
MB9D
MB9S
MB6
GWBFAB
MB1
MB1AB
MB2
MB2AB
SHALL6AB
MB3AB
MB3
MB4
MB4AB
0
0.5
1
1.5
2
km
Scale: 1:20,000

Client: MMG Dugald River Pty Ltd
Project Number: 2023.03002
Publication Date: 30/11/2023

Spatial Reference
PCS: GDA2020 MGA Zone 54
GCS: GDA2020
Datum: GDA2020

Print on A3

Schedule K - Figure 4 (Stream Flow Gauge, Receiving Waters and Stream Sediment)

Legend

- Mining Lease
- Mine Footprint
- Monitoring Bore
- Watercourse
- Contour (10m)

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Department of Resources, Dept.of Environment and Science, Esri, HERE, Garmin, Foursquare, METI/NASA, USGS, Esri, Geoscience Australia, NASA, NGA, USGS

APPENDIX C: Sediment Dam Spillways



Sediment Dam C Spillway



Sediment Dam D Spillway

APPENDIX D: Review of the Saturday Bore as a groundwater monitoring bore in the Environmental Authority (Rob Lait & Associates, 2023)

Rob Lait & Associates PTY LTD
ABN 15 127 209 965

27 Scheu Street
INNISFAIL
Queensland 4860
AUSTRALIA
Phone 617 4061 3103
Fax 617 4061 8094

RL/rl: (Dugald River Project Saturday Bore)
Project No. 116
June 2023

DUGALD RIVER MINING PROJECT

REVIEW OF SATURDAY BORE AS A GROUNDWATER MONITORING BORE IN THE ENVIRONMENTAL AUTHORITY

MMG LIMITED

TABLE OF CONTENTS

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1.0 INTRODUCTION

One of the groundwater monitoring bores that is currently in the Environmental Authority (EA) for the Dugald River mine site (Saturday Bore) has collapsed and is no longer serviceable for obtaining groundwater levels or groundwater quality parameters.

Rob Lait and Associates Pty Ltd (RLA) was requested by MMG Limited to provide comment on the requirement for Saturday Bore to be renewed and maintained in the Environmental Authority.

2.0 DUGALD RIVER MINE GROUNDWATER MONITORING BORE SUITE

Following a groundwater census of the area in March 2008 a suite of six groundwater monitoring bores was installed at the Dugald River Project late in 2008 to complement the data from the private bores in the area and previously drilled exploration bores.

The 2008 groundwater monitoring bores complemented the limited historical groundwater monitoring data that existed at the time. Since 2008 a further nine groundwater monitoring bores have been installed at Dugald River Mine.

The dedicated groundwater monitoring bores installed since 2008 have been constructed according to the Minimum Construction Standards for Water Bores In Australia[1].

The locations of the dedicated groundwater monitoring bores within the Dugald River project leases are shown in Figure 1.

RLA considers that the 15 dedicated groundwater monitoring bores within the Dugald River Mine leases comprehensively monitor groundwater conditions at the site.

[1] Australian Government, National Water Commission, National Uniform Drillers Licensing Committee. February 2012. MINIMUM CONSTRUCTION REQUIREMENTS FOR WATER BORES IN AUSTRALIA Third edition

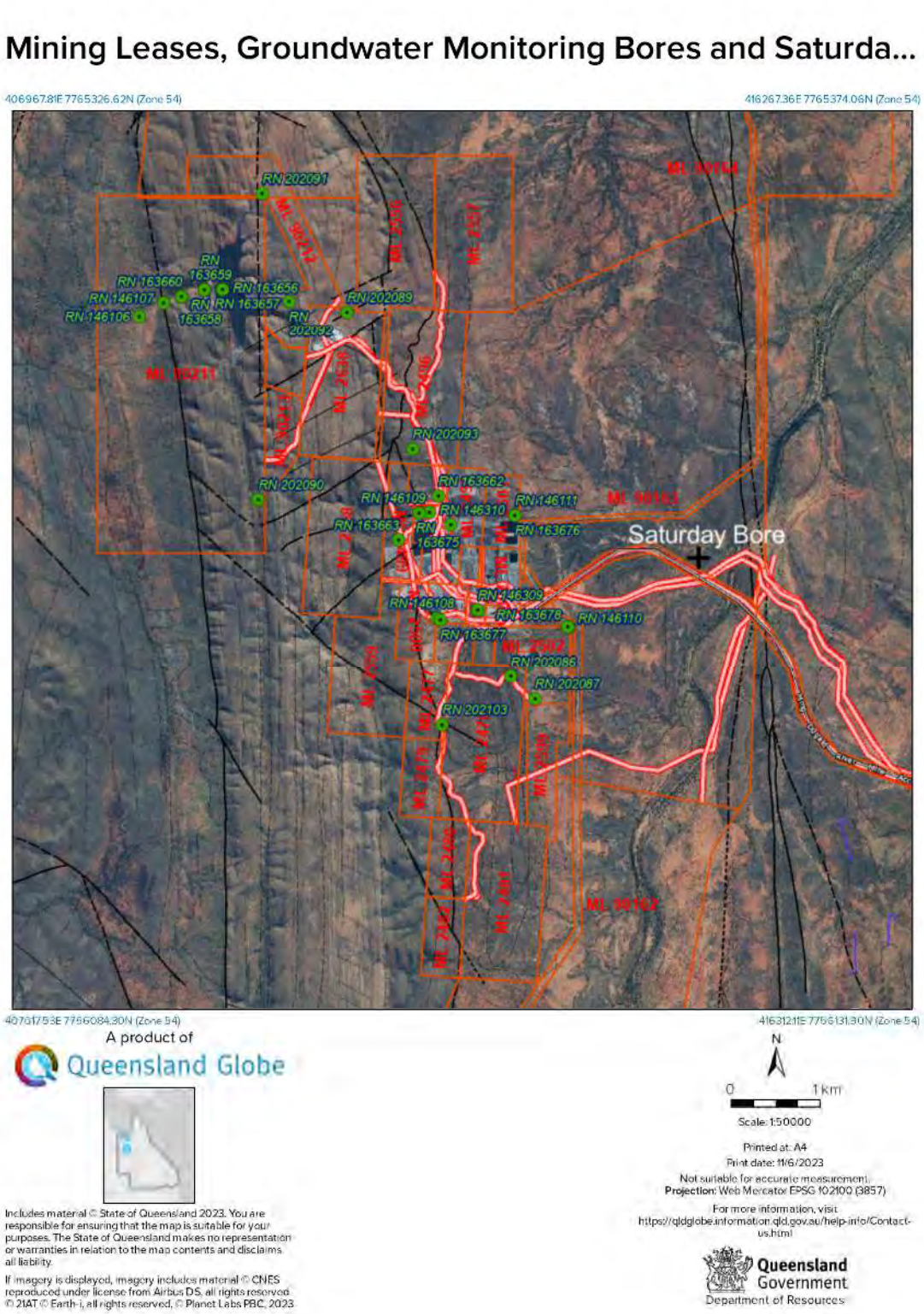


Figure 1: Location of Saturday Bore and Dugald River Mine Features

3.0 SATURDAY BORE AS PART OF THE EA

3.1 History of Saturday Bore

CRA[2] reported on groundwater in a 1989 exploration drilling program at Dugald River. Groundwater was intersected in broken vuggy ground at the calc-silicate/ black slate boundary and there were reports of loss of drilling fluids in deeper sections. This essentially indicates that, while fractures and void spaces exist at depth, these void spaces are not filled with significant volumes of groundwater.

The first dedicated groundwater exploration program commenced in 1990 with 15 groundwater locations being assessed. Groundwater yield, depth and quality were recorded[3]. The bores drilled during that investigation have several names. Saturday Bore (also known as SB1) was the most successful of the bores drilled during the 1990 program. As a result, it was used as a groundwater supply for drilling exploration activities. No drilling and construction details are available for Saturday Bore other than the fact that it was originally 36m deep and lined with 125mm internal diameter PVC casing.

Mackie Martin & Associates [4] analysed the results of a formal pumping test on Saturday Bore. The pumping test showed that dewatering of the aquifer was occurring after approximately 400 minutes, indicating that the volume of water in storage would be limited and not able to satisfy long term demand for any industrial purposes.

CRA Exploration Pty. Ltd[5] (CRA) suggested that Saturday Bore was located in a zone of structural weakness which would most likely be fed by the Dugald River.

3.2 Original Intention

In 2008 Saturday Bore was considered valuable from a historical perspective and potentially for assessing impacts of mining and processing and it was included in the groundwater monitoring bore suite until more comprehensive groundwater data could be obtained for assessing the impacts of Dugald River Mine.

3.3 Saturday Bore Construction

Saturday Bore was not constructed according to the Minimum Construction Requirements for Water Bores in Australia as no such requirements existed when it was installed. No construction details for Saturday Bore exist but it is likely that the borehole annulus around the casing was filled with gravel from total depth (36m) to ground surface. No grout envelope exists at the surface and the bore is therefore vulnerable to direct contamination from any source.

---

[2] CRA Exploration Pty. Ltd. Dugald River Lead Zinc Project, Report on the 1989 Diamond Drill Program (DD89DR90 to DD89DR178), including geological interpretation and geochemical results. Sheppard W.A. and Hawkes N. April 1990 Volume 1.
[3] CRA Exploration Pty. Ltd., Note from Steve Allnutt, Dugald Camp to Ian Bell MINENCO Pty. Ltd. 19th August 1990.
[4] Fax from Mackie Martin & Associates to Steve Allnutt CRA 11th August 1990.
[5] CRA Exploration Pty. Ltd. Note to Locon Wall , AGC Woodward Clyde, from Steve Allnutt, 19th March 1991. Re: Groundwater in the Dugald River Project Environs.

3.4 Hydrogeological Sequence

Saturday Bore is constructed within the Roseby Schist which consists of calcareous and scapolitic metasediments of mixed greenschist to amplibolite metamorphic grade. This is the same geological formation and lithologies that monitoring bores MB2 and MB4 are constructed in (RN 146111 and RN 146110 respectively – Figure 1).

There is very little primary porosity within the Roseby Schist and water-bearing sequences only occur within fractures. The effective porosity of the Roseby Schist is assumed to be 1%.

Groundwater occurs in fractures, joints, solution channels and along bedding planes (secondary porosity).

Figure 1 also shows that there is no structural connection (faulting) between Saturday Bore and the Dugald River mine.

Groundwater monitoring data collected by MMG since 2008 indicate that that there is little, if any, significant hydraulic connectivity in the 1.8km between MB4 / MB4 and Saturday Bore.

3.5 Groundwater Levels

Figure 2 shows the comparison of groundwater elevations from monitoring carried out since 2013. Groundwater level behaviour in both bores is broadly similar. Therefore, MB2 is considered to adequately inform on aquifer conditions in the eastern portion of the Dugald River leases. Saturday Bore is surplus to requirement for groundwater levels.

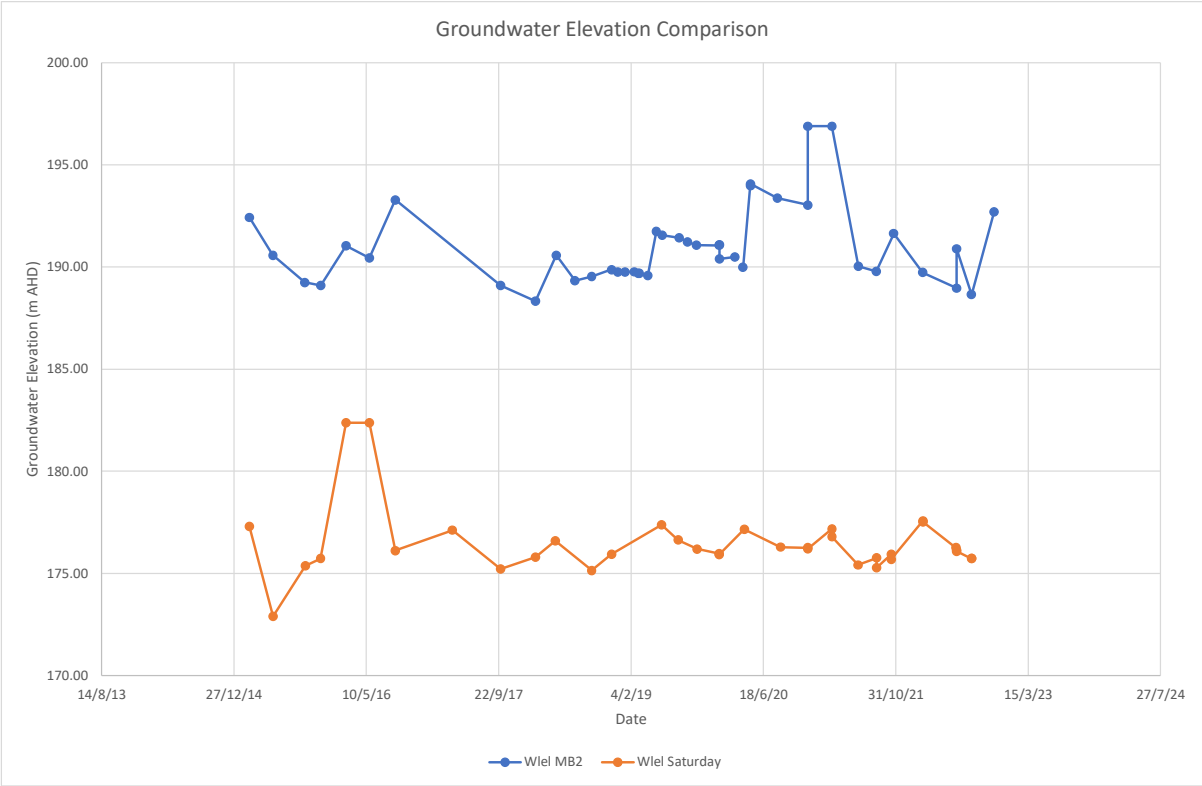


Figure 2: Groundwater Elevation Comparison MB2 and Saturday Bore

3.6 Groundwater Flow

Figure 2 shows that the groundwater elevation in MB2 is between 10 and 15m higher than that in Saturday Bore. Therefore, if hydraulic connectivity existed between MB2 and Saturday Bore, groundwater flow would be from west to east.

The hydraulic conductivity (or permeability) of the Roseby Schist sequence in the 2008 groundwater monitoring bores was measured by a program of falling head permeability tests in 2010. Table 1 shows the results obtained from that program.

TABLE 1: AQUIFER HYDRAULIC CONDUCTIVITY OF THE ROSEBY SCHIST				
Bore Identifier	***Aquifer Transmissivity***	***Aquifer Permeability***	***Aquifer Permeability***	***Aquifer Permeability***
	m^2/day	***m/day***	***m/s***	***cm/s***
MB1	5.88×10^{-4}	7.53E-06	8.71E-11	8.71E-09
MB2	3.18×10^{1}	4.08E-01	4.72E-06	4.72E-04
MB3	2.29×10^{1}	2.60E-01	3.01E-06	3.01E-04
MB4	4.06×10^{0}	7.52E-02	8.70E-07	8.70E-05
MB5	7.19×10^{0}	9.21E-02	1.07E-06	1.07E-04
MB6	1.73×10^{-1}	2.23E-03	2.58E-08	2.58E-06

In general, the hydraulic conductivity of the Roseby Schist is very low. The groundwater gradient in the Roseby Schist to the east of the Dugald River mine leases (calculated from the MB2 and Saturday Bore measurements) is 0.009 which is typical of a low bulk permeability aquifer sequence. Assuming an effective porosity of 1% the groundwater flow velocity from MB2 to Saturday Bore is of the order of 0.2m/day. Therefore, groundwater would take 23.6 years to travel from MB2 to Saturday Bore if the hydraulic conductivity remained everywhere consistent. It is doubtful that this is the case and significant groundwater flow from west to east appears to not be occurring.

3.7 Groundwater Quality

Table 2 shows the comparison of groundwater quality between MB2 and Saturday Bore.

Notably the electrical conductivity, and the concentrations of copper, manganese, iron and nickel are higher in the groundwater from Saturday Bore than in the groundwater from MB2.

It is reasonable to contend that the groundwater quality in Saturday Bore is poorer than the groundwater quality from MB2.

It is therefore assessed that the groundwater from the Dugald River leases is having no impact of the groundwater quality at Saturday Bore. This suggests that there is very little, if any hydraulic connection between the two features.

TABLE 2: GROUNDWATER QUALITY COMPARISON MB2 AND SATURDAY BORE						
		MB2		***Saturday***		***Comparison***
Analyte	***Units***	***No of Results***	***Result***	***No of Results***	***Result***	
Electrical Conductivity (Lab)	µS/cm	102	1,040	23	1,700	SB higher
pH (Lab)	pH unit	107	7.53	23	7.53	same
Total Dissolved Solids	mg/L	140	662	25	1,010	SB higher
Suspended Solids	mg/L	130	2.5	24	2.5	same
Turbidity	NTU	38	0.2	14	1.6	SB higher
Sulfate as SO4 - Turbidimetric (filtered)	mg/L	139	139	24	134.5	lower
Sulphur as S (filtered)	mg/L	7	110	1	47	lower
Bicarbonate as CaCO3	mg/L	112	330.5	22	553	SB higher
Chloride	mg/L	139	51	24	165.5	SB higher
Fluoride	mg/L	138	1.4	24	1.7	SB higher
Calcium (filtered)	mg/L	133	95	24	77	lower
Magnesium (filtered)	mg/L	133	42	24	53.5	SB higher
Potassium (filtered)	mg/L	133	5	24	4	lower
Sodium (filtered)	mg/L	133	76	24	232	SB higher
Total Hardness as CaCO3	mg/L	7	460	1	410	lower
Total Hardness as CaCO3 (filtered)	mg/L	117	412	23	412	lower
Carbonate Alkalinity as CaCO3	mg/L	112	0.5	22	0.5	lower
Hydroxide Alkalinity as CaCO3	mg/L	112	0.5	22	0.5	lower
Total Alkalinity as CaCO3	mg/L	112	331.5	22	553	SB higher
Aluminium	mg/L	132	0.005	24	0.005	same
Aluminium (filtered)	mg/L	134	0.005	24	0.005	same
Arsenic	mg/L	137	0.0005	24	0.0005	same
Arsenic (filtered)	mg/L	139	0.0005	24	0.0005	same
Cadmium	mg/L	137	0.00005	24	0.00005	same
Cadmium (filtered)	mg/L	138	0.00005	24	0.00005	same
Copper	mg/L	137	0.012	24	0.0005	lower
Copper (filtered)	mg/L	139	0.003	24	0.0005	lower
Iron	mg/L	12	0.025	6	0.125	SB higher
Iron (filtered)	mg/L	12	0.025	6	0.055	SB higher
Lead	mg/L	137	0.0005	24	0.0005	same
Lead (filtered)	mg/L	139	0.0005	24	0.0005	same
Manganese	mg/L	136	0.0355	24	0.589	SB higher
Manganese (filtered)	mg/L	136	0.031	24	0.566	SB higher
Nickel	mg/L	137	0.0005	24	0.00075	SB higher
Nickel (filtered)	mg/L	139	0.0005	24	0.0005	same
Zinc	mg/L	137	0.0025	24	0.0025	same

TABLE 2: GROUNDWATER QUALITY COMPARISON MB2 AND SATURDAY BORE						
		MB2		***Saturday***		***Comparison***
Analyte	***Units***	***No of Results***	***Result***	***No of Results***	***Result***	
Zinc (filtered)	mg/L	139	0.0025	24	0.0025	same

4.0 CONCLUSIONS

This review has reached the following conclusions:

1. Saturday Bore was not constructed according to the Minimum Construction Requirements for Water Bores in Australia as no such requirements existed when it was installed. No construction details for Saturday Bore exist other than the fact that it was originally 36m deep and lined with 125mm internal diameter PVC casing. It is likely that the borehole annulus around the casing was filled with gravel from total depth (36m) to ground surface. No grout envelope exists at the surface and the bore is therefore vulnerable to direct contamination from any source.

2. Fifteen dedicated groundwater monitoring bores installed since 2008 have been constructed within the Dugald River Mine leases according to the Minimum Construction Standards for Water Bores In Australia[6] since 2008. This suite of bores comprehensively monitors groundwater conditions at the site.

3. MB2 adequately informs on aquifer conditions in the eastern portion of the Dugald River leases. Saturday Bore is surplus to requirement for groundwater levels.

4. Saturday Bore is constructed within the Roseby Schist which consists of calcareous and scapolitic metasediments of mixed greenschist to amplibolite metamorphic grade. This is the same geological formation and lithologies that monitoring bores MB2 and MB4 are constructed in (RN 146111 and RN 146110 respectively).

5. There is very little primary porosity within the Roseby Schist and water-bearing sequences only occur within fractures. The effective porosity of the Roseby Schist is assumed to be 1%. Groundwater occurs in fractures, joints, solution channels and along bedding planes (secondary porosity).

6. There is no structural connection (faulting) between Saturday Bore and the Dugald River mine.

7. There is little, if any, significant hydraulic connectivity in the 1.8km between MB4 / MB4 and Saturday Bore. the groundwater elevation in MB2 is between 10 and 15m higher than that in Saturday Bore.

8. If hydraulic connectivity existed between MB2 and Saturday Bore, groundwater flow would be from west to east. Groundwater monitoring data suggest that there is very little, if any hydraulic connection between the two features and there is no evidence to suggest that significant west to east groundwater flow is occurring.

[6] Australian Government, National Water Commission, National Uniform Drillers Licensing Committee. February 2012. MINIMUM CONSTRUCTION REQUIREMENTS FOR WATER BORES IN AUSTRALIA Third edition

9. The groundwater quality in Saturday Bore is poorer than the groundwater quality from MB2.

10. It is assessed that the groundwater from the Dugald River leases is having no impact of the groundwater quality at Saturday Bore.

11. Both MB2 and MB4 monitor the same hydrogeological regime as Saturday Bore and there would be no reduction in the mechanism for assessment of the hydrogeological regime to the east of the Dugald River mine processing plant if Saturday Bore was to be removed from the EA,.

12. Even if Saturday Bore was serviceable RLA considers it to be superfluous. Removal of Saturday Bore from the EA will not diminish the effectiveness of groundwater monitoring at the Dugald River site.

5.0 RECOMMENDATION

It is recommended that Saturday Bore should be removed from the Dugald River Mine Environmental Authority groundwater monitoring bore suite.



ROB LAIT
Principal Hydrogeologist
Rob Lait and Associates Pty Ltd

APPENDIX E: Aluminium Dataset

APPENDIX F: PAF 2 Run Off Dam Consequence Category Assessment (ATC Williams, 2023)

Instructions

Delete the existing data in the template and add your data. Use the right template for the format of your data. DO NOT change the column headings or sheet names (except if indicated below). Column can be left
The sheets within the excel data template include:

Monitoring Points – enter the water quality monitoring points and the associated spatial coordinates

Type: can be groundwater, surface water or on-site storage.

Group: this is used to group monitoring points together. E.g. compliance, reference, upstream,

Basin: refers to the Queensland river basin or groundwater zone

Surface RL (m), install date, depth (m) screened section (m): applicable to groundwater bores

Stream: applicable to surface water, the name of the waterbody. E.g. Deep Creek or Isaac River.

Raw Data – all raw data. If indicators are missing from the template. Add the new indicator. Standing Water level (m) or flow (m^3/s) can be added in this sheet. If data is not available for an indicator the column can be

Major Ions – add major ion data here for piper plot analysis. This feature is not available yet.

Rainfall – Add rainfall data if available.

Guideline – Common guideline values have been included in this sheet. Additional guidelines can be added.

Outliers Removed – Initially copy all data from the raw data sheet into this sheet. After the raw data has been imported in the Power BI file go to the outlier analysis page. On this page the outliers are determined by comparing the maximum value for each monitoring point with the mean + 4*standard deviation (SD). An x in the outlier column identifies that there is potentially an outlier in the raw dataset.

Group summary stats – Initially leave blank until the summary statistics have been calculated in Power BI. Export the summary statistics for “Group monitoring points” calculated in the Summary Stats page in Power BI as a .csv file. Copy this data into the Group summary stats sheet.

Individual summary stats - Initially leave blank until the summary statistics have been calculated in Power BI. Export the summary statistics for “Each monitoring point” calculated in the Summary Stats page in Power BI

DO NOT change column headings. Latitude and longitude must be added as decimal degrees. Only en

Monitoring Point	Type	Group	Basin	Stream	latitude
CC-05	Surface	Reference	Leichhardt	Cabbage Tree Creek	-20.223931
DR-10	Surface	Reference	Flinders	Dugald River	-20.261856
DR-14	Surface	Reference	Flinders	Dugald River	-20.252137

ıter relevant data, columns can be left blank.

longitude	Surface RL (m)	Install Date	Depth (m)	Screened Section (m)
140.103722				
140.177892				
140.180691				

DO NOT change column headings. Values in the Data columns must be a number. If < is entered in a cell it wi

Monitoring Point	Date	DO % Saturation (Field)	Dissolved Oxygen - % Saturation	Electrical Conductivity (field) (µS/cm)	Electrical Conductivity (Lab) (µS/cm)	Electrical Conductivity @ 25oC (µS/cm)	Electrical Conductivity (Non Compensated) (µS/cm)	pH (Field)	pH (Lab)
CC-05	11 Jan 2015				126				7.94
CC-05	03 Jan 2016	73		197.3	234	191.8327662		7.53	7.99
CC-05	04 Jan 2016	73		320.7	280	299.1046447		7.66	8.17
CC-05	05 Jan 2016	78		360	312	329.9120235		7.95	8.24
CC-05	07 Jan 2016	202.5		380.7	51	326.1651816		8.15	7.61
CC-05	08 Jan 2016	126.6		339.1	350	309.1439511		8.24	8.44
CC-05	01 Feb 2016	49.2		182	159	165.0643933		7.78	8.05
CC-05	14 Feb 2016	58		253	229	235.1301115		8.08	7.89
CC-05	10 Mar 2016	41.5		149	122	127.2416738		8.01	7.78
CC-05	05 Mar 2018	15		122.3	92	111.3032399		7.21	7.43
CC-05	06 Mar 2018	21.6		137.7	106	128.884313		7.06	7.5
CC-05	18 Mar 2018	37.7		300.8	274	294.0946422		8.66	8.07
CC-05	19 Mar 2018	88.7		321.8	272	298.5434641		8.95	8.41
CC-05	20 Mar 2018	81.2		322	281	298.203371		8.85	8.43
CC-05	11 Feb 2019	61		502	433	483.6223507		7.8	8.1
CC-05	12 Feb 2019	101		495	376	429.6875		8.2	8.2
CC-05	13 Feb 2019	140		541	377	465.7770125		8.33	8.1
CC-05	27 Jan 2020	78.3		84.4				7.37	
CC-05	27 Jan 2020				80				6.92
CC-05	28 Jan 2020	86.2		106				7.5	
CC-05	28 Jan 2020				98				7.34
CC-05	02 Feb 2020	98.2		227.1				7.9	
CC-05	02 Feb 2020				194				8.07
CC-05	03 Feb 2020	89.6		163.3				7.71	
CC-05	03 Feb 2020				149				7.86
CC-05	08 Feb 2020	84		191.9				8.1	
CC-05	08 Feb 2020				183				8.05
CC-05	06 Mar 2020				139				7.75
CC-05	08 Mar 2020				223				8.19
CC-05	24 Dec 2020	85.4		105.8				7.61	
CC-05	24 Dec 2020				98				7.03
CC-05	07 Feb 2023				97				7.26
CC-05	15 Mar 2023				400				8.11
CC-05	16 Mar 2023				445				8.16
CC-05	17 Mar 2023				479				8.33
CC-05	18 Mar 2023				516				8.31
CC-05	19 Mar 2023				516				8.36
DR-10	19 Dec 2015	42.6		87.2	94	87.0346342		7.16	7.26

DR-10	31 Dec 2015	77	111.7	112	109.0075144	7.49	7.65
DR-10	01 Jan 2016	65	169	158	163.7120992	7.61	7.88
DR-10	02 Jan 2016	84.7	109	103	105.9795819	7.54	7.76
DR-10	03 Jan 2016	81	145	171	142.8289992	7.51	7.95
DR-10	04 Jan 2016	63	241	219	234.3218279	7.59	7.89
DR-10	05 Jan 2016	58	297	261	284.0474369	7.73	8.09
DR-10	06 Jan 2016	61.3	324.7	302	306.0897436	7.6	8.23
DR-10	07 Jan 2016	63	347.7	325	332.5363428	7.6	8.5
DR-10	08 Jan 2016	55	368.5		347.3793363	7.8	
DR-10	09 Jan 2016	56.3	397.7	369	370.9196046	7.75	8.36
DR-10	10 Jan 2016	46.5	444	392	404.7770991	7.49	8.16
DR-10	11 Jan 2016	28	456.3	396	415.9905187	7.28	8.18
DR-10	12 Jan 2016	71.9	137	139	132.2266191	7.63	7.82
DR-10	16 Jan 2016	41	257		238.0070383	7.61	
DR-10	31 Jan 2016	34.2	569	492	504.7458529	7.57	8.23
DR-10	14 Feb 2016	50.4	449	400	415.817744	7.63	7.99
DR-10	05 Mar 2016	20	104.8	116	106.8297655	8.03	7.75
DR-10	06 Mar 2016	14.6	139.4	119	133.5632845	7.64	7.81
DR-10	07 Mar 2016	8.3	142.1	136	136.398541	7.9	7.83
DR-10	08 Mar 2016	3.8	155.3	141	147.4553741	7.46	7.63
DR-10	09 Mar 2016	85.4	171	152	147.464643	8.12	7.72
DR-10	10 Mar 2016	8.5	290	136	276.3483896	7.75	7.65
DR-10	11 Mar 2016	39	202	138	188.064426	7.91	7.8
DR-10	12 Mar 2016	55	111	93	108.7275933	8.2	7.61
DR-10	13 Mar 2016	48	130	116	124.1050119	7.72	7.74
DR-10	14 Mar 2016	55	98.2	90	93.57728226	7.46	7.69
DR-10	15 Mar 2016	47	124.5	110	115.5023657	7.48	7.85
DR-10	16 Mar 2016	44	134	124	128.1560826	6.99	7.89
DR-10	17 Mar 2016	54	158	170	147.3605671	7.6	8.08
DR-10	18 Mar 2016	46	111	173	102.7968142	7.3	8.08
DR-10	19 Mar 2016	22.7	185	168	174.7096043	7.55	8.07
DR-10	20 Mar 2016	42	159	169	150.6966164	7.2	8.09
DR-10	21 Mar 2016	44	178.6	182	174.6186938	7.64	8.08
DR-10	23 May 2016	40.4	62.2	71	65.04235073	8.45	7.06
DR-10	24 May 2016	23.9	77.7	63	81.90154949	8.43	7.11
DR-10	25 May 2016	0.5	89.3	77	93.56663873	6.4	7.25
DR-10	09 Mar 2017	60.1	147.6	96	133.4056399	7.91	7.46
DR-10	10 Mar 2017			136	0		7.66
DR-10	11 Mar 2017			160			7.85
DR-10	12 Mar 2017			175			8.01
DR-10	13 Mar 2017			200			8.01
DR-10	14 Mar 2017			209			7.67
DR-10	16 Mar 2017			207			7.83
DR-10	17 Mar 2017			212			7.82
DR-10	18 Mar 2017			215			7.82
DR-10	19 Mar 2017			217			7.87
DR-10	20 Mar 2017			221			7.91
DR-10	20 Mar 2017			222			7.8
DR-10	21 Mar 2017	41	250.6	209	232.8996283	7.26	7.67
DR-10	12 Mar 2018		191.9	162	172.8517384	7.53	7.78

DR-10	15 Mar 2018	60.9	260.7	243	256.3169796	8.17	7.93
DR-10	17 Mar 2018	56.9	306.6	266	288.510398	8.18	7.94
DR-10	18 Mar 2018	40.9	323.9	286	308.0947398	8.41	7.84
DR-10	19 Mar 2018	45	340.5	299	322.7182258	8.46	7.92
DR-10	20 Mar 2018	47.4	345.1	308	330.6505701	8.67	7.83
DR-10	21 Mar 2018	46.5	359.9	328	343.5799523	8.7	7.89
DR-10	22 Mar 2018	480.8	379.5	330	342.4163133	7.9	8.06
DR-10	23 Mar 2018	461.4	343.2	328	314.516129	7.9	8.03
DR-10	20 Feb 2019	70	784	572	702.571915	8	8.26
DR-10	21 Feb 2019	90.5	803	602	720.8258528	8	8.13
DR-10	22 Feb 2019	93.6	862	610	754.4857768	8.19	8.32
DR-10	23 Feb 2019	88.8	888	634	777.2428884	8.13	8.34
DR-10	24 Feb 2019	88.2	878	640	762.1527778	8.16	8.25
DR-10	25 Feb 2019	85.2	877	649	767.6148796	8.16	8.19
DR-10	26 Feb 2019	65.7	888	701	826.7386649	8.08	8.18
DR-10	27 Feb 2019	94	1,000	697	866.6262241	8.2	8.33
DR-10	28 Feb 2019	81.7	5.92	701	5.130427247	8.18	8.35
DR-10	01 Mar 2019	63.4	900	730	797.0244421	8.06	8.24
DR-10	02 Mar 2019	64.1	709	745	618.5117334	8.13	8.23
DR-10	27 Jan 2020	81	59.5			7.58	
DR-10	27 Jan 2020			64			6.91
DR-10	28 Jan 2020	78.3	116.6			7.6	
DR-10	28 Jan 2020			113			7.17
DR-10	02 Feb 2020	94	203.8			7.7	
DR-10	02 Feb 2020			179			7.95
DR-10	03 Feb 2020	100.7	230.8			7.87	
DR-10	03 Feb 2020			209			8.03
DR-10	04 Feb 2020	80.9	121.7			7.5	
DR-10	04 Feb 2020			118			7.68
DR-10	05 Feb 2020	85.9	109.8			7.7	
DR-10	05 Feb 2020			105			7.76
DR-10	06 Feb 2020	85.6	85.7			7.69	
DR-10	06 Feb 2020			84			7.59
DR-10	07 Feb 2020	84	94.9			7.7	
DR-10	07 Feb 2020			90			7.71
DR-10	08 Feb 2020	79.9	151.7			7.8	
DR-10	08 Feb 2020			145			7.95
DR-10	09 Feb 2020	68	119.7			7.8	
DR-10	09 Feb 2020			117			7.72
DR-10	10 Feb 2020	78.8	210.2			8.4	
DR-10	10 Feb 2020			202			8.14
DR-10	11 Feb 2020	101.3	245.9			7.98	
DR-10	11 Feb 2020			234			7.93
DR-10	12 Feb 2020	90	258.9			7.77	
DR-10	12 Feb 2020			223			7.94
DR-10	13 Feb 2020	68.9	261			7.82	
DR-10	13 Feb 2020			253			7.93
DR-10	14 Feb 2020	63	268.7			8.02	
DR-10	14 Feb 2020			262			7.94
DR-10	15 Feb 2020	59.2	273.2			8.13	

DR-10	15 Feb 2020			264		7.9
DR-10	16 Feb 2020	57.1	281.5		8.05	
DR-10	16 Feb 2020			265		7.92
DR-10	06 Mar 2020			106		7.56
DR-10	07 Mar 2020			143		7.78
DR-10	08 Mar 2020			165		7.95
DR-10	09 Mar 2020			185		7.99
DR-10	10 Mar 2020	98.1	207.2		8.04	
DR-10	10 Mar 2020			195		7.9
DR-10	11 Mar 2020	77	208		7.82	
DR-10	11 Mar 2020			199		7.83
DR-10	12 Mar 2020	74.4	214.5		7.82	
DR-10	12 Mar 2020			206		7.74
DR-10	13 Mar 2020	68.8	217.2		7.78	
DR-10	13 Mar 2020			208		7.94
DR-10	25 Apr 2020			296		8.23
DR-10	24 Dec 2020	82.1	133.8		7.43	
DR-10	24 Dec 2020			122		7.17
DR-10	25 Dec 2020	77	161.2		7.76	
DR-10	25 Dec 2020			150		7.32
DR-10	26 Dec 2020	73.9	192.9		7.72	
DR-10	26 Dec 2020			180		7.65
DR-10	27 Dec 2020	80.7	92.5		7.9	
DR-10	27 Dec 2020			88		6.97
DR-10	28 Dec 2020	87.7	89.2		7.7	
DR-10	28 Dec 2020			81		7.12
DR-10	29 Dec 2020	82.7	107.1		7.8	
DR-10	29 Dec 2020			102		7.22
DR-10	30 Dec 2020	99.2	118.8		7.91	
DR-10	30 Dec 2020			114		7.44
DR-10	31 Dec 2020	76	132.4		7.42	
DR-10	31 Dec 2020			127		7.37
DR-10	03 Feb 2021	9.8	88		7.31	
DR-10	03 Feb 2021			94		6.81
DR-10	04 Feb 2021	59.2	100		7.25	
DR-10	04 Feb 2021			94		6.83
DR-10	05 Feb 2021	79.8	113.3		8.09	
DR-10	05 Feb 2021			108		6.92
DR-10	06 Feb 2021	69.4	113.8		7.58	
DR-10	06 Feb 2021			109		6.94
DR-10	07 Feb 2021	86.5	71		7.69	
DR-10	07 Feb 2021			70		6.73
DR-10	08 Feb 2021	91	90.4		7.55	
DR-10	08 Feb 2021			87		6.91
DR-10	09 Feb 2021	80	99.3		7.6	
DR-10	09 Feb 2021			94		7.07
DR-10	10 Feb 2021	79	117.6		7.6	
DR-10	10 Feb 2021			110		7.11
DR-10	11 Feb 2021	83.1	136.8		7.8	
DR-10	11 Feb 2021			126		7.29

DR-10	12 Feb 2021	84.6		140.4			7.98	
DR-10	12 Feb 2021				135			7.32
DR-10	13 Feb 2021	80.8		44.9			7.9	
DR-10	13 Feb 2021				140			7.47
DR-10	14 Feb 2021	78.3		153.4			7.88	
DR-10	14 Feb 2021				140			7.36
DR-10	15 Feb 2021	89.5		65.1			7.83	
DR-10	15 Feb 2021				60			6.84
DR-10	16 Feb 2021	91.4		110.6			7.97	
DR-10	16 Feb 2021				103			7.11
DR-10	17 Feb 2021	93.6		135.7			7.87	
DR-10	17 Feb 2021				127			7.33
DR-10	18 Feb 2021	103.1		150.3			8.01	
DR-10	18 Feb 2021				138			7.61
DR-10	19 Feb 2021	99.6		150.6			8.2	
DR-10	19 Feb 2021				140			7.5
DR-10	20 Feb 2021	94.4		154.8			8.26	
DR-10	20 Feb 2021				141			7.49
DR-10	21 Feb 2021	90		158.1			7.82	
DR-10	21 Feb 2021				145			7.49
DR-10	22 Feb 2021	91.5		161.7			8.09	
DR-10	22 Feb 2021				152			7.6
DR-10	23 Feb 2021	79.3		162.1			8.1	
DR-10	23 Feb 2021				154			7.49
DR-10	18 May 2021				210			7.35
DR-10	18 May 2021							
DR-10	03 Sep 2021		59		60	81	7.3	7.05
DR-10 R1	30 Sep 2021				149			7.87
DR-10 R2 (Field_B)	30 Sep 2021				1			5.89
DR-10	21 Jan 2022	82.8		156.3			7.67	
DR-10	21 Jan 2022				143			7.37
DR-10	22 Jan 2022	88.8		119.8			7.66	
DR-10	22 Jan 2022				99			7.37
DR-10	23 Jan 2022	84.4		134.9			7.59	
DR-10	23 Jan 2022				110			7.51
DR-10	26 Jan 2022	106.3		100.7			7.62	
DR-10	26 Jan 2022				88			7.44
DR-10	27 Jan 2022	89.9		104.2			7.75	
DR-10	27 Jan 2022				116			7.53
DR-10	28 Jan 2022	89.7		125.5			7.79	
DR-10	28 Jan 2022				127			7.74
DR-10	29 Jan 2022	91.3		92.6			7.78	
DR-10	29 Jan 2022				98			7.64
DR-10	30 Jan 2022	98		92			7.78	
DR-10	30 Jan 2022				86			7.62
DR-10	31 Jan 2022	95.4		70.1			7.63	
DR-10	31 Jan 2022				74			7.49
DR-10	01 Feb 2022	95		106.9			7.66	
DR-10	01 Feb 2022				112			7.77
DR-10	02 Feb 2022	101.2		152.4			7.83	

DR-10	02 Feb 2022			144			7.94
DR-10	03 Feb 2022	104.2	176.4			7.96	
DR-10	03 Feb 2022			167			8.02
DR-10	04 Feb 2022	98.7	225.7			7.97	
DR-10	04 Feb 2022			181			8.04
DR-10	05 Feb 2022	98.5	239.3			7.98	
DR-10	05 Feb 2022			188			7.97
DR-10	06 Feb 2022	98.9	255.7			7.89	
DR-10	06 Feb 2022			194			7.99
DR-10	30 Mar 2022			138			7.89
DR-10 R1	29 Sep 2022			134			7.7
DR-10 R2	29 Sep 2022			<1			5.99
DR-10	28 Nov 2022			60			7.14
DR-10	25 Dec 2022	93.6	71.1			7.4	
DR-10	25 Dec 2022			71			7.13
DR-10	27 Dec 2022			73			7.34
DR-10	14 Jan 2023			74			7.24
DR-10	07 Feb 2023			60			6.97
DR-10	08 Feb 2023			97			7.34
DR-10	07 Mar 2023			84			7.39
DR-10	11 Mar 2023			153			7.77
DR-10	12 Mar 2023			146			7.98
DR-10	13 Mar 2023			240			8.15
DR-10	14 Mar 2023			322			8.28
DR-10	15 Mar 2023			350			8.19
DR-10	16 Mar 2023			389			8.2
DR-10	17 Mar 2023			434			8.19
DR-10	18 Mar 2023			496			8.25
DR-10	19 Mar 2023			501			8.3
DR-10	20 Mar 2023			561			8.26
DR-10	21 Mar 2023			559			8.28
DR-10	22 Mar 2023			600			8.15
DR-10	23 Mar 2023			632			8.18
DR-10 (Duplicate01)	17 Jan 2015						
DR-14	17 Jan 2015	69.3	78.4	91	74.84486874	7.52	7.66
DR-14	24 Jan 2015	4.2	363.2	360	321.1033507	7.67	8.5
DR-14	26 Jan 2015	39.4	169.1	173	158.5560244	7.42	8.03
DR-14	31 Jan 2015	3	451.1	446	419.2379182	7.32	7.88
DR-14	19 Dec 2015	31.5	88.5	94	86.20689655	7.22	7.22
DR-14	30 Dec 2015	82.8	76.5	74	76.35492564	7.37	7.43
DR-14	31 Dec 2015	74	100.1	95	98.05073954	7.53	7.66
DR-14	01 Jan 2016	69.1	167.2	155	161.6708567	7.48	7.89
DR-14	02 Jan 2016	75.3	63.6	63	64.33340077	7.52	7.51
DR-14	03 Jan 2016	80.5	181.7	167	178.6451676	7.35	7.75
DR-14	04 Jan 2016	73	237	217	229.5844231	7.47	8.01
DR-14	05 Jan 2016	62	295	262	282.1346595	7.61	8.09
DR-14	07 Jan 2016	81.1	350	322	327.5926619	7.9	8.27
DR-14	08 Jan 2016	94.3	376.2	345	352.742616	8.07	8.36
DR-14	09 Jan 2016	76.2	403.7	371	375.1858736	7.87	8.37
DR-14	10 Jan 2016	77.9	476.8	392	406.5137693	7.08	8.19

DR-14	11 Jan 2016	52.9	458.3	398	416.3714	7.82	8.19
DR-14	12 Jan 2016	71	157	163	149.8806683	7.58	7.83
DR-14	16 Jan 2016	52	253		234.7156508	7.85	
DR-14	31 Jan 2016	48	556	475	489.0921886	7.94	8.34
DR-14	14 Feb 2016	54	458	448	424.900269	8.03	8.07
DR-14	05 Mar 2016	21	63	69	63.48246675	8.05	7.58
DR-14	06 Mar 2016	21.1	137.5	140	129.1564907	7.62	7.91
DR-14	07 Mar 2016	20.3	155.7	151	146.5135974	7.73	7.92
DR-14	08 Mar 2016	54.4	181	155	157.6380422	7.78	7.7
DR-14	09 Mar 2016	43.5	168.3	146	150.053495	7.82	7.62
DR-14	10 Mar 2016	37.5	169	151	157.8996543	7.63	7.72
DR-14	11 Mar 2016	35	183.2	164	169.6610483	7.64	7.86
DR-14	12 Mar 2016	58	91.3	90	88.60636646	7.76	7.58
DR-14	13 Mar 2016	51	124	115	118.3770883	7.52	7.71
DR-14	14 Mar 2016	68	100.4	93	95.50080852	7.54	7.73
DR-14	15 Mar 2016	58	121	109	112.2553113	7.54	7.84
DR-14	16 Mar 2016	50	126.7	120	120.0834044	7.28	7.87
DR-14	17 Mar 2016	64	126	156	116.6882756	7.5	8.06
DR-14	18 Mar 2016	63	141	157	131.9730438	8	8.07
DR-14	19 Mar 2016	66.7	194	156	161.4782753	8.28	8.07
DR-14	20 Mar 2016	55	148	157	135.8670706	8.1	8.08
DR-14	21 Mar 2016	50	165.3	178	165.3	7.88	8.07
DR-14	23 May 2016	50.3	60.7	66	63.47380529	8.12	7.08
DR-14	24 May 2016	19.7	76.7	75	81.33616119	7.85	7.18
DR-14	25 May 2016	20.4	85.7	84	88.90963793	6.46	7.34
DR-14	08 Mar 2017	74	57.4	54	56.54058314	7.61	6.97
DR-14	09 Mar 2017			94	0		7.44
DR-14	10 Mar 2017	70.9	160.7	131	140.6564551	8.68	7.57
DR-14	11 Mar 2017			154			7.72
DR-14	12 Mar 2017			178			7.87
DR-14	13 Mar 2017			198			8.03
DR-14	14 Mar 2017			210			7.79
DR-14	16 Mar 2017			218			7.9
DR-14	17 Mar 2017			223			7.88
DR-14	18 Mar 2017			229			7.91
DR-14	19 Mar 2017			234			7.94
DR-14	20 Mar 2017			235			7.99
DR-14	20 Mar 2017			240			7.99
DR-14	21 Mar 2017	53	267.8	240	251.1017346	6.2	7.99
DR-14	04 Mar 2018	18.5	79.6	66	80.05632103	7.69	7.18
DR-14	05 Mar 2018	18	145	127	141.5048307	7.74	7.34
DR-14	06 Mar 2018	22.8	272.2	172	262.7159541	7.93	7.22
DR-14	07 Mar 2018	24.6	145.2	135	143.833581	7.75	7.64
DR-14	08 Mar 2018	27.8	82	75	83.26563769	7.85	7.23
DR-14	09 Mar 2018	15.6	130.6	126	131.3486875	7.68	7.47
DR-14	10 Mar 2018	18.5	156.2	133	155.0218341	7.82	7.59
DR-14	11 Mar 2018	16.6	184.9	152	175.2440527	7.82	7.69
DR-14	12 Mar 2018			176			7.77
DR-14	13 Mar 2018	58.8	230.6	193	212.4366651	8.93	7.92
DR-14	15 Mar 2018	62.6	287	252	266.2584655	8.31	7.87

DR-14	17 Mar 2018	72	326.5	285	306.6879579	8.2	7.96
DR-14	18 Mar 2018	37.8	346.7	312	335.2349642	8.29	7.83
DR-14	19 Mar 2018	42.8	370.6	335	359.6661491	8.36	7.89
DR-14	20 Mar 2018	38.5	392.3	364	384.9852797	8.7	7.74
DR-14	21 Mar 2018	42	420.7	381	408.2880435	8.77	7.86
DR-14	22 Mar 2018	644.6	470.6	404	418.1624311	7.99	8.1
DR-14	23 Mar 2018	301.7	454.9	409	422.7695167	7.92	8.05
DR-14	31 Jan 2019	58.2	41.9	59	40.44011196	7.57	6.84
DR-14	01 Feb 2019	112.4	81.3	52	76.23066104	7.44	6.74
DR-14	02 Feb 2019	139.7	116.7	53	115.1682621	8.13	6.81
DR-14	03 Feb 2019	31.4	106.3	48	107.3195356	7.75	6.84
DR-14	04 Feb 2019	65.1	74.1	80	74.81070167	7.87	7.01
DR-14	05 Feb 2019	66.2	131.6	289	136.2600953	7.57	7.12
DR-14	06 Feb 2019	74	164.4	144	165.9767794	7.68	7.67
DR-14	07 Feb 2019	72.5	234.8	7.87	236.5981459	7.78	7.87
DR-14	08 Feb 2019	67	331.9	270	310.6514414	7.57	7.9
DR-14	09 Feb 2019	59	411	313	370.8382207	7.6	7.92
DR-14	10 Feb 2019	70.4	412.4	342	385.9977537	7.83	7.92
DR-14	11 Feb 2019	76.2	475.8	366	427.1095153	8.08	8.18
DR-14	12 Feb 2019	75.1	458.7	391	420.3629032	7.94	8.02
DR-14	13 Feb 2019	74	540	419	487.2326987	8.08	7.96
DR-14	14 Feb 2019	96	576	447	520.6073753	8	8.08
DR-14	15 Feb 2019	73	585	459	553.4531693	7.87	8.14
DR-14	16 Feb 2019	60	573	492	539.1926226	7.91	8.19
DR-14	17 Feb 2019	66.6	689	530	634.7305389	7.88	8.19
DR-14	18 Feb 2019	46.9	702	539	647.8405316	7.9	8.15
DR-14	19 Feb 2019	73.6	775	573	692.149683	8.1	8.13
DR-14	20 Feb 2019	62	695	580	623.8779174	8.08	8.19
DR-14	21 Feb 2019	87.3	852	616	742.0310051	8.1	8.15
DR-14	22 Feb 2019	84.5	863	629	769.4365193	8.14	8.36
DR-14	23 Feb 2019	68.2	791	650	732.5430635	8.08	8.31
DR-14	24 Feb 2019	65.4	868	649	805.2695055	8.06	8.21
DR-14	25 Feb 2019	64.4	912	663	824.2950108	8.08	8.19
DR-14	26 Feb 2019	64.9	928	692	843.0998456	8.04	8.19
DR-14	27 Feb 2019	72	1,010	703	881.0956992	8.12	8.28
DR-14	28 Feb 2019	69.3	1,010	718	884.0262582	8.17	8.26
DR-14	01 Mar 2019	73.5	1,012	732	893.2038835	8.18	8.25
DR-14	02 Mar 2019	59	1,027	760	928.2357195	8.16	8.21
DR-14	26 Jan 2020	80	75			7.6	
DR-14	26 Jan 2020			77			6.84
DR-14	27 Jan 2020	79	64.5			7.72	
DR-14	27 Jan 2020			66			6.9
DR-14	28 Jan 2020	79	120			7.5	
DR-14	28 Jan 2020			116			7.19
DR-14	29 Jan 2020	90.7	103.6			7.6	
DR-14	29 Jan 2020			100			7.12
DR-14	30 Jan 2020	90.9	101.5			7.35	
DR-14	30 Jan 2020			94			7.1
DR-14	31 Jan 2020	91.1	123.6			7.61	
DR-14	31 Jan 2020			113			7.44

DR-14	01 Feb 2020	86.1	171.3		7.63	
DR-14	01 Feb 2020			157		7.74
DR-14	02 Feb 2020	87.3	203		7.58	
DR-14	02 Feb 2020			182		7.85
DR-14	03 Feb 2020	104.8	226		7.88	
DR-14	03 Feb 2020			208		8.04
DR-14	04 Feb 2020			130		7.73
DR-14	05 Feb 2020	85.3	109.7		7.7	
DR-14	05 Feb 2020			110		7.79
DR-14	06 Feb 2020	84.2	86.6		7.45	
DR-14	06 Feb 2020			88		7.61
DR-14	07 Feb 2020	82.2	75.1		7.5	
DR-14	07 Feb 2020			99		7.69
DR-14	08 Feb 2020	82.2	145.2		7.7	
DR-14	08 Feb 2020			141		7.91
DR-14	09 Feb 2020	70	152.9		8.5	
DR-14	09 Feb 2020			146		7.91
DR-14	10 Feb 2020	73.8	190		7.9	
DR-14	10 Feb 2020			184		8.07
DR-14	11 Feb 2020	98.9	227.8		8.04	
DR-14	11 Feb 2020			216		7.85
DR-14	12 Feb 2020	91.1	239		7.9	
DR-14	12 Feb 2020			228		7.9
DR-14	13 Feb 2020	66.2	244.6		7.72	
DR-14	13 Feb 2020			233		7.86
DR-14	14 Feb 2020	60.1	257		7.72	
DR-14	14 Feb 2020			248		7.84
DR-14	15 Feb 2020	56.7	267.1		7.98	
DR-14	15 Feb 2020			255		7.89
DR-14	16 Feb 2020	55.8	276.9		7.92	
DR-14	16 Feb 2020			271		7.97
DR-14	06 Mar 2020			104		7.55
DR-14	07 Mar 2020			142		7.78
DR-14	08 Mar 2020			155		7.97
DR-14	09 Mar 2020			172		8.01
DR-14	10 Mar 2020	105.6	189.8		8.18	
DR-14	10 Mar 2020			178		7.92
DR-14	11 Mar 2020	80.5	197.4		7.78	
DR-14	11 Mar 2020			188		7.78
DR-14	12 Mar 2020	72.8	206.6		7.72	
DR-14	12 Mar 2020			198		7.84
DR-14	13 Mar 2020	64.5	214		7.68	
DR-14	13 Mar 2020			204		7.92
DR-14	04 Apr 2020	77.6	88		7.5	
DR-14	23 Apr 2020			298		8.26
DR-14	23 Dec 2020	85.8	82.8		7.37	
DR-14	23 Dec 2020			40		6.75
DR-14	24 Dec 2020	83.8	134.3		7.39	
DR-14	24 Dec 2020			122		7.14
DR-14	25 Dec 2020	76.3	161.6		7.7	

DR-14	25 Dec 2020			151		7.47
DR-14	26 Dec 2020	75.8	185.1		7.75	
DR-14	26 Dec 2020			171		7.6
DR-14	27 Dec 2020	72.7	116.9		7.58	
DR-14	27 Dec 2020			111		7.09
DR-14	28 Dec 2020	85.5	98.6		7.69	
DR-14	28 Dec 2020			90		7.16
DR-14	29 Dec 2020	79.1	106.5		7.77	
DR-14	29 Dec 2020			109		7.22
DR-14	30 Dec 2020	89.8	113.1		7.81	
DR-14	30 Dec 2020			108		7.31
DR-14	31 Dec 2020	76.1	126.7		7.43	
DR-14	31 Dec 2020			122		7.42
DR-14	03 Feb 2021	56.3	95.9		7.41	
DR-14	03 Feb 2021			90		6.81
DR-14	04 Feb 2021	55.7	95.9		7.3	
DR-14	04 Feb 2021			90		6.82
DR-14	05 Feb 2021	82	115.4		7.89	
DR-14	05 Feb 2021			105		6.92
DR-14	06 Feb 2021	54.4	116.8		7.44	
DR-14	06 Feb 2021			116		7.1
DR-14	07 Feb 2021	87.4	68.1		7.7	
DR-14	07 Feb 2021			70		6.72
DR-14	08 Feb 2021	88.5	90.6		7.42	
DR-14	08 Feb 2021			88		6.83
DR-14	09 Feb 2021	77.2	100.1		7.58	
DR-14	09 Feb 2021			95		7.05
DR-14	10 Feb 2021	78.8	116.2		7.63	
DR-14	10 Feb 2021			109		7.12
DR-14	11 Feb 2021	77.8	63		7.69	
DR-14	11 Feb 2021			120		7.15
DR-14	12 Feb 2021	76.6	71.2		7.83	
DR-14	12 Feb 2021			135		7.25
DR-14	13 Feb 2021	68.5	73.3		7.73	
DR-14	13 Feb 2021			144		7.31
DR-14	14 Feb 2021	75.8	157.3		7.83	
DR-14	14 Feb 2021			148		7.33
DR-14	15 Feb 2021	87.9	64.7		7.65	
DR-14	15 Feb 2021			60		6.82
DR-14	16 Feb 2021	91.9	108.9		7.81	
DR-14	16 Feb 2021			101		7.14
DR-14	17 Feb 2021	92.5	133.6		7.9	
DR-14	17 Feb 2021			37		7.4
DR-14	18 Feb 2021	102.2	150.5		8	
DR-14	18 Feb 2021			138		7.56
DR-14	19 Feb 2021	96.4	156.4		8.21	
DR-14	19 Feb 2021			144		7.47
DR-14	20 Feb 2021	101.1	161.9		8.24	
DR-14	20 Feb 2021			148		7.55
DR-14	21 Feb 2021	101.3	169.9		7.9	

DR-14	21 Feb 2021				157			7.79
DR-14	22 Feb 2021	102.1		175.7			8.13	
DR-14	22 Feb 2021				166			7.79
DR-14	23 Feb 2021	75.8		177.3			7.92	
DR-14	23 Feb 2021				168			7.53
DR-14	19 May 2021				280			7.62
DR-14	19 May 2021							
DR-14	03 Sep 2021		55.3		69	64	7.06	7.09
DR-14	30 Sep 2021				282			8.13
DR-14	21 Jan 2022				143			7.35
DR-14	22 Jan 2022	87.1		126.4			7.54	
DR-14	22 Jan 2022				103			7.38
DR-14	23 Jan 2022	70		138.8			7.39	
DR-14	23 Jan 2022				112			7.39
DR-14	27 Jan 2022	88.7		106.2			7.73	
DR-14	27 Jan 2022				116			7.59
DR-14	28 Jan 2022	83.3		129.2			7.69	
DR-14	28 Jan 2022				126			7.79
DR-14	29 Jan 2022	89.7		91.7			7.73	
DR-14	29 Jan 2022				95			7.56
DR-14	30 Jan 2022	97.5		91.1			7.75	
DR-14	30 Jan 2022				88			7.54
DR-14	31 Jan 2022	95.2		71.3			7.62	
DR-14	31 Jan 2022				75			7.53
DR-14	01 Feb 2022	94.5		106.9			7.62	
DR-14	01 Feb 2022				107			7.74
DR-14	02 Feb 2022	98.4		148.6			7.71	
DR-14	02 Feb 2022				141			7.89
DR-14	03 Feb 2022	104.6		171.4			7.91	
DR-14	03 Feb 2022				163			7.81
DR-14	04 Feb 2022	98.6		225.9			7.9	
DR-14	04 Feb 2022				178			8.01
DR-14	05 Feb 2022	94		237.9			7.75	
DR-14	05 Feb 2022				188			7.89
DR-14	06 Feb 2022	98.2		263.3			7.8	
DR-14	06 Feb 2022				194			7.95
DR-14 R1	31 Mar 2022				184			7.9
DR-14 R2 (Field_B)	31 Mar 2022				107			7.27
DR-14	28 Sep 2022				135			7.78
DR-14	28 Nov 2022				63			7.12
DR-14	25 Dec 2022	92.8		72.5			7.43	
DR-14	25 Dec 2022				71			7.16
DR-14	27 Dec 2022				72			7.23
DR-14	14 Jan 2023				92			7.35
DR-14	07 Feb 2023				60			7
DR-14	08 Feb 2023				94			7.32
DR-14	07 Mar 2023				82			7.31
DR-14	09 Mar 2023				77			7.4
DR-14	10 Mar 2023				98			7.27
DR-14	11 Mar 2023				158			7.84

DR-14	12 Mar 2023	148	7.99
DR-14	13 Mar 2023	242	8.18
DR-14	14 Mar 2023	337	8.03
DR-14	15 Mar 2023	358	8.2
DR-14	16 Mar 2023	396	8.18
DR-14	17 Mar 2023	469	8.21
DR-14	18 Mar 2023	498	8.23
DR-14	19 Mar 2023	502	8.3
DR-14	20 Mar 2023	562	8.29
DR-14	21 Mar 2023	555	8.29
DR-14	22 Mar 2023	601	8.14
DR-14	23 Mar 2023	641	8.16

ll be treated as a blank in Power BI. Column can be added if indicator is not present. Column can be dele

Temp (Field) °C	Temperature °C	Redox Potential (Field) (mV)	Flow Rate (m/sec)	Redox Potential (Lab) (mV)	Turbidity (Field) (NTU)	Turbidity (NTU)	Total Dissolved Solids (mg/L)	Suspended Solids (mg/L)	Aluminium (dissolved) (µg/L)	Aluminium (µg/L)	Arsenic (dissolved) (µg/L)
							119	545	1020	15300	0.5
26.5		156					159	10	5	500	0.5
28.8		135					176	2.5	5	90	0.5
29.8		131					180	12	5	100	0.5
33.8		89.5					56	2.5	20	20	0.5
30.1		45					228	2.5	5	5	0.5
30.4		155					100	7	10	750	0.5
29		141					163	5	5	140	0.5
34		47.9					125	42	10	1610	0.5
30.2		36.1					52	22	70	2190	0.5
28.6		37					87	43	40	4060	0.5
26.2		-10.8					190	2.5	5	20	0.5
29.1		-23.3					178	2.5	5	20	0.5
29.2		-14					182	8	5	50	0.5
27		120.4				1.7	253	2.5	5	70	0.5
33		85				0.7	238	6	5	20	0.5
33.5		79				0.9	274	2.5	5	20	0.5
28.9		151.5	0.5		92.6				0	0	0
						100	46	67	290	3400	0.5
30.8		106.8	0.1		96				0	0	0
						132	91	55	370	3320	0.5
30.6		56	0.1		4.3				0	0	0
						2.9	126	2.5	50	110	0.5
31.3		68.9	0.3		29.6				0	0	0
						18.7	94	19	190	560	0.5
30.5		201	0.5		32				0	0	0
						38.9	122	9	70	1090	0.5
						12.7	125	9	170	700	0.5
						2.5	196	7	30	80	0.5
34.4		288.6	1		60.06				0	0	0
						141	96	108	360	3970	0.5
						85.2	80	50	5	1610	0.5
						5.6	286	5	5	200	0.5
						3.8	307	8	5	140	0.5
						1.6	329	2.5	5	60	0.5
						0.7	351	5	5	40	0.5
						0.9	323	8	5	30	0.5
25.1		98.6					135	62	160	5540	0.5

26.3	143	82	78	100	4330	0.5
26.7	154.5	141	23	20	1250	0.5
26.5	139	86	142	40	3940	0.5
25.8	165	70	30	5	1580	0.5
26.5	151	135	10	5	280	0.5
27.4	153	158	10	5	370	0.5
28.2	133	175	6	5	5	0.5
27.4	97	216	2.5	5	5	0.5
28.2	79			5	5	0.5
28.8	86.6	209	2.5	5	5	0.5
30.1	57.2	259	2.5	5	5	0.5
30.1	44.9	247	2.5	5	5	0.5
26.9	67.2	114	148	10	4490	0.5
29.2	114			0	0	0
31.7	151	282	8	5	30	0.5
29.2	138	248	2.5	5	60	0.5
24	39.3	112	558	230	18300	0.5
27.3	63.3	108	44	210	2750	0.5
27.2	71.8	106	19	310	1730	0.5
27.8	-26	108	24	30	1570	0.5
33.4	-6	94	118	20	3480	0.5
27.6	58	114	23	10	720	0.5
28.9	62	111	20	20	1000	0.5
26.1	123	85	140	140	4290	0.5
27.5	123	104	109	40	3300	0.5
27.6	144	90	52	120	1610	0.5
29.1	138	65	10	50	1140	0.5
27.4	161	82	8	40	1260	0.5
28.8	119	105	5	5	530	0.5
29.2	142	103	2.5	5	720	0.5
28.1	127	105	2.5	5	590	0.5
27.9	72	94	2.5	5	620	0.5
26.2	206	114	6	5	240	0.5
22.7	38.7	67		230	7240	0.5
22.3	147.5	59	71	190	2980	0.5
22.6	64.7	74	29	160	1290	0.5
30.6	43.1	116	59	110	4300	0.5
		146	21	250	2630	0.5
		160	8	5	1810	0.5
		194	2.5	5	1390	0.5
		131	12	220	1020	0.5
		135	6	5	800	0.5
		115	6	5	720	0.5
		120	9	5	730	0.5
		129	9	5	560	0.5
		123	7	5	560	0.5
		126	15	5	530	0.5
		125	10	5	460	0.5
29	116.8	135	6	5	530	0.5
30.8		114	2.5	10	550	0.5

25.9	49.1				173	2.5	30	80	0.5
28.3	16.2				185	5	5	30	0.5
27.7	2.2				186	2.5	5	80	0.5
27.9	-7.7				206	2.5	5	40	0.5
27.3	-12.6				184	2.5	5	30	0.5
27.5	-16.5				189	2.5	5	40	0.5
30.7	-53.8				204	5	40	40	0.5
29.8	-61.7				210	2.5	5	20	0.5
31.1	122			0.5	373	2.5	10	20	0.5
31	84				363	2.5	5	20	0.5
32.5	106.8			0.7	392	2.5	30	20	0.5
32.5	101.7			0.7	382	2.5	10	10	0.5
33	84.4			1	382	2.5	5	20	0.5
32.5	63.3			4.2	374	2.5	10	120	0.5
28.9	75.2			1.9	432	2.5	5	30	1
33.1	48.7			1.8	404	2.5	10	30	1
33.1	63.9			7.4	434	18	5	30	0.5
31.8	71.4			3.1	436	2.5	10	20	1
32.7	60			2.4	494	2.5	5	40	1
26.3	171	0.8	500				0	0	0
				806	48	702	290	19300	0.5
27.3	102.5	0.25	122				0	0	0
				125	106	74	460	3990	0.5
33	44.9	0.05	13.1				0	0	0
				9.6	103	8	150	480	0.5
35.3	36.7	0.05	6.8				0	0	0
				4.2	121	2.5	110	320	0.5
31	55.1	0.25	164				0	0	0
				170	98	257	350	3960	0.5
31.5	57	0.2	150				0	0	0
				190	96	158	310	5250	0.5
28.8	43.6	5	340.4				0	0	0
				354	101	334	520	11500	0.5
31.2	142	0.2	179				0	0	0
				212	101	114	170	5270	0.5
33.9	89	0.05	76				0	0	0
				85.5	115	20	190	2170	0.5
29.2	116	0.05	275				0	0	0
				253	112	132	130	7280	0.5
30.9	89	0.1	26				0	0	0
				24.8	128	10	70	750	0.5
35.6	75.5	0.02	15.7				0	0	0
				15	144	11	60	470	0.5
34.9	51.4	0.02	12.8				0	0	0
				13.8	156	8	60	400	0.5
28.4	83	0.02	14.2				0	0	0
				12.3	152	8	40	420	0.5
27.6	65.7	0.02	10.7				0	0	0
				8.3	156	6	30	310	0.5
28.8	59.9	0.02	8.4				0	0	0

				6.1	154	7	20	300	0.5
28.5	68.7	0.02	5.9				0	0	0
				9	151	2.5	20	250	0.5
				30.5	101	30	420	1930	0.5
				68.9	110	26	380	1990	0.5
				41.3	133	17	320	460	0.5
				29.4	127	12	240	1010	0.5
35	11.4	0.02	24.9				0	0	0
				28.1	113	6	180	820	0.5
29	37.5	0.02	22.5				0	0	0
				26.5	132	9	140	810	0.5
29.8	63.8	0.01	17.2				0	0	0
				21	129	7	130	690	0.5
28	67.8	0.01	14.3				0	0	0
				15.3	142	7	120	610	0.5
				7.9	163	8	5	220	0.5
32.9	309.3	0.2	89.81				0	0	0
				104	110	32	380	3350	0.5
28.3	295.3	0.1	64.7				0	0	0
				60.6	109	15	240	2190	0.5
28.5	296.6	0.01	41.9				0	0	0
				28.7	126	2.5	130	1040	0.5
29.3	261.5	0.01	274.3				0	0	0
				393	99	279	440	12600	0.5
29	261.9	0.01	184.4				0	0	0
				153	64	76	570	3840	0.5
28.7	256.7	0.01	69.66				0	0	0
				79.3	116	16	420	1610	0.5
33.9	276.6	0.01	101.7				0	0	0
				135	118	32	320	3600	0.5
29.5	280.1	0.01	55.4				0	0	0
				64.2	109	14	5	1600	0.5
27.3	307.3	0.1	116.8				0	0	0
				97.8	78	30	290	2440	0.5
29.8	223.5	0.01	80.6				0	0	0
				99.6	99	29	300	2560	0.5
33.1	249.1	0.01	50.1				0	0	0
				53.2	77	11	260	1420	0.5
30	269.7	0.01	36.3				0	0	0
				37.7	101	8	250	1110	0.5
27	306.1	1	433.8				0	0	0
				632	54	552	420	38400	0.5
31.6	288	0.1	192.38				0	0	0
				226	95	107	250	6040	0.5
28.7	305.9	0.01	138.2				0	0	0
				149	91	55	10	4150	0.5
29	295.6	0.01	99.8				0	0	0
				108	100	33	5	2920	0.5
30.9	281.7	0.01	71.8				0	0	0
				73.9	95	17	5	2250	0.5

30.7		289.5	0.01		57.3				0	0	0
						54.9	90	15	5	1930	0.5
30.4		270.3	0.01		49.75				0	0	0
						51.5	106	15	5	1430	0.5
30.4		263.6	0.01		44.58				0	0	0
						43.7	119	11	5	1330	0.5
28.8		274.4	0.7		254.3				0	0	0
						361	126	252	40	12100	0.5
32.3		302	0.7		101.9				0	0	0
						120	81	38	5	3360	0.5
31.3		291.2	0.7		74.4				0	0	0
						83.6	101	24	5	2220	0.5
31.1		270.9	0.1		72.4				0	0	0
						83.7	87	31	5	2800	0.5
32.3		283.5	0.1		56.4				0	0	0
						61.1	146	25	5	1970	0.5
33.8		253.4	0.01		54.9				0	0	0
						60.8	121	9	5	1960	0.5
33.3		295.7	0.001		48.2				0	0	0
						48.7	100	11	5	1680	0.5
34		282.4	0.001		44.4				0	0	0
						45.4	96	11	5	1730	0.5
29.1		253.7	0.001		40				0	0	0
						45	107	9	5	1570	0.5
						110	110	91	9	990	#VALUE!
							120		0	0	0
	23.5			101.1	255.6	386	168	180	50	29100	0.5
						44.8	118	10	5	1770	0.5
						0.2	<10	2.5	5	5	0.5
26.8		95.9	2		377.8				0	0	0
						431	160	522	10	29300	0.5
30.3		105.7	0.1		155.4				0	0	0
						171	108	76	20	7250	0.5
28.9		143	0.01		94.5				0	0	0
						71.9	110	27	10	7850	0.5
30		168			123.3				0	0	0
						160	81	72	5	15300	0.5
26.8		222.5			270.56				0	0	0
						184	90	334	10	12800	0.5
28.2		210.8	0.01		74.03				0	0	0
						54.1	96	32	5	4980	0.5
27.9		256.3	0.3		247.2				0	0	0
						172	74	300	5	15700	0.5
29.6		235.7	0.2		182.91				0	0	0
						183	52	140	5	11700	0.5
28.7		232.5	0.9		300.01				0	0	0
						514	262	400	30	26800	0.5
29.4		241.9	0.1		52.7				0	0	0
						70.3	80	30	5	1800	0.5
33.2		145.2	0.001		28.7				0	0	0

				36.5	101	9	5	1200	0.5
32.7	159.8	0.01	10.79				0	0	0
				14.9	109	6	5	510	0.5
30	163.2	0.02	7.88				0	0	0
				10.3	124	2.5	5	450	0.5
30.8	151.8	0.01	13.81				0	0	0
				9.8	120	6	5	340	0.5
33.3	121.3	0.01	4.46				0	0	0
				7	125	2.5	5	250	0.5
				19.4	77	20	5	440	0.5
				4.6	97	10	5	520	0.5
				0.1	<10	2.5	5	5	0.5
				420	140	179	30	12500	0.5
27.9		0.2	236.4				0	0	0
				287	96	175	130	8240	0.5
				535	128	336	60	14700	0.5
				483	133	268	5	9820	0.5
				293	97	262	80	4800	0.5
				74.6	104	19	10	1780	0.5
				269	140	187	10	8320	0.5
				29	136	12	5	1360	0.5
				61.5	126	34	5	2020	0.5
				30.8	185	12	5	1460	0.5
				9.4	223	2.5	5	430	0.5
				5.5	260	8	5	400	0.5
				4.2	276	6	5	180	0.5
				2.4	307	2.5	5	90	0.5
				3.1	348	2.5	5	50	0.5
				2.4	342	2.5	5	50	0.5
				3.1	384	6	5	30	0.5
				3.3	373	2.5	5	40	0.5
				4.8	359	2.5	5	70	0.5
				4	363	2.5	5	50	0.5
							180	220	0.5
27.5	97.7				60	211	520	5690	0.5
31.9	86.1				212	2.5	5	20	0.5
28.5	51.3				136	62	520	1060	0.5
29	160.5				230	2.5	50	390	1
26.4	95.8				156	60	190	3980	0.5
25.1	183				94	337	180	8100	0.5
26.1	139				84	89	90	3260	0.5
26.8	149.3				121	26	20	1570	0.5
24.4	151				57	278	140	8880	0.5
25.9	246				116	25	10	1190	0.5
26.7	165				129	7	5	270	0.5
27.4	165				157	11	5	330	0.5
28.6	117				214	2.5	5	5	0.5
28.5	84.9				227	2.5	5	5	0.5
29	107.2				217	2.5	5	5	0.5
34.1	67.7				218	2.5	5	20	0.5

30.3	46.8	293	2.5	5	5	0.5
27.5	85	126	98	5	3050	0.5
29.1	124			0	0	0
32.2	140	267	2.5	5	100	0.5
29.1	143	291	2.5	5	50	0.5
24.6	41.8	117	492	530	13300	0.5
28.4	62.2	132	61	300	3250	0.5
28.3	65.2	125	21	240	2030	0.5
32.8	35.2	125	16	20	1400	0.5
31.4	28.5	107	73	10	2310	0.5
28.7	66.8	122	28	10	1370	0.5
29.2	71	153	11	5	930	0.5
26.6	135	81	189	150	3080	0.5
27.5	133	105	98	60	2700	0.5
27.7	150	80	52	100	2130	0.5
29.1	149	64	9	60	1000	0.5
27.9	161	77	9	50	1180	0.5
29.2	103	91	6	180	470	0.5
28.6	148	94	5	10	530	0.5
35.6	109	97	2.5	10	480	0.5
29.7	124	96	2.5	5	510	0.5
25	182	108	6	5	390	0.5
22.7	42	63	218	290	6920	0.5
22	139.4	66	61	160	2420	0.5
23.1	109	76	24	100	1160	0.5
25.8	32	88	394	270	13600	0.5
		113	63	110	4230	0.5
32.5	-80.4	137	19	30	2370	0.5
		159	9	20	1780	0.5
		174	7	5	1350	0.5
		128	14	250	1000	0.5
		124	7	5	960	0.5
		126	7	5	750	0.5
		126	10	5	630	0.5
		144	7	5	550	0.5
		129	2.5	5	350	0.5
		136	6	5	370	0.5
		145	2.5	5	240	0.5
28.5	160.4	145	2.5	5	240	0.5
24.7	21.1	76	218	220	14800	0.5
26.3	12.2	88	30	140	1150	0.5
26.9	9.1	121	12	5	540	0.5
25.5	10	126	191	110	9640	0.5
24.2	11.8	100	215	220	9590	0.5
24.7	8.5	94	22	90	2360	0.5
25.4	5.7	100	16	40	1390	0.5
27.9	12.9	110	2.5	20	590	0.5
		130	6	5	5	0.5
29.5	7.5	118	2.5	5	390	0.5
29.1	47.3	164	2.5	30	120	0.5

28.4	9.5				196	2.5	5	30	0.5
26.8	16.7				216	2.5	5	30	0.5
26.6	3.1				216	2.5	5	100	0.5
26	-18.9				221	2.5	5	70	0.5
26.6	-20				224	2.5	5	40	0.5
31.6	-59.4				248	2.5	5	30	0.5
29	-55.2				259	5	5	20	0.5
26.9	-52.2			310	57	234	640	9360	0.5
28.5	-45.2			289	50	433	300	12100	0.5
25.7	-86.4			485	50	1,030	320	20800	0.5
24.5	-63.1			132	44	187	200	5830	0.5
24.5	95.9			73.7	58	79	170	2650	0.5
23.2	99.7			46.3	205	80	20	2290	1
24.5	124.4			31.3	119	61	100	1590	1
24.6	240			18.1	118	16	60	680	0.5
28.6	96.7			6.3	163	8	30	310	0.5
30.7	155			3	178	2.5	20	140	0.5
28.6	242.6			1.5	192	2.5	10	100	0.5
31	82.1			1.4	218	2.5	5	30	0.5
29.8	95			1.5	230	6	5	20	0.5
30.7	206			2	274	2.5	5	30	0.5
30.6	102			1.2	282	2.5	5	20	0.5
28	80			1.4	296	6	5	30	0.5
28.3	84.5			2.6	316	8	5	110	0.5
29.5	166.3			1.4	338	12	5	30	0.5
29.4	115.1			1.8	318	2.5	5	30	0.5
31.3	114			0.9	351	2.5	10	20	0.5
31	96.3			0.4	338	2.5	5	20	0.5
32.8	95.2				366	2.5	5	70	0.5
31.4	68.6			0.8	390	2.5	20	40	0.5
29.2	94.1			1.2	375	8	5	20	0.5
29.1	88.3			1	402	2.5	10	40	0.5
30.6	61.1			2.1	400	2.5	10	50	0.5
30.3	78.3			3.4	392	2.5	5	70	1
32.7	80.5			2.1	466	2.5	5	30	1
32.5	89.9			2.2	410	8	5	40	1
32	54.9			2.8	424	8	10	20	1
30.6	71			2.4	472	10	5	20	1
26.6	114	0.4	390				0	0	0
				249	66	410	430	15000	0.5
26.5	121	0.3	469				0	0	0
				733	49	593	300	18400	0.5
27.4	130.1	0.1	119				0	0	0
				134	111	67	390	3030	0.5
27	114.3	0.75	115.38				0	0	0
				149	111	96	330	4540	0.5
30.3	65.1	0.2	132.1				0	0	0
				91.3	75	160	450	5610	0.5
28.9	80.7	0.3	116.1				0	0	0
				147	98	83	290	4650	0.5

31.5	59.5	0.2	25.8				0	0	0
				25.1	95	11	180	850	0.5
32.5	56	0.2	13.6				0	0	0
				10	106	2.5	140	520	0.5
35	35.6	0.2	7				0	0	0
				4.6	131	2.5	100	300	0.5
				134	105	117	280	3270	0.5
31.8	56.2	0.4	72				0	0	0
				73.5	87	54	290	1840	0.5
29	55	5	354				0	0	0
				382	100	358	160	12600	0.5
30.8	81	0.15	185				0	0	0
				199	117	93	190	5120	0.5
33.1	95	0.1	78				0	0	0
				86.1	104	21	170	2310	0.5
30.8	133	0.1	132				0	0	0
				160	116	89	150	4940	0.5
30.9	114	0.1	33				0	0	0
				39.2	123	14	80	1240	0.5
35.9	74.7	0.02	16.4				0	0	0
				15.8	133	13	60	530	0.5
36.3	44.5	0.02	15.5				0	0	0
				13.1	141	9	60	290	0.5
28.4	77.9	0.02	13.9				0	0	0
				12.1	143	6	40	400	0.5
27.6	63.6	0.02	11.3				0	0	0
				11.8	149	5	30	340	0.5
29.5	58.2	0.02	8.9				0	0	0
				9.4	150	9	30	280	0.5
28.2	71.7	0.01	8.8				0	0	0
				3.2	161	2.5	20	200	0.5
				42.3	113	29	330	1740	0.5
				59.4	98	13	260	1260	0.5
				31.9	127	18	280	860	0.5
				24.9	128	12	250	810	0.5
33.6	12.8	0.05	26.4				0	0	0
				30.4	122	13	190	880	0.5
30.8	27.7	0.05	22.5				0	0	0
				27.6	123	14	130	740	0.5
30.6	62.8	0.02	17.5				0	0	0
				19.8	132	2.5	140	680	0.5
28.4	74.2	0.01	14.3				0	0	0
				17.2	134	7	110	570	0.5
31.2	55.3	0.3	116				0	0	0
				11.7	191	22	5	400	0.5
28.7	282.2	2	215.2				0	0	0
				268	67	206	390	8000	0.5
32.4	297.4	0.6	89.5				0	0	0
				98.1	110	35	390	3300	0.5
28.6	265.1	0.2	57.7				0	0	0

				64.1	138	15	250	2090	0.5
29.7	266.7	0.1	26.6				0	0	0
				34.6	138	8	150	1250	0.5
31.5	275.4	0.1	191.4				0	0	0
				265	82	151	440	7320	0.5
30.6	259	0.1	113.6				0	0	0
				134	63	57	550	3060	0.5
29.3	274.1	0.05	72.75				0	0	0
				87.9	134	15	430	1720	0.5
32.9	294.7	0.03	148.2				0	0	0
				214	103	104	320	5430	0.5
29.4	274.3	0.01	75.04				0	0	0
				96.1	113	22	5	2210	0.5
31.5	268.3	0.5	99.4				0	0	0
				128	84	45	330	3110	0.5
31.1	246.1	0.5	99.7				0	0	0
				124	91	47	350	3180	0.5
35	262.4	0.1	54.3				0	0	0
				56.7	84	14	260	1620	0.5
30.1	286.5	0.1	42.1				0	0	0
				37	95	12	220	1350	0.5
26.9	246.2	1	492.8				0	0	0
				899	16	654	360	41900	0.5
31.3	291.4	0.1	178.4				0	0	0
				193	66	101	250	6210	0.5
28.4	275.6	0.01	131.8				0	0	0
				171	89	75	20	4800	0.5
29.7	271.8	0.01	103.8				0	0	0
				115	96	39	10	3470	0.5
30.8	286.7	0.01	78.6				0	0	0
				84.2	79	20	5	2430	0.5
30.7	291.4	0.01	58.14				0	0	0
				61.2	92	18	5	1810	0.5
30.6	314.4	0.01	49.42				0	0	0
				53	113	17	5	1620	0.5
30.2	242.3	0.01	42.43				0	0	0
				43	127	16	5	1360	0.5
29.1	327.1	0.5	268.7				0	0	0
				359	58	244	40	9180	0.5
33.3	305.4	0.5	101.9				0	0	0
				121	89	51	10	3550	0.5
31.5	284.7	0.5	72.9				0	0	0
				79.6	90	17	5	2380	0.5
31.4	260.8	0.01	58.4				0	0	0
				60	101	17	5	1940	0.5
31.8	283.4	0.05	55.8				0	0	0
				57.8	105	17	5	2020	0.5
34.2	272.8	0.05	64.5				0	0	0
				47.9	108	15	5	1510	0.5
34.1	283.1	0.01	38.7				0	0	0

					44.1	98	11	5	1220	0.5
35.1		269.1	0.001		35			0	0	0
					31.1	123	11	5	1340	1
29		238.9	0.001		33.3			0	0	0
					28.8	97	13	5	1200	0.5
					66	140	62	2.5	600	0.61
						160		0	0	0
	25.2			170.3	260	335	212	160	50	19700	0.5
						37.8	161	18	5	1230	0.5
						499	86	530	30	21700	0.5
31		135.6	0.5		166.3				0	0	0
						89.1	100	99	20	9860	0.5
29.1		146.1	0.05		102				0	0	0
						73.5	100	45	5	7770	0.5
27.1		204.8			184.2				0	0	0
						144	126	220	5	8380	0.5
27.5		224.6	0.1		7,567				0	0	0
						48.2	90	32	5	7030	0.5
27.6		260.7	0.25		238.6				0	0	0
						203	96	266	5	15100	0.5
29.9		238	0.4		207.19				0	0	0
						254	72	232	5	15000	0.5
28.9		237.2	1.1		342.35				0	0	0
						515	130	410	20	32200	0.5
29.9		295.3	0.12		55.3				0	0	0
						72.2	79	31	5	1730	0.5
33.2		162.5	0.3		33.8				0	0	0
						40.8	98	12	5	2530	0.5
32.8		210.8	0.02		13.01				0	0	0
						19	117	10	5	610	0.5
30.9		161	0.01		10.02				0	0	0
						13.5	98	6	5	500	0.5
31.1		154.8	0.01		8.44				0	0	0
						11.4	118	6	5	450	0.5
33.6		140.3	0.01		6.99				0	0	0
						8.8	113	2.5	5	310	0.5
						21.3	103	16	5	590	0.5
						0.3	62	2.5	5	5	0.5
						169	170	22	5	5800	0.5
						439	132	167	40	12400	0.5
29.4			0.3		230.2				0	0	0
						286	88	160	140	8010	0.5
						423	96	276	70	12500	0.5
						243	109	140	5	7710	0.5
						287	121	190	90	6310	0.5
						77.7	112	24	10	1820	0.5
						244	176	163	30	9180	0.5
						93	78	78	30	3700	0.5
						50.3	94	25	30	1450	0.5
						30.4	146	8	5	1750	0.5

65.8	122	40	5	2090	0.5
29.5	187	12	5	1150	0.5
5.5	237	2.5	5	360	0.5
7.1	263	6	5	300	0.5
5.6	289	9	5	420	0.5
2.8	333	2.5	5	100	0.5
2.8	357	6	5	60	0.5
2.3	346	5	5	60	0.5
3.2	381	5	5	40	0.5
3.8	372	2.5	5	40	0.5
5.2	365	10	5	70	0.5
5	354	2.5	5	70	0.5

eted if no data. Note: <LOR have been changed to 0.5*LOR and shaded grey. Metals results originally in

Arsenic (µg/L)	Cadmium (dissolved) (µg/L)	Cadmium (µg/L)	Copper (dissolved) (µg/L)	Copper (µg/L)	Iron (dissolved) (µg/L)	Iron (µg/L)	Lead (dissolved) (µg/L)	Lead (µg/L)
2	0.05	0.1	2	30	0	0	0.5	12
0.5	0.05	0.05	2	2	0	0	0.5	0.5
0.5	0.05	0.05	0.5	2	0	0	0.5	0.5
0.5	0.05	0.05	0.5	2	0	0	0.5	0.5
0.5	0.05	0.05	0.5	0.5	0	0	0.5	0.5
0.5	0.05	0.05	0.5	1	0	0	0.5	0.5
0.5	0.05	0.05	2	3	0	0	0.5	0.5
0.5	0.05	0.05	0.5	0.5	0	0	0.5	0.5
1	0.05	0.05	2	4	0	0	0.5	0.5
0.5	0.05	0.05	2	4	0	0	0.5	1
0.5	0.05	0.05	1	6	0	0	0.5	2
0.5	0.05	0.05	2	1	0	0	0.5	0.5
0.5	0.05	0.05	1	2	0	0	0.5	0.5
0.5	0.05	0.05	1	5	0	0	0.5	0.5
0.5	0.05	0.05	1	0.5	0	0	0.5	0.5
0.5	0.05	0.05	1	1	0	0	0.5	0.5
0.5	0.05	0.05	1	1	0	0	0.5	0.5
0	0	0	0	0	0	0	0	0
0.5	0.05	0.05	3	8	0	0	0.5	1
0	0	0	0	0	0	0	0	0
0.5	0.05	0.05	2	8	0	0	0.5	2
0	0	0	0	0	0	0	0	0
0.5	0.05	0.05	1	2	0	0	0.5	0.5
0	0	0	0	0	0	0	0	0
0.5	0.05	0.05	2	3	0	0	0.5	0.5
0	0	0	0	0	0	0	0	0
0.5	0.05	0.05	2	3	0	0	0.5	0.5
0.5	0.05	0.05	2	3	0	0	0.5	0.5
0.5	0.05	0.05	2	2	0	0	0.5	0.5
0	0	0	0	0	0	0	0	0
1	0.05	0.05	2	7	0	0	0.5	2
0.5	0.05	0.05	2	6	0	0	0.5	2
0.5	0.05	0.05	0.5	1	0	0	0.5	0.5
0.5	0.05	0.05	0.5	1	0	0	0.5	0.5
0.5	0.05	0.05	0.5	0.5	0	0	0.5	0.5
0.5	0.05	0.05	1	1	0	0	0.5	0.5
0.5	0.05	0.05	1	1	0	0	0.5	0.5
0.5	0.05	0.05	3	12	0	0	0.5	2

0.5	0.05	0.05	2	5	0	0	0.5	2
0.5	0.05	0.05	2	4	0	0	0.5	0.5
0.5	0.05	0.05	2	11	0	0	0.5	2
0.5	0.05	0.05	2	3	0	0	0.5	0.5
0.5	0.05	0.05	0.5	2	0	0	0.5	0.5
0.5	0.05	0.05	0.5	2	0	0	0.5	0.5
0.5	0.05	0.05	0.5	2	0	0	0.5	0.5
0.5	0.05	0.05	0.5	2	0	0	0.5	0.5
0.5	0.05	0.05	0.5	2	0	0	0.5	0.5
0.5	0.05	0.05	0.5	1	0	0	0.5	0.5
0.5	0.05	0.05	2	2	0	0	0.5	0.5
0.5	0.05	0.05	2	1	0	0	0.5	0.5
0.5	0.05	0.05	2	11	0	0	0.5	2
0	0	0	0	0	0	0	0	0
0.5	0.05	0.05	1	2	0	0	0.5	0.5
0.5	0.05	0.05	1	8	0	0	0.5	0.5
1	0.05	0.05	2	59	0	0	0.5	7
0.5	0.05	0.05	4	18	0	0	0.5	1
0.5	0.05	0.05	5	12	0	0	0.5	0.5
0.5	0.05	0.05	6	10	0	0	0.5	0.5
1	0.05	0.05	4	16	0	0	0.5	1
1	0.05	0.05	4	7	0	0	0.5	0.5
1	0.05	0.05	4	8	0	0	0.5	0.5
1	0.05	0.05	2	11	0	0	0.5	3
0.5	0.05	0.05	2	9	0	0	0.5	2
0.5	0.05	0.05	2	7	0	0	0.5	0.5
0.5	0.05	0.05	2	4	0	0	0.5	0.5
0.5	0.05	0.05	2	5	0	0	0.5	1
0.5	0.05	0.05	2	3	0	0	0.5	0.5
0.5	0.05	0.05	2	3	0	0	0.5	0.5
0.5	0.05	0.05	2	3	0	0	0.5	0.5
0.5	0.05	0.05	2	5	0	0	0.5	0.5
0.5	0.05	0.05	2	3	0	0	0.5	0.5
2	0.05	0.6	5	22	0	0	0.5	7
0.5	0.05	0.05	5	10	0	0	1	3
3	0.05	1.3	4	9	0	0	0.5	4
0.5	0.05	0.05	3	10	0	0	0.5	2
0.5	0.05	0.05	2	7	0	0	0.5	1
0.5	0.05	0.05	2	5	0	0	0.5	0.5
0.5	0.05	0.05	2	4	0	0	0.5	0.5
0.5	0.05	0.05	2	4	0	0	0.5	0.5
0.5	0.05	0.05	1	4	0	0	0.5	0.5
0.5	0.05	0.05	2	4	0	0	0.5	0.5
0.5	0.05	0.05	4	54	0	0	0.5	2
0.5	0.05	0.05	1	3	0	0	0.5	0.5
0.5	0.05	0.05	1	3	0	0	0.5	0.5
0.5	0.05	0.05	1	3	0	0	0.5	0.5
0.5	0.05	0.05	1	3	0	0	0.5	0.5
0.5	0.05	0.05	1	3	0	0	0.5	0.5
0.5	0.05	0.05	2	3	0	0	0.5	1

0.5	0.05	0.05	2	4	0	0	0.5	0.5
0.5	0.05	0.05	2	3	0	0	0.5	0.5
0.5	0.05	0.05	2	2	0	0	0.5	0.5
0.5	0.05	0.05	2	3	0	0	0.5	0.5
0.5	0.05	0.05	2	2	0	0	0.5	0.5
0.5	0.05	0.05	1	2	0	0	0.5	0.5
0.5	0.05	0.05	2	2	0	0	0.5	0.5
0.5	0.05	0.05	3	2	0	0	3	0.5
0.5	0.05	0.05	2	3	0	0	0.5	0.5
0.5	0.05	0.05	1	20	0	0	0.5	0.5
0.5	0.05	0.05	2	2	0	0	0.5	0.5
0.5	0.05	0.05	3	1	0	0	0.5	0.5
0.5	0.05	0.05	2	1	0	0	0.5	0.5
0.5	0.05	0.05	1	3	0	0	0.5	0.5
0.5	0.05	0.1	1	2	0	0	0.5	0.5
0.5	0.05	0.05	1	2	0	0	0.5	0.5
0.5	0.3	0.05	1	2	0	0	0.5	0.5
0.5	0.05	0.05	2	2	0	0	0.5	0.5
0.5	0.05	0.8	1	2	0	0	0.5	0.5
0	0	0	0	0	0	0	0	0
2	0.05	0.05	0.5	44	0	0	0.5	11
0	0	0	0	0	0	0	0	0
1	0.05	0.05	3	16	0	0	0.5	1
0	0	0	0	0	0	0	0	0
0.5	0.05	0.05	2	3	0	0	0.5	0.5
0	0	0	0	0	0	0	0	0
0.5	0.05	0.05	2	7	0	0	0.5	0.5
0	0	0	0	0	0	0	0	0
1	0.05	0.05	6	13	0	0	5	6
0	0	0	0	0	0	0	0	0
0.5	0.05	0.05	3	13	0	0	0.5	3
0	0	0	0	0	0	0	0	0
1	0.05	0.05	2	24	0	0	0.5	7
0	0	0	0	0	0	0	0	0
0.5	0.05	0.05	2	13	0	0	0.5	4
0	0	0	0	0	0	0	0	0
0.5	0.05	0.05	2	5	0	0	0.5	1
0	0	0	0	0	0	0	0	0
0.5	0.05	0.05	3	26	0	0	0.5	3
0	0	0	0	0	0	0	0	0
0.5	0.05	0.05	2	3	0	0	0.5	0.5
0	0	0	0	0	0	0	0	0
1	0.05	0.05	2	3	0	0	0.5	0.5
0	0	0	0	0	0	0	0	0
0.5	0.05	0.05	2	3	0	0	0.5	0.5
0	0	0	0	0	0	0	0	0
0.5	0.05	0.05	2	3	0	0	0.5	0.5
0	0	0	0	0	0	0	0	0
0.5	0.05	0.05	2	3	0	0	0.5	0.5
0	0	0	0	0	0	0	0	0

0.5	0.05	0.05	2	3	0	0	0.5	0.5
0	0	0	0	0	0	0	0	0
0.5	0.05	0.05	2	3	0	0	0.5	0.5
0.5	0.05	0.05	2	5	0	0	0.5	0.5
0.5	0.05	0.05	2	6	0	0	0.5	0.5
0.5	0.05	0.05	2	3	0	0	0.5	0.5
0.5	0.05	0.05	2	3	0	0	0.5	0.5
0	0	0	0	0	0	0	0	0
0.5	0.05	0.05	2	3	0	0	0.5	0.5
0	0	0	0	0	0	0	0	0
0.5	0.05	0.05	2	3	0	0	0.5	0.5
0	0	0	0	0	0	0	0	0
0.5	0.05	0.05	2	3	0	0	0.5	0.5
0	0	0	0	0	0	0	0	0
0.5	0.05	0.05	2	3	0	0	0.5	0.5
0.5	0.05	0.05	2	3	25	340	0.5	0.5
0	0	0	0	0	0	0	0	0
0.5	0.05	0.05	3	8	0	0	0.5	1
0	0	0	0	0	0	0	0	0
0.5	0.05	0.05	3	6	0	0	0.5	0.5
0	0	0	0	0	0	0	0	0
0.5	0.05	0.05	3	6	0	0	0.5	0.5
0	0	0	0	0	0	0	0	0
2	0.05	0.05	5	62	0	0	0.5	5
0	0	0	0	0	0	0	0	0
1	0.05	0.05	2	9	0	0	0.5	1
0	0	0	0	0	0	0	0	0
1	0.05	0.05	2	5	0	0	0.5	0.5
0	0	0	0	0	0	0	0	0
1	0.05	0.05	2	8	0	0	0.5	2
0	0	0	0	0	0	0	0	0
0.5	0.05	0.05	1	5	0	0	0.5	1
0	0	0	0	0	0	0	0	0
1	0.05	0.05	3	8	0	0	0.5	2
0	0	0	0	0	0	0	0	0
1	0.05	0.05	3	9	0	0	0.5	3
0	0	0	0	0	0	0	0	0
0.5	0.05	0.05	3	7	0	0	0.5	2
0	0	0	0	0	0	0	0	0
0.5	0.05	0.05	3	6	0	0	0.5	4
0	0	0	0	0	0	0	0	0
3	0.05	0.2	4	109	0	0	0.5	22
0	0	0	0	0	0	0	0	0
1	0.05	0.05	3	12	0	0	0.5	2
0	0	0	0	0	0	0	0	0
2	0.05	0.05	2	8	0	0	0.5	2
0	0	0	0	0	0	0	0	0
1	0.05	0.05	1	7	0	0	0.5	1
0	0	0	0	0	0	0	0	0
0.5	0.05	0.05	1	5	0	0	0.5	0.5

0	0	0	0	0	0	0	0	0
0.5	0.05	0.05	1	4	0	0	0.5	0.5
0	0	0	0	0	0	0	0	0
0.5	0.05	0.05	1	4	0	0	0.5	0.5
0	0	0	0	0	0	0	0	0
0.5	0.05	0.05	1	4	0	0	0.5	0.5
0	0	0	0	0	0	0	0	0
0.5	0.05	0.05	2	25	0	0	0.5	6
0	0	0	0	0	0	0	0	0
0.5	0.05	0.05	1	7	0	0	0.5	2
0	0	0	0	0	0	0	0	0
2	0.05	0.05	1	6	0	0	0.5	1
0	0	0	0	0	0	0	0	0
0.5	0.05	0.05	1	6	0	0	0.5	1
0	0	0	0	0	0	0	0	0
0.5	0.05	0.05	1	4	0	0	0.5	0.5
0	0	0	0	0	0	0	0	0
0.5	0.05	0.05	1	4	0	0	0.5	0.5
0	0	0	0	0	0	0	0	0
0.5	0.05	0.05	2	4	0	0	0.5	0.5
0	0	0	0	0	0	0	0	0
0.5	0.05	0.05	1	5	0	0	0.5	0.5
0	0	0	0	0	0	0	0	0
0.5	0.05	0.05	1	5	0	0	0.5	0.5
0.82	0.05	0.05	3.5	7.9	0	0	0.05	1.4
0	0	0	0	0	0	0	0	0
5	0.05	0.05	3	32	0	0	0.5	15
1	0.05	0.05	2	6	0	0	0.5	1
0.5	0.05	0.05	0.5	0.5	0	0	0.5	0.5
0	0	0	0	0	0	0	0	0
3	0.05	0.3	2	119	0	0	0.5	41
0	0	0	0	0	0	0	0	0
2	0.05	0.05	2	12	0	0	0.5	6
0	0	0	0	0	0	0	0	0
2	0.05	0.05	2	10	0	0	0.5	4
0	0	0	0	0	0	0	0	0
2	0.05	0.05	0.5	15	0	0	0.5	4
0	0	0	0	0	0	0	0	0
2	0.05	0.05	2	40	0	0	0.5	8
0	0	0	0	0	0	0	0	0
2	0.05	0.05	2	10	0	0	0.5	2
0	0	0	0	0	0	0	0	0
2	0.05	0.05	1	36	0	0	0.5	6
0	0	0	0	0	0	0	0	0
2	0.05	0.05	0.5	25	0	0	0.5	5
0	0	0	0	0	0	0	0	0
2	0.05	0.05	1	34	0	0	0.5	6
0	0	0	0	0	0	0	0	0
0.5	0.05	0.05	1	6	0	0	0.5	1
0	0	0	0	0	0	0	0	0

0.5	0.05	0.05	2	4	0	0	0.5	0.5
0	0	0	0	0	0	0	0	0
0.5	0.05	0.05	1	2	0	0	0.5	0.5
0	0	0	0	0	0	0	0	0
0.5	0.05	0.05	1	2	0	0	0.5	0.5
0	0	0	0	0	0	0	0	0
0.5	0.05	0.05	1	6	0	0	0.5	0.5
0	0	0	0	0	0	0	0	0
0.5	0.05	0.05	2	1	0	0	0.5	0.5
0.5	0.05	0.05	2	2	0	0	0.5	0.5
0.5	0.05	0.05	2	3	0	0	0.5	0.5
0.5	0.05	0.05	0.5	0.5	0	0	0.5	0.5
2	0.05	0.05	2	29	0	0	0.5	5
0	0	0	0	0	0	0	0	0
1	0.05	0.05	2	18	0	0	0.5	4
2	0.05	0.05	2	37	0	0	0.5	5
1	0.05	0.05	2	28	0	0	0.5	3
1	0.05	0.05	2	17	0	0	0.5	4
0.5	0.05	0.05	2	6	0	0	0.5	0.5
0.5	0.05	0.05	2	18	0	0	0.5	3
0.5	0.05	0.05	0.5	4	0	0	0.5	0.5
0.5	0.05	0.05	0.5	7	0	0	0.5	1
0.5	0.05	0.05	1	4	0	0	0.5	0.5
0.5	0.05	0.05	1	2	0	0	0.5	0.5
0.5	0.05	0.05	0.5	2	0	0	0.5	0.5
0.5	0.05	0.05	1	2	0	0	0.5	0.5
0.5	0.05	0.2	1	0.5	0	0	0.5	0.5
0.5	0.05	0.05	1	2	0	0	0.5	0.5
0.5	0.05	0.05	1	1	0	0	0.5	0.5
0.5	0.05	0.05	1	1	0	0	0.5	0.5
0.5	0.05	0.05	1	2	0	0	0.5	0.5
0.5	0.05	0.05	1	0.5	0	0	0.5	0.5
0.5	0.05	0.05	1	1	0	0	0.5	0.5
0.5	0.05	0.05	0.5	0.5	0	0	0.5	0.5
0.5	0.05	0.05	2	15	0	0	0.5	3
0.5	0.05	0.05	2	2	0	0	0.5	0.5
0.5	0.05	0.05	4	8	0	0	0.5	0.5
1	0.05	0.05	2	16	0	0	0.5	0.5
0.5	0.05	0.05	2	10	0	0	0.5	2
0.5	0.05	0.05	2	13	0	0	0.5	3
0.5	0.05	0.05	2	7	0	0	0.5	1
0.5	0.05	0.05	2	4	0	0	0.5	3
1	0.05	0.05	2	20	0	0	0.5	6
0.5	0.05	0.05	2	4	0	0	0.5	0.5
0.5	0.05	0.05	0.5	2	0	0	0.5	0.5
0.5	0.05	0.05	0.5	2	0	0	0.5	0.5
0.5	0.05	0.05	0.5	4	0	0	0.5	0.5
0.5	0.05	0.05	0.5	2	0	0	0.5	0.5
0.5	0.05	0.05	0.5	2	0	0	0.5	0.5
0.5	0.05	0.05	2	1	0	0	0.5	0.5

0.5	0.05	0.05	2	1	0	0	0.5	0.5
0.5	0.05	0.05	2	9	0	0	0.5	1
0	0	0	0	0	0	0	0	0
0.5	0.05	0.05	1	3	0	0	0.5	0.5
0.5	0.05	0.05	1	0.5	0	0	0.5	0.5
1	0.05	0.05	3	53	0	0	0.5	5
0.5	0.05	0.05	4	19	0	0	0.5	1
0.5	0.05	0.05	4	13	0	0	0.5	0.5
0.5	0.05	0.05	5	9	0	0	0.5	0.5
1	0.05	0.05	4	12	0	0	0.5	1
1	0.05	0.05	4	9	0	0	0.5	0.5
1	0.05	0.05	3	6	0	0	0.5	0.5
1	0.05	0.05	2	10	0	0	0.5	4
0.5	0.05	0.05	2	8	0	0	0.5	2
1	0.05	0.05	2	6	0	0	0.5	1
0.5	0.05	0.05	2	4	0	0	0.5	0.5
0.5	0.05	0.3	2	16	0	0	0.5	0.5
0.5	0.05	0.05	2	9	0	0	0.5	0.5
1	0.05	0.05	2	3	0	0	0.5	0.5
0.5	0.05	0.05	2	3	0	0	0.5	0.5
0.5	0.05	0.05	2	3	0	0	0.5	0.5
0.5	0.05	0.05	2	3	0	0	0.5	0.5
2	0.05	0.4	5	25	0	0	0.5	5
0.5	0.05	0.05	5	10	0	0	0.5	3
2	0.05	0.4	4	8	0	0	0.5	2
2	0.05	0.05	4	35	0	0	5	6
0.5	0.05	0.05	2	10	0	0	0.5	2
0.5	0.05	0.05	2	6	0	0	0.5	0.5
0.5	0.05	0.05	2	6	0	0	0.5	0.5
0.5	0.05	0.05	2	4	0	0	0.5	0.5
0.5	0.05	0.05	2	4	0	0	0.5	0.5
0.5	0.05	0.05	2	4	0	0	0.5	0.5
0.5	0.05	0.05	2	3	0	0	0.5	0.5
0.5	0.05	0.05	1	3	0	0	0.5	0.5
0.5	0.05	0.05	2	3	0	0	0.5	0.5
0.5	0.05	0.05	2	2	0	0	0.5	0.5
0.5	0.05	0.05	2	3	0	0	0.5	0.5
0.5	0.05	0.05	2	2	0	0	0.5	0.5
0.5	0.05	0.05	2	2	0	0	0.5	0.5
2	0.05	0.05	2	29	0	0	0.5	4
0.5	0.05	0.05	5	9	0	0	0.5	0.5
0.5	0.05	0.05	2	4	0	0	0.5	0.5
1	0.05	0.05	3	37	0	0	0.5	3
1	0.05	0.05	2	19	0	0	0.5	4
0.5	0.05	0.5	3	7	0	0	0.5	0.5
0.5	0.05	0.05	2	4	0	0	0.5	0.5
0.5	0.05	0.05	2	4	0	0	0.5	0.5
0.5	0.05	0.05	2	3	0	0	0.5	0.5
1	0.05	0.05	2	3	0	0	0.5	0.5
0.5	0.05	0.05	2	3	0	0	0.5	0.5

0.5	0.05	0.05	2	3	0	0	0.5	0.5
0.5	0.05	0.05	2	2	0	0	0.5	0.5
0.5	0.05	0.05	2	4	0	0	0.5	0.5
1	0.05	0.05	3	2	0	0	0.5	0.5
0.5	0.05	0.05	1	1	0	0	0.5	0.5
0.5	0.05	0.05	2	2	0	0	0.5	0.5
0.5	0.05	0.05	2	2	0	0	0.5	0.5
1	0.05	0.05	4	27	0	0	0.5	4
1	0.05	0.05	3	37	0	0	0.5	6
2	0.05	0.1	2	61	0	0	0.5	18
0.5	0.05	0.05	2	16	0	0	0.5	2
0.5	0.05	0.05	2	9	0	0	0.5	1
1	0.05	0.05	10	10	0	0	1	1
0.5	0.05	0.05	3	8	0	0	0.5	0.5
0.5	0.05	0.05	2	4	0	0	0.5	0.5
0.5	0.05	0.05	3	3	0	0	0.5	0.5
0.5	0.05	0.05	2	2	0	0	0.5	0.5
0.5	0.05	0.05	2	3	0	0	0.5	0.5
0.5	0.05	0.05	2	2	0	0	0.5	0.5
0.5	0.05	0.05	2	2	0	0	0.5	0.5
0.5	0.05	0.05	2	3	0	0	0.5	0.5
0.5	0.05	0.05	2	2	0	0	0.5	0.5
0.5	0.05	0.05	2	2	0	0	0.5	0.5
0.5	0.05	0.05	2	3	0	0	0.5	0.5
0.5	0.05	0.05	2	2	0	0	0.5	0.5
0.5	0.05	0.05	1	2	0	0	0.5	0.5
0.5	0.05	0.05	2	2	0	0	0.5	0.5
0.5	0.05	0.05	2	2	0	0	0.5	0.5
0.5	0.05	0.05	1	70	0	0	0.5	0.5
0.5	0.05	0.05	3	2	0	0	0.5	2
0.5	0.05	0.05	2	2	0	0	0.5	0.5
0.5	0.05	0.05	2	2	0	0	0.5	0.5
0.5	0.05	0.05	2	2	0	0	0.5	6
0.5	0.05	0.05	2	2	0	0	0.5	0.5
0.5	0.05	0.05	2	2	0	0	1	0.5
0.5	0.05	0.05	2	2	0	0	0.5	0.5
0.5	0.05	0.05	2	2	0	0	0.5	0.5
0.5	0.05	0.05	2	1	0	0	0.5	0.5
0	0	0	0	0	0	0	0	0
2	0.05	0.05	2	33	0	0	0.5	6
0	0	0	0	0	0	0	0	0
2	0.05	0.05	1	37	0	0	0.5	11
0	0	0	0	0	0	0	0	0
1	0.05	0.05	4	10	0	0	0.5	0.5
0	0	0	0	0	0	0	0	0
0.5	0.05	0.05	2	13	0	0	0.5	3
0	0	0	0	0	0	0	0	0
1	0.05	0.05	5	25	0	0	0.5	5
0	0	0	0	0	0	0	0	0
0.5	0.05	0.05	2	8	0	0	0.5	3

0	0	0	0	0	0	0	0	0
0.5	0.05	0.05	2	3	0	0	0.5	0.5
0	0	0	0	0	0	0	0	0
0.5	0.05	0.05	2	3	0	0	0.5	0.5
0	0	0	0	0	0	0	0	0
0.5	0.05	0.05	2	3	0	0	3	0.5
1	0.05	0.05	2	10	0	0	0.5	6
0	0	0	0	0	0	0	0	0
0.5	0.05	0.05	2	7	0	0	0.5	2
0	0	0	0	0	0	0	0	0
1	0.05	0.05	2	25	0	0	0.5	7
0	0	0	0	0	0	0	0	0
0.5	0.05	0.05	2	12	0	0	0.5	3
0	0	0	0	0	0	0	0	0
0.5	0.05	0.05	2	7	0	0	0.5	4
0	0	0	0	0	0	0	0	0
0.5	0.05	0.05	3	17	0	0	0.5	2
0	0	0	0	0	0	0	0	0
0.5	0.05	0.05	2	5	0	0	0.5	0.5
0	0	0	0	0	0	0	0	0
0.5	0.05	0.05	2	3	0	0	0.5	0.5
0	0	0	0	0	0	0	0	0
0.5	0.05	0.05	2	3	0	0	0.5	0.5
0	0	0	0	0	0	0	0	0
0.5	0.05	0.05	2	3	0	0	0.5	0.5
0	0	0	0	0	0	0	0	0
0.5	0.05	0.05	2	3	0	0	0.5	0.5
0	0	0	0	0	0	0	0	0
0.5	0.05	0.05	2	3	0	0	0.5	0.5
0	0	0	0	0	0	0	0	0
0.5	0.05	0.05	2	2	0	0	0.5	0.5
0.5	0.05	0.05	2	5	0	0	0.5	0.5
0.5	0.05	0.05	2	4	0	0	0.5	0.5
0.5	0.05	0.05	2	4	0	0	0.5	0.5
0.5	0.05	0.05	2	4	0	0	0.5	0.5
0	0	0	0	0	0	0	0	0
0.5	0.05	0.05	2	3	0	0	0.5	0.5
0	0	0	0	0	0	0	0	0
0.5	0.05	0.05	2	3	0	0	0.5	0.5
0	0	0	0	0	0	0	0	0
0.5	0.05	0.05	2	3	0	0	0.5	0.5
0	0	0	0	0	0	0	0	0
0.5	0.05	0.05	2	3	0	0	0.5	0.5
0	0	0	0	0	0	0	0	0
0.5	0.05	0.05	2	4	25	800	0.5	0.5
0	0	0	0	0	0	0	0	0
0.5	0.05	0.05	3	19	0	0	0.5	3
0	0	0	0	0	0	0	0	0
0.5	0.05	0.05	3	7	0	0	0.5	1
0	0	0	0	0	0	0	0	0

0.5	0.05	0.05	3	6	0	0	0.5	0.5
0	0	0	0	0	0	0	0	0
0.5	0.05	0.05	3	5	0	0	0.5	0.5
0	0	0	0	0	0	0	0	0
1	0.05	0.05	6	32	0	0	0.5	3
0	0	0	0	0	0	0	0	0
1	0.05	0.05	2	7	0	0	0.5	1
0	0	0	0	0	0	0	0	0
1	0.05	0.05	3	6	0	0	0.5	0.5
0	0	0	0	0	0	0	0	0
1	0.05	0.05	2	10	0	0	0.5	2
0	0	0	0	0	0	0	0	0
0.5	0.05	0.05	1	6	0	0	0.5	1
0	0	0	0	0	0	0	0	0
1	0.05	0.05	3	10	0	0	0.5	3
0	0	0	0	0	0	0	0	0
2	0.05	0.05	3	10	0	0	0.5	3
0	0	0	0	0	0	0	0	0
1	0.05	0.05	3	6	0	0	0.5	2
0	0	0	0	0	0	0	0	0
1	0.05	0.05	3	6	0	0	0.5	1
0	0	0	0	0	0	0	0	0
4	0.05	0.7	4	121	0	0	0.5	16
0	0	0	0	0	0	0	0	0
1	0.05	0.05	3	13	0	0	0.5	3
0	0	0	0	0	0	0	0	0
2	0.05	0.05	2	10	0	0	0.5	2
0	0	0	0	0	0	0	0	0
1	0.05	0.05	1	7	0	0	0.5	1
0	0	0	0	0	0	0	0	0
0.5	0.05	0.05	1	5	0	0	0.5	0.5
0	0	0	0	0	0	0	0	0
0.5	0.05	0.05	1	4	0	0	0.5	0.5
0	0	0	0	0	0	0	0	0
0.5	0.05	0.05	1	5	0	0	0.5	0.5
0	0	0	0	0	0	0	0	0
0.5	0.1	0.05	1	4	0	0	0.5	0.5
0	0	0	0	0	0	0	0	0
0.5	0.05	0.05	1	20	0	0	0.5	5
0	0	0	0	0	0	0	0	0
0.5	0.05	0.05	1	7	0	0	0.5	1
0	0	0	0	0	0	0	0	0
1	0.05	0.05	1	6	0	0	0.5	1
0	0	0	0	0	0	0	0	0
0.5	0.05	0.05	1	5	0	0	0.5	0.5
0	0	0	0	0	0	0	0	0
0.5	0.05	0.05	1	4	0	0	0.5	0.5
0	0	0	0	0	0	0	0	0
0.5	0.05	0.05	1	4	0	0	0.5	0.5
0	0	0	0	0	0	0	0	0

0.5	0.05	0.05	2	3	0	0	0.5	0.5
0	0	0	0	0	0	0	0	0
0.5	0.05	0.05	1	4	0	0	0.5	0.5
0	0	0	0	0	0	0	0	0
0.5	0.05	0.05	1	4	0	0	0.5	0.5
0.9	0.05	0.05	2	4.9	0	0	0.05	0.9
0	0	0	0	0	0	0	0	0
3	0.05	0.05	2	24	0	0	0.5	18
1	0.05	0.05	4	8	0	0	0.5	0.5
3	0.05	0.1	2	71	0	0	0.5	21
0	0	0	0	0	0	0	0	0
2	0.05	0.05	2	14	0	0	0.5	6
0	0	0	0	0	0	0	0	0
2	0.05	0.05	2	10	0	0	0.5	3
0	0	0	0	0	0	0	0	0
2	0.05	0.05	2	24	0	0	0.5	5
0	0	0	0	0	0	0	0	0
2	0.05	0.05	2	10	0	0	0.5	2
0	0	0	0	0	0	0	0	0
2	0.05	0.05	1	30	0	0	0.5	6
0	0	0	0	0	0	0	0	0
2	0.05	0.05	0.5	24	0	0	0.5	5
0	0	0	0	0	0	0	0	0
3	0.05	0.05	1	38	0	0	0.5	6
0	0	0	0	0	0	0	0	0
0.5	0.05	0.05	1	6	0	0	0.5	0.5
0	0	0	0	0	0	0	0	0
0.5	0.05	0.05	1	4	0	0	0.5	0.5
0	0	0	0	0	0	0	0	0
0.5	0.05	0.05	1	2	0	0	0.5	0.5
0	0	0	0	0	0	0	0	0
0.5	0.05	0.05	1	2	0	0	0.5	0.5
0	0	0	0	0	0	0	0	0
0.5	0.05	0.05	1	2	0	0	0.5	0.5
0	0	0	0	0	0	0	0	0
0.5	0.05	0.05	1	1	0	0	0.5	0.5
0.5	0.05	0.05	2	4	0	0	0.5	0.5
0.5	0.05	0.05	3	4	0	0	0.5	0.5
0.5	0.05	0.05	4	18	0	0	0.5	2
2	0.05	0.05	2	32	0	0	0.5	5
0	0	0	0	0	0	0	0	0
1	0.05	0.05	2	17	0	0	0.5	4
2	0.05	0.05	2	34	0	0	0.5	5
1	0.05	0.05	2	25	0	0	0.5	2
1	0.05	0.05	2	18	0	0	0.5	3
0.5	0.05	0.05	2	8	0	0	0.5	0.5
1	0.05	0.05	2	21	0	0	0.5	3
0.5	0.05	0.05	0.5	11	0	0	0.5	2
0.5	0.05	0.05	0.5	5	0	0	0.5	0.5
0.5	0.05	0.05	0.5	5	0	0	0.5	0.5

0.5	0.05	0.05	0.5	6	0	0	0.5	1
0.5	0.05	0.05	1	5	0	0	0.5	0.5
0.5	0.05	0.05	1	2	0	0	0.5	0.5
0.5	0.05	0.05	2	0.5	0	0	0.5	0.5
0.5	0.05	0.05	1	3	0	0	0.5	0.5
0.5	0.05	0.05	1	0.5	0	0	0.5	0.5
0.5	0.05	0.05	1	1	0	0	0.5	0.5
0.5	0.05	0.05	1	1	0	0	0.5	0.5
0.5	0.05	0.05	1	2	0	0	0.5	0.5
0.5	0.1	0.05	2	1	0	0	0.5	0.5
0.5	0.05	0.05	1	1	0	0	0.5	0.5
0.5	0.05	0.05	1	0.5	0	0	0.5	0.5

mg/L; these have been converted to µg/L

Manganese (dissolved) (µg/L)	Manganese (µg/L)	Nickel (dissolved) (µg/L)	Nickel (µg/L)	Zinc (dissolved) (µg/L)	Zinc (µg/L)
13	990	1	18	2.5	38
17	43	0.5	0.5	2.5	2.5
28	42	0.5	0.5	2.5	2.5
35	59	0.5	0.5	2.5	6
2	3	0.5	0.5	2.5	2.5
30	31	0.5	0.5	2.5	2.5
9	54	0.5	1	2.5	2.5
9	63	0.5	0.5	2.5	2.5
7	79	0.5	1	2.5	6
12	78	0.5	2	2.5	19
23	147	0.5	3	2.5	11
5	21	0.5	0.5	2.5	20
10	30	0.5	1	2.5	11
9	46	0.5	0.5	2.5	12
108	120	0.5	0.5	2.5	2.5
110	116	0.5	0.5	2.5	2.5
31	48	0.5	0.5	2.5	2.5
0	0	0	0	0	0
10	80	0.5	3	8	2.5
0	0	0	0	0	0
12	82	0.5	3	2.5	2.5
0	0	0	0	0	0
28	58	0.5	0.5	2.5	2.5
0	0	0	0	0	0
7	52	0.5	1	2.5	30
0	0	0	0	0	0
25	68	0.5	2	2.5	2.5
17	42	0.5	0.5	2.5	2.5
28	48	0.5	13	2.5	2.5
0	0	0	0	0	0
30	226	0.5	4	2.5	7
0.5	105	0.5	2	2.5	2.5
8	43	0.5	0.5	2.5	2.5
0.5	39	0.5	0.5	2.5	2.5
0.5	40	0.5	0.5	2.5	10
0.5	21	0.5	0.5	2.5	2.5
0.5	29	0.5	0.5	2.5	2.5
6	130	0.5	5	2.5	7

6	124	0.5	2	2.5	2.5
13	75	0.5	1	2.5	2.5
5	170	0.5	4	2.5	2.5
11	69	0.5	0.5	2.5	2.5
34	68	0.5	0.5	2.5	2.5
53	64	0.5	0.5	2.5	2.5
43	46	0.5	0.5	2.5	2.5
22	21	0.5	0.5	2.5	2.5
46	44	0.5	0.5	2.5	2.5
31	31	0.5	0.5	2.5	2.5
53	31	0.5	0.5	2.5	2.5
43	12	0.5	0.5	2.5	2.5
0.5	161	0.5	4	2.5	7
0	0	0	0	0	0
16	140	0.5	0.5	2.5	2.5
11	65	0.5	0.5	2.5	2.5
2	777	0.5	20	2.5	24
3	134	0.5	4	2.5	5
3	146	1	3	2.5	2.5
0.5	76	0.5	0.5	102	6
5	156	0.5	3	2.5	19
19	63	0.5	0.5	2.5	11
1	53	0.5	0.5	2.5	2.5
4	350	0.5	2	2.5	8
1	160	0.5	2	2.5	8
2	101	0.5	2	2.5	6
15	65	0.5	1	2.5	2.5
17	89	0.5	1	2.5	2.5
0.5	110	0.5	0.5	2.5	2.5
0.5	116	0.5	1	2.5	2.5
0.5	110	0.5	1	2.5	2.5
0.5	109	0.5	0.5	2.5	2.5
0.5	144	0.5	0.5	2.5	2.5
5	388	0.5	9	2.5	39
4	171	0.5	3	2.5	10
16	76	0.5	4	2.5	7
1	107	0.5	3	2.5	2.5
1	76	0.5	1	2.5	6
3	75	0.5	2	2.5	2.5
5	76	0.5	0.5	10	2.5
20	101	0.5	0.5	2.5	2.5
1	133	0.5	1	2.5	2.5
18	119	0.5	1	2.5	2.5
8	89	0.5	1	2.5	35
7	87	0.5	1	2.5	2.5
10	81	0.5	0.5	2.5	2.5
3	77	0.5	1	2.5	6
31	117	0.5	1	2.5	2.5
3	77	0.5	1	2.5	6
23	45	0.5	0.5	2.5	7

36	78	0.5	0.5	2.5	13
26	104	0.5	0.5	2.5	9
26	252	0.5	0.5	2.5	15
16	168	0.5	0.5	2.5	20
6	133	0.5	2	2.5	2.5
6	133	0.5	1	2.5	2.5
122	103	0.5	0.5	2.5	2.5
5	66	0.5	0.5	2.5	2.5
56	97	0.5	0.5	2.5	2.5
61	0.05	0.5	0.5	2.5	2.5
78	110	0.5	0.5	2.5	2.5
79	119	0.5	0.5	2.5	2.5
78	117	0.5	0.5	2.5	2.5
73	143	0.5	0.5	2.5	8
104	170	0.5	0.5	2.5	2.5
52	93	0.5	0.5	2.5	2.5
56	107	0.5	0.5	2.5	2.5
53	92	0.5	0.5	2.5	2.5
76	207	0.5	1	2.5	37
0	0	0	0	0	0
6	632	0.5	16	2.5	25
0	0	0	0	0	0
8	127	0.5	3	5	2.5
0	0	0	0	0	0
30	47	0.5	0.5	2.5	2.5
0	0	0	0	0	0
34	46	0.5	2	2.5	207
0	0	0	0	0	0
18	183	1	4	31	14
0	0	0	0	0	0
6	208	0.5	6	5	7
0	0	0	0	0	0
4	345	0.5	11	2.5	18
0	0	0	0	0	0
7	135	0.5	4	2.5	15
0	0	0	0	0	0
12	71	0.5	2	2.5	2.5
0	0	0	0	0	0
4	232	0.5	11	2.5	16
0	0	0	0	0	0
14	48	0.5	1	2.5	2.5
0	0	0	0	0	0
21	53	0.5	0.5	2.5	2.5
0	0	0	0	0	0
11	54	0.5	0.5	2.5	2.5
0	0	0	0	0	0
3	53	0.5	0.5	2.5	2.5
0	0	0	0	0	0
2	54	0.5	0.5	2.5	2.5
0	0	0	0	0	0

2	53	0.5	0.5	2.5	2.5
0	0	0	0	0	0
46	128	0.5	0.5	2.5	2.5
5	61	0.5	2	2.5	2.5
9	83	0.5	2	2.5	2.5
10	30	0.5	0.5	2.5	2.5
11	49	0.5	0.5	2.5	2.5
0	0	0	0	0	0
9	51	19	0.5	2.5	2.5
0	0	0	0	0	0
10	61	0.5	1	2.5	2.5
0	0	0	0	0	0
5	51	0.5	0.5	2.5	2.5
0	0	0	0	0	0
4	48	0.5	0.5	2.5	2.5
0.5	91	0.5	0.5	2.5	2.5
0	0	0	0	0	0
14	114	0.5	3	2.5	2.5
0	0	0	0	0	0
8	80	0.5	2	2.5	2.5
0	0	0	0	0	0
20	64	0.5	1	2.5	2.5
0	0	0	0	0	0
7	496	0.5	13	2.5	23
0	0	0	0	0	0
7	157	0.5	9	2.5	2.5
0	0	0	0	0	0
7	70	0.5	2	2.5	2.5
0	0	0	0	0	0
17	160	0.5	3	2.5	5
0	0	0	0	0	0
0.5	95	0.5	2	2.5	2.5
0	0	0	0	0	0
6	89	0.5	2	2.5	15
0	0	0	0	0	0
5	88	0.5	2	2.5	13
0	0	0	0	0	0
10	96	0.5	2	2.5	11
0	0	0	0	0	0
4	63	8	2	2.5	16
0	0	0	0	0	0
11	1820	0.5	39	2.5	93
0	0	0	0	0	0
5	133	0.5	5	2.5	7
0	0	0	0	0	0
0.5	108	0.5	3	2.5	6
0	0	0	0	0	0
0.5	119	0.5	3	2.5	2.5
0	0	0	0	0	0
0.5	98	0.5	2	2.5	2.5

0	0	0	0	0	0
0.5	74	0.5	2	2.5	2.5
0	0	0	0	0	0
0.5	88	0.5	2	2.5	2.5
0	0	0	0	0	0
0.5	84	0.5	2	2.5	7
0	0	0	0	0	0
1	305	0.5	11	2.5	16
0	0	0	0	0	0
0.5	84	0.5	3	2.5	8
0	0	0	0	0	0
0.5	65	0.5	2	2.5	2.5
0	0	0	0	0	0
0.5	100	0.5	2	2.5	6
0	0	0	0	0	0
0.5	56	0.5	2	2.5	2.5
0	0	0	0	0	0
0.5	58	0.5	2	2.5	2.5
0	0	0	0	0	0
0.5	66	0.5	2	2.5	2.5
0	0	0	0	0	0
0.5	59	0.5	2	2.5	7
0	0	0	0	0	0
0.5	50	0.5	2	2.5	2.5
6.3	120	0.73	2.1	1.4	#VALUE!
0	0	0	0	0	0
1	670	0.5	14	2.5	29
0.5	155	0.5	1	2.5	8
0.5	0.5	0.5	0.5	2.5	2.5
0	0	0	0	0	0
0.5	1400	0.5	39	2.5	84
0	0	0	0	0	0
0.5	137	0.5	6	2.5	8
0	0	0	0	0	0
0.5	91	0.5	4	2.5	2.5
0	0	0	0	0	0
0.5	222	0.5	9	2.5	13
0	0	0	0	0	0
0.5	499	0.5	12	2.5	19
0	0	0	0	0	0
0.5	112	0.5	2	2.5	2.5
0	0	0	0	0	0
0.5	436	0.5	12	2.5	21
0	0	0	0	0	0
0.5	332	0.5	11	2.5	14
0	0	0	0	0	0
0.5	432	0.5	14	2.5	18
0	0	0	0	0	0
0.5	87	0.5	2	2.5	2.5
0	0	0	0	0	0

0.5	61	0.5	0.5	2.5	2.5
0	0	0	0	0	0
0.5	62	0.5	2	2.5	2.5
0	0	0	0	0	0
0.5	67	0.5	0.5	2.5	2.5
0	0	0	0	0	0
0.5	64	0.5	0.5	2.5	2.5
0	0	0	0	0	0
0.5	63	0.5	0.5	2.5	2.5
0.5	144	0.5	1	2.5	2.5
0.5	48	0.5	0.5	2.5	2.5
0.5	0.5	0.5	0.5	2.5	2.5
0.5	366	0.5	10	2.5	20
0	0	0	0	0	0
1	179	0.5	8	2.5	17
1	379	0.5	15	2.5	18
0.5	265	0.5	8	2.5	11
1	241	0.5	5	2.5	8
0.5	54	0.5	2	2.5	2.5
0.5	225	0.5	7	2.5	12
0.5	75	0.5	2	2.5	5
0.5	128	0.5	2	2.5	6
0.5	102	0.5	1	2.5	2.5
0.5	94	0.5	0.5	2.5	2.5
0.5	100	0.5	0.5	2.5	2.5
0.5	127	0.5	0.5	2.5	2.5
60	123	0.5	0.5	9	28
0.5	148	0.5	0.5	2.5	7
0.5	135	0.5	0.5	2.5	6
0.5	157	0.5	0.5	2.5	2.5
0.5	184	0.5	0.5	2.5	2.5
0.5	157	0.5	0.5	2.5	2.5
0.5	157	0.5	0.5	2.5	2.5
0.5	2	0.5	0.5	2.5	2.5
7	224	0.5	6	2.5	8
57	91	0.5	0.5	2.5	2.5
79	127	1	1	2.5	2.5
329	389	0.5	1	2.5	9
1	145	0.5	3	2.5	6
4	346	0.5	4	8	12
2	138	0.5	2	2.5	2.5
16	85	0.5	0.5	2.5	2.5
6	297	0.5	7	2.5	11
17	81	0.5	1	2.5	2.5
50	77	0.5	0.5	2.5	2.5
71	87	0.5	2	2.5	2.5
91	91	0.5	0.5	2.5	2.5
52	52	0.5	0.5	2.5	2.5
36	37	0.5	0.5	2.5	2.5
45	33	0.5	0.5	2.5	2.5

49	18	0.5	0.5	2.5	2.5
1	119	0.5	3	2.5	2.5
0	0	0	0	0	0
6	99	0.5	0.5	2.5	2.5
5	50	0.5	0.5	2.5	2.5
4	692	0.5	16	2.5	17
2	155	0.5	4	2.5	6
2	159	0.5	3	2.5	2.5
0.5	106	1	0.5	100	2.5
6	122	0.5	2	2.5	2.5
8	110	0.5	0.5	2.5	2.5
2	97	0.5	0.5	2.5	2.5
4	439	0.5	2	2.5	9
2	186	0.5	0.5	2.5	8
2	116	0.5	2	2.5	2.5
45	116	0.5	1	2.5	2.5
72	173	0.5	1	2.5	2.5
4	191	0.5	1	2.5	5
2	194	0.5	1	2.5	2.5
2	193	0.5	0.5	2.5	2.5
1	178	0.5	0.5	2.5	2.5
0.5	160	0.5	0.5	2.5	2.5
6	388	0.5	8	2.5	21
3	156	0.5	2	2.5	9
9	71	1	2	2.5	6
6	425	0.5	12	7	22
1	98	0.5	3	2.5	2.5
6	88	0.5	0.5	2.5	2.5
10	104	0.5	1	2.5	2.5
16	124	0.5	1	13	2.5
61	164	0.5	0.5	2.5	2.5
1	126	0.5	1	2.5	2.5
19	107	0.5	1	2.5	2.5
10	87	0.5	1	2.5	2.5
3	62	0.5	0.5	2.5	2.5
1	45	0.5	0.5	2.5	2.5
2	38	0.5	0.5	2.5	2.5
0.5	31	0.5	0.5	2.5	2.5
0.5	31	0.5	0.5	2.5	2.5
5	378	0.5	13	2.5	17
50	123	0.5	1	2.5	2.5
270	371	0.5	0.5	2.5	6
12	304	0.5	9	2.5	11
2	268	0.5	8	2.5	0
12	84	0.5	2	2.5	2.5
24	68	0.5	1	2.5	2.5
53	72	0.5	0.5	5	2.5
50	76	0.5	0.5	2.5	2.5
47	47	0.5	0.5	2.5	7
105	166	0.5	0.5	2.5	8

59	148	0.5	0.5	2.5	8
66	183	0.5	0.5	2.5	2.5
61	240	0.5	1	2.5	12
13	212	0.5	2	2.5	2.5
11	134	0.5	2	2.5	2.5
24	154	0.5	0.5	2.5	2.5
43	146	0.5	0.5	2.5	2.5
6	330	0.5	8	2.5	12
13	536	0.5	13	2.5	33
4	871	0.5	24	2.5	86
4	238	0.5	5	2.5	9
49	132	0.5	2	2.5	6
690	690	3	3	5	5
33	105	0.5	2	2.5	5
28	70	0.5	1	2.5	2.5
57	76	0.5	0.5	2.5	2.5
68	79	0.5	0.5	2.5	2.5
86	108	0.5	0.5	2.5	2.5
73	84	0.5	0.5	2.5	2.5
74	106	0.5	0.5	2.5	2.5
80	117	0.5	0.5	2.5	2.5
76	104	0.5	0.5	2.5	2.5
44	132	0.5	0.5	2.5	2.5
62	125	0.5	0.5	7	2.5
58	125	0.5	0.5	2.5	2.5
74	116	0.5	0.5	2.5	2.5
52	107	0.5	0.5	2.5	2.5
46	104	0.5	0.5	2.5	2.5
65	0.05	0.5	0.5	2.5	2.5
72	122	0.5	0.5	2.5	2.5
85	135	0.5	0.5	2.5	2.5
76	150	0.5	0.5	2.5	2.5
61	156	0.5	0.5	2.5	2.5
51	167	0.5	0.5	5	2.5
94	150	0.5	0.5	2.5	2.5
84	153	0.5	0.5	2.5	2.5
36	106	0.5	0.5	7	2.5
18	162	0.5	0.5	24	2.5
0	0	0	0	0	0
12	464	0.5	13	5	19
0	0	0	0	0	0
6	566	0.5	16	5	31
0	0	0	0	0	0
8	118	0.5	3	2.5	6
0	0	0	0	0	0
23	156	0.5	8	2.5	10
0	0	0	0	0	0
137	343	0.5	6	2.5	14
0	0	0	0	0	0
13	129	0.5	4	2.5	2.5

0	0	0	0	0	0
24	66	0.5	0.5	2.5	2.5
0	0	0	0	0	0
43	62	0.5	1	2.5	9
0	0	0	0	0	0
37	51	0.5	1	9	2.5
5	108	0.5	3	2.5	13
0	0	0	0	0	0
8	113	0.5	6	2.5	7
0	0	0	0	0	0
5	369	0.5	12	2.5	22
0	0	0	0	0	0
28	140	0.5	4	2.5	17
0	0	0	0	0	0
14	91	0.5	3	2.5	25
0	0	0	0	0	0
6	163	0.5	4	2.5	9
0	0	0	0	0	0
21	85	0.5	1	2.5	2.5
0	0	0	0	0	0
25	67	0.5	0.5	2.5	2.5
0	0	0	0	0	0
25	86	0.5	0.5	2.5	2.5
0	0	0	0	0	0
9	102	0.5	0.5	2.5	2.5
0	0	0	0	0	0
46	125	0.5	0.5	2.5	2.5
0	0	0	0	0	0
52	122	0.5	1	2.5	2.5
0	0	0	0	0	0
3	47	0.5	0.5	2.5	2.5
5	53	0.5	2	2.5	2.5
9	56	0.5	1	2.5	2.5
12	52	0.5	0.5	2.5	6
13	52	0.5	0.5	2.5	2.5
0	0	0	0	0	0
22	80	19	1	2.5	2.5
0	0	0	0	0	0
25	89	0.5	0.5	2.5	2.5
0	0	0	0	0	0
34	102	0.5	0.5	2.5	2.5
0	0	0	0	0	0
35	110	0.5	0.5	2.5	2.5
0	0	0	0	0	0
0.5	284	0.5	0.5	13	2.5
0	0	0	0	0	0
8	262	0.5	8	2.5	12
0	0	0	0	0	0
14	107	0.5	3	2.5	6
0	0	0	0	0	0

19	83	0.5	2	2.5	2.5
0	0	0	0	0	0
28	83	0.5	1	2.5	2.5
0	0	0	0	0	0
40	338	0.5	7	2.5	11
0	0	0	0	0	0
12	118	0.5	4	2.5	2.5
0	0	0	0	0	0
19	96	0.5	2	2.5	2.5
0	0	0	0	0	0
13	238	0.5	5	2.5	6
0	0	0	0	0	0
0.5	156	0.5	2	2.5	2.5
0	0	0	0	0	0
10	129	0.5	3	2.5	15
0	0	0	0	0	0
10	138	0.5	3	2.5	15
0	0	0	0	0	0
15	109	0.5	2	2.5	8
0	0	0	0	0	0
14	100	0.5	1	2.5	6
0	0	0	0	0	0
10	1990	0.5	43	2.5	90
0	0	0	0	0	0
5	140	1	5	2.5	8
0	0	0	0	0	0
0.5	174	0.5	4	2.5	6
0	0	0	0	0	0
0.5	185	0.5	3	2.5	2.5
0	0	0	0	0	0
0.5	186	0.5	2	2.5	2.5
0	0	0	0	0	0
0.5	234	0.5	2	2.5	2.5
0	0	0	0	0	0
0.5	154	0.5	2	2.5	2.5
0	0	0	0	0	0
0.5	133	0.5	1	2.5	2.5
0	0	0	0	0	0
1	268	0.5	8	2.5	14
0	0	0	0	0	0
0.5	91	0.5	3	2.5	5
0	0	0	0	0	0
0.5	72	0.5	2	2.5	2.5
0	0	0	0	0	0
0.5	72	0.5	2	2.5	2.5
0	0	0	0	0	0
0.5	79	0.5	2	2.5	2.5
0	0	0	0	0	0
0.5	102	0.5	1	2.5	2.5
0	0	0	0	0	0

0.5	83	0.5	1	2.5	2.5
0	0	0	0	0	0
0.5	66	0.5	1	2.5	2.5
0	0	0	0	0	0
0.5	77	0.5	1	2.5	2.5
71	430	1.1	2	2.8	#VALUE!
0	0	0	0	0	0
4	800	0.5	10	2.5	26
0.5	137	0.5	0.5	2.5	2.5
0.5	774	0.5	23	2.5	42
0	0	0	0	0	0
0.5	165	0.5	7	2.5	16
0	0	0	0	0	0
0.5	133	0.5	4	2.5	2.5
0	0	0	0	0	0
0.5	310	0.5	8	2.5	10
0	0	0	0	0	0
1	115	0.5	4	2.5	2.5
0	0	0	0	0	0
0.5	367	0.5	12	2.5	17
0	0	0	0	0	0
0.5	344	0.5	11	2.5	15
0	0	0	0	0	0
0.5	453	0.5	16	2.5	26
0	0	0	0	0	0
0.5	86	0.5	2	2.5	2.5
0	0	0	0	0	0
0.5	73	0.5	1	2.5	8
0	0	0	0	0	0
0.5	94	0.5	0.5	2.5	2.5
0	0	0	0	0	0
0.5	114	0.5	0.5	2.5	2.5
0	0	0	0	0	0
0.5	144	0.5	0.5	2.5	2.5
0	0	0	0	0	0
0.5	136	0.5	0.5	2.5	2.5
0.5	180	0.5	1	2.5	2.5
1	1	0.5	0.5	15	15
2	116	0.5	5	2.5	6
0.5	358	0.5	12	2.5	18
0	0	0	0	0	0
2	168	0.5	7	2.5	14
1	334	0.5	13	2.5	17
0.5	243	0.5	6	2.5	9
2	223	0.5	6	2.5	10
1	59	0.5	2	2.5	2.5
0.5	202	0.5	8	2.5	11
0.5	200	0.5	4	2.5	12
0.5	56	0.5	1	2.5	10
0.5	82	0.5	2	2.5	17

0.5	128	0.5	2	2.5	2.5
0.5	129	0.5	1	2.5	28
0.5	123	0.5	0.5	2.5	2.5
0.5	115	0.5	0.5	2.5	2.5
0.5	171	0.5	0.5	2.5	2.5
51	185	0.5	0.5	2.5	10
0.5	144	0.5	0.5	2.5	2.5
0.5	143	0.5	0.5	2.5	2.5
0.5	158	0.5	0.5	2.5	2.5
0.5	164	8	0.5	54	2.5
0.5	203	0.5	0.5	2.5	2.5
0.5	231	0.5	0.5	2.5	2.5

DO NOT change column headings. Values in the Data columns must be a number. If < is entered in a cell it wi

Monitoring Point	Date	DO % Saturation (Field)	Dissolved Oxygen - % Saturation	Electrical Conductivity (field) (µS/cm)	Electrical Conductivity (Lab) (µS/cm)	Electrical Conductivity @ 25oC (µS/cm)	Electrical Conductivity (Non Compensated) (µS/cm)	pH (Field)	pH (Lab)
CC-05	11 Jan 2015				126				7.94
CC-05	03 Jan 2016	73		197.3	234	191.8327662		7.53	7.99
CC-05	04 Jan 2016	73		320.7	280	299.1046447		7.66	8.17
CC-05	05 Jan 2016	78		360	312	329.9120235		7.95	8.24
CC-05	07 Jan 2016	202.5		380.7	51	326.1651816		8.15	7.61
CC-05	08 Jan 2016	126.6		339.1	350	309.1439511		8.24	8.44
CC-05	01 Feb 2016	49.2		182	159	165.0643933		7.78	8.05
CC-05	14 Feb 2016	58		253	229	235.1301115		8.08	7.89
CC-05	10 Mar 2016	41.5		149	122	127.2416738		8.01	7.78
CC-05	05 Mar 2018	15		122.3	92	111.3032399		7.21	7.43
CC-05	06 Mar 2018	21.6		137.7	106	128.884313		7.06	7.5
CC-05	18 Mar 2018	37.7		300.8	274	294.0946422		8.66	8.07
CC-05	19 Mar 2018	88.7		321.8	272	298.5434641		8.95	8.41
CC-05	20 Mar 2018	81.2		322	281	298.203371		8.85	8.43
CC-05	11 Feb 2019	61		502	433	483.6223507		7.8	8.1
CC-05	12 Feb 2019	101		495	376	429.6875		8.2	8.2
CC-05	13 Feb 2019	140		541	377	465.7770125		8.33	8.1
CC-05	27 Jan 2020	78.3		84.4				7.37	
CC-05	27 Jan 2020				80				6.92
CC-05	28 Jan 2020	86.2		106				7.5	
CC-05	28 Jan 2020				98				7.34
CC-05	02 Feb 2020	98.2		227.1				7.9	
CC-05	02 Feb 2020				194				8.07
CC-05	03 Feb 2020	89.6		163.3				7.71	
CC-05	03 Feb 2020				149				7.86
CC-05	08 Feb 2020	84		191.9				8.1	
CC-05	08 Feb 2020				183				8.05
CC-05	06 Mar 2020				139				7.75
CC-05	08 Mar 2020				223				8.19
CC-05	24 Dec 2020	85.4		105.8				7.61	
CC-05	24 Dec 2020				98				7.03
CC-05	07 Feb 2023				97				7.26
CC-05	15 Mar 2023				400				8.11
CC-05	16 Mar 2023				445				8.16
CC-05	17 Mar 2023				479				8.33
CC-05	18 Mar 2023				516				8.31
CC-05	19 Mar 2023				516				8.36
DR-10	19 Dec 2015	42.6		87.2	94	87.0346342		7.16	7.26

DR-10	31 Dec 2015	77	111.7	112	109.0075144	7.49	7.65
DR-10	01 Jan 2016	65	169	158	163.7120992	7.61	7.88
DR-10	02 Jan 2016	84.7	109	103	105.9795819	7.54	7.76
DR-10	03 Jan 2016	81	145	171	142.8289992	7.51	7.95
DR-10	04 Jan 2016	63	241	219	234.3218279	7.59	7.89
DR-10	05 Jan 2016	58	297	261	284.0474369	7.73	8.09
DR-10	06 Jan 2016	61.3	324.7	302	306.0897436	7.6	8.23
DR-10	07 Jan 2016	63	347.7	325	332.5363428	7.6	8.5
DR-10	08 Jan 2016	55	368.5		347.3793363	7.8	
DR-10	09 Jan 2016	56.3	397.7	369	370.9196046	7.75	8.36
DR-10	10 Jan 2016	46.5	444	392	404.7770991	7.49	8.16
DR-10	11 Jan 2016	28	456.3	396	415.9905187	7.28	8.18
DR-10	12 Jan 2016	71.9	137	139	132.2266191	7.63	7.82
DR-10	16 Jan 2016	41	257		238.0070383	7.61	
DR-10	31 Jan 2016	34.2	569	492	504.7458529	7.57	8.23
DR-10	14 Feb 2016	50.4	449	400	415.817744	7.63	7.99
DR-10	05 Mar 2016	20	104.8	116	106.8297655	8.03	7.75
DR-10	06 Mar 2016	14.6	139.4	119	133.5632845	7.64	7.81
DR-10	07 Mar 2016	8.3	142.1	136	136.398541	7.9	7.83
DR-10	08 Mar 2016	3.8	155.3	141	147.4553741	7.46	7.63
DR-10	09 Mar 2016	85.4	171	152	147.464643	8.12	7.72
DR-10	10 Mar 2016	8.5	290	136	276.3483896	7.75	7.65
DR-10	11 Mar 2016	39	202	138	188.064426	7.91	7.8
DR-10	12 Mar 2016	55	111	93	108.7275933	8.2	7.61
DR-10	13 Mar 2016	48	130	116	124.1050119	7.72	7.74
DR-10	14 Mar 2016	55	98.2	90	93.57728226	7.46	7.69
DR-10	15 Mar 2016	47	124.5	110	115.5023657	7.48	7.85
DR-10	16 Mar 2016	44	134	124	128.1560826	6.99	7.89
DR-10	17 Mar 2016	54	158	170	147.3605671	7.6	8.08
DR-10	18 Mar 2016	46	111	173	102.7968142	7.3	8.08
DR-10	19 Mar 2016	22.7	185	168	174.7096043	7.55	8.07
DR-10	20 Mar 2016	42	159	169	150.6966164	7.2	8.09
DR-10	21 Mar 2016	44	178.6	182	174.6186938	7.64	8.08
DR-10	23 May 2016	40.4	62.2	71	65.04235073	8.45	7.06
DR-10	24 May 2016	23.9	77.7	63	81.90154949	8.43	7.11
DR-10	25 May 2016	0.5	89.3	77	93.56663873	6.4	7.25
DR-10	09 Mar 2017	60.1	147.6	96	133.4056399	7.91	7.46
DR-10	10 Mar 2017			136	0		7.66
DR-10	11 Mar 2017			160			7.85
DR-10	12 Mar 2017			175			8.01
DR-10	13 Mar 2017			200			8.01
DR-10	14 Mar 2017			209			7.67
DR-10	16 Mar 2017			207			7.83
DR-10	17 Mar 2017			212			7.82
DR-10	18 Mar 2017			215			7.82
DR-10	19 Mar 2017			217			7.87
DR-10	20 Mar 2017			221			7.91
DR-10	20 Mar 2017			222			7.8
DR-10	21 Mar 2017	41	250.6	209	232.8996283	7.26	7.67
DR-10	12 Mar 2018		191.9	162	172.8517384	7.53	7.78

DR-10	15 Mar 2018	60.9	260.7	243	256.3169796	8.17	7.93
DR-10	17 Mar 2018	56.9	306.6	266	288.510398	8.18	7.94
DR-10	18 Mar 2018	40.9	323.9	286	308.0947398	8.41	7.84
DR-10	19 Mar 2018	45	340.5	299	322.7182258	8.46	7.92
DR-10	20 Mar 2018	47.4	345.1	308	330.6505701	8.67	7.83
DR-10	21 Mar 2018	46.5	359.9	328	343.5799523	8.7	7.89
DR-10	22 Mar 2018	480.8	379.5	330	342.4163133	7.9	8.06
DR-10	23 Mar 2018	461.4	343.2	328	314.516129	7.9	8.03
DR-10	20 Feb 2019	70	784	572	702.571915	8	8.26
DR-10	21 Feb 2019	90.5	803	602	720.8258528	8	8.13
DR-10	22 Feb 2019	93.6	862	610	754.4857768	8.19	8.32
DR-10	23 Feb 2019	88.8	888	634	777.2428884	8.13	8.34
DR-10	24 Feb 2019	88.2	878	640	762.1527778	8.16	8.25
DR-10	25 Feb 2019	85.2	877	649	767.6148796	8.16	8.19
DR-10	26 Feb 2019	65.7	888	701	826.7386649	8.08	8.18
DR-10	27 Feb 2019	94	1,000	697	866.6262241	8.2	8.33
DR-10	28 Feb 2019	81.7	5.92	701	5.130427247	8.18	8.35
DR-10	01 Mar 2019	63.4	900	730	797.0244421	8.06	8.24
DR-10	02 Mar 2019	64.1	709	745	618.5117334	8.13	8.23
DR-10	27 Jan 2020	81	59.5			7.58	
DR-10	27 Jan 2020			64			6.91
DR-10	28 Jan 2020	78.3	116.6			7.6	
DR-10	28 Jan 2020			113			7.17
DR-10	02 Feb 2020	94	203.8			7.7	
DR-10	02 Feb 2020			179			7.95
DR-10	03 Feb 2020	100.7	230.8			7.87	
DR-10	03 Feb 2020			209			8.03
DR-10	04 Feb 2020	80.9	121.7			7.5	
DR-10	04 Feb 2020			118			7.68
DR-10	05 Feb 2020	85.9	109.8			7.7	
DR-10	05 Feb 2020			105			7.76
DR-10	06 Feb 2020	85.6	85.7			7.69	
DR-10	06 Feb 2020			84			7.59
DR-10	07 Feb 2020	84	94.9			7.7	
DR-10	07 Feb 2020			90			7.71
DR-10	08 Feb 2020	79.9	151.7			7.8	
DR-10	08 Feb 2020			145			7.95
DR-10	09 Feb 2020	68	119.7			7.8	
DR-10	09 Feb 2020			117			7.72
DR-10	10 Feb 2020	78.8	210.2			8.4	
DR-10	10 Feb 2020			202			8.14
DR-10	11 Feb 2020	101.3	245.9			7.98	
DR-10	11 Feb 2020			234			7.93
DR-10	12 Feb 2020	90	258.9			7.77	
DR-10	12 Feb 2020			223			7.94
DR-10	13 Feb 2020	68.9	261			7.82	
DR-10	13 Feb 2020			253			7.93
DR-10	14 Feb 2020	63	268.7			8.02	
DR-10	14 Feb 2020			262			7.94
DR-10	15 Feb 2020	59.2	273.2			8.13	

DR-10	15 Feb 2020			264		7.9
DR-10	16 Feb 2020	57.1	281.5		8.05	
DR-10	16 Feb 2020			265		7.92
DR-10	06 Mar 2020			106		7.56
DR-10	07 Mar 2020			143		7.78
DR-10	08 Mar 2020			165		7.95
DR-10	09 Mar 2020			185		7.99
DR-10	10 Mar 2020	98.1	207.2		8.04	
DR-10	10 Mar 2020			195		7.9
DR-10	11 Mar 2020	77	208		7.82	
DR-10	11 Mar 2020			199		7.83
DR-10	12 Mar 2020	74.4	214.5		7.82	
DR-10	12 Mar 2020			206		7.74
DR-10	13 Mar 2020	68.8	217.2		7.78	
DR-10	13 Mar 2020			208		7.94
DR-10	25 Apr 2020			296		8.23
DR-10	24 Dec 2020	82.1	133.8		7.43	
DR-10	24 Dec 2020			122		7.17
DR-10	25 Dec 2020	77	161.2		7.76	
DR-10	25 Dec 2020			150		7.32
DR-10	26 Dec 2020	73.9	192.9		7.72	
DR-10	26 Dec 2020			180		7.65
DR-10	27 Dec 2020	80.7	92.5		7.9	
DR-10	27 Dec 2020			88		6.97
DR-10	28 Dec 2020	87.7	89.2		7.7	
DR-10	28 Dec 2020			81		7.12
DR-10	29 Dec 2020	82.7	107.1		7.8	
DR-10	29 Dec 2020			102		7.22
DR-10	30 Dec 2020	99.2	118.8		7.91	
DR-10	30 Dec 2020			114		7.44
DR-10	31 Dec 2020	76	132.4		7.42	
DR-10	31 Dec 2020			127		7.37
DR-10	03 Feb 2021	9.8	88		7.31	
DR-10	03 Feb 2021			94		6.81
DR-10	04 Feb 2021	59.2	100		7.25	
DR-10	04 Feb 2021			94		6.83
DR-10	05 Feb 2021	79.8	113.3		8.09	
DR-10	05 Feb 2021			108		6.92
DR-10	06 Feb 2021	69.4	113.8		7.58	
DR-10	06 Feb 2021			109		6.94
DR-10	07 Feb 2021	86.5	71		7.69	
DR-10	07 Feb 2021			70		6.73
DR-10	08 Feb 2021	91	90.4		7.55	
DR-10	08 Feb 2021			87		6.91
DR-10	09 Feb 2021	80	99.3		7.6	
DR-10	09 Feb 2021			94		7.07
DR-10	10 Feb 2021	79	117.6		7.6	
DR-10	10 Feb 2021			110		7.11
DR-10	11 Feb 2021	83.1	136.8		7.8	
DR-10	11 Feb 2021			126		7.29

DR-10	12 Feb 2021	84.6		140.4			7.98	
DR-10	12 Feb 2021				135			7.32
DR-10	13 Feb 2021	80.8		44.9			7.9	
DR-10	13 Feb 2021				140			7.47
DR-10	14 Feb 2021	78.3		153.4			7.88	
DR-10	14 Feb 2021				140			7.36
DR-10	15 Feb 2021	89.5		65.1			7.83	
DR-10	15 Feb 2021				60			6.84
DR-10	16 Feb 2021	91.4		110.6			7.97	
DR-10	16 Feb 2021				103			7.11
DR-10	17 Feb 2021	93.6		135.7			7.87	
DR-10	17 Feb 2021				127			7.33
DR-10	18 Feb 2021	103.1		150.3			8.01	
DR-10	18 Feb 2021				138			7.61
DR-10	19 Feb 2021	99.6		150.6			8.2	
DR-10	19 Feb 2021				140			7.5
DR-10	20 Feb 2021	94.4		154.8			8.26	
DR-10	20 Feb 2021				141			7.49
DR-10	21 Feb 2021	90		158.1			7.82	
DR-10	21 Feb 2021				145			7.49
DR-10	22 Feb 2021	91.5		161.7			8.09	
DR-10	22 Feb 2021				152			7.6
DR-10	23 Feb 2021	79.3		162.1			8.1	
DR-10	23 Feb 2021				154			7.49
DR-10	18 May 2021				210			7.35
DR-10	18 May 2021							
DR-10	03 Sep 2021		59		60	81	7.3	7.05
DR-10 R1	30 Sep 2021				149			7.87
DR-10 R2 (Field_B)	30 Sep 2021				1			5.89
DR-10	21 Jan 2022	82.8		156.3			7.67	
DR-10	21 Jan 2022				143			7.37
DR-10	22 Jan 2022	88.8		119.8			7.66	
DR-10	22 Jan 2022				99			7.37
DR-10	23 Jan 2022	84.4		134.9			7.59	
DR-10	23 Jan 2022				110			7.51
DR-10	26 Jan 2022	106.3		100.7			7.62	
DR-10	26 Jan 2022				88			7.44
DR-10	27 Jan 2022	89.9		104.2			7.75	
DR-10	27 Jan 2022				116			7.53
DR-10	28 Jan 2022	89.7		125.5			7.79	
DR-10	28 Jan 2022				127			7.74
DR-10	29 Jan 2022	91.3		92.6			7.78	
DR-10	29 Jan 2022				98			7.64
DR-10	30 Jan 2022	98		92			7.78	
DR-10	30 Jan 2022				86			7.62
DR-10	31 Jan 2022	95.4		70.1			7.63	
DR-10	31 Jan 2022				74			7.49
DR-10	01 Feb 2022	95		106.9			7.66	
DR-10	01 Feb 2022				112			7.77
DR-10	02 Feb 2022	101.2		152.4			7.83	

DR-10	02 Feb 2022			144			7.94
DR-10	03 Feb 2022	104.2	176.4			7.96	
DR-10	03 Feb 2022			167			8.02
DR-10	04 Feb 2022	98.7	225.7			7.97	
DR-10	04 Feb 2022			181			8.04
DR-10	05 Feb 2022	98.5	239.3			7.98	
DR-10	05 Feb 2022			188			7.97
DR-10	06 Feb 2022	98.9	255.7			7.89	
DR-10	06 Feb 2022			194			7.99
DR-10	30 Mar 2022			138			7.89
DR-10 R1	29 Sep 2022			134			7.7
DR-10 R2	29 Sep 2022			<1			5.99
DR-10	28 Nov 2022			60			7.14
DR-10	25 Dec 2022	93.6	71.1			7.4	
DR-10	25 Dec 2022			71			7.13
DR-10	27 Dec 2022			73			7.34
DR-10	14 Jan 2023			74			7.24
DR-10	07 Feb 2023			60			6.97
DR-10	08 Feb 2023			97			7.34
DR-10	07 Mar 2023			84			7.39
DR-10	11 Mar 2023			153			7.77
DR-10	12 Mar 2023			146			7.98
DR-10	13 Mar 2023			240			8.15
DR-10	14 Mar 2023			322			8.28
DR-10	15 Mar 2023			350			8.19
DR-10	16 Mar 2023			389			8.2
DR-10	17 Mar 2023			434			8.19
DR-10	18 Mar 2023			496			8.25
DR-10	19 Mar 2023			501			8.3
DR-10	20 Mar 2023			561			8.26
DR-10	21 Mar 2023			559			8.28
DR-10	22 Mar 2023			600			8.15
DR-10	23 Mar 2023			632			8.18
DR-10 (Duplicate01)	17 Jan 2015						
DR-14	17 Jan 2015	69.3	78.4	91	74.84486874	7.52	7.66
DR-14	24 Jan 2015	4.2	363.2	360	321.1033507	7.67	8.5
DR-14	26 Jan 2015	39.4	169.1	173	158.5560244	7.42	8.03
DR-14	31 Jan 2015	3	451.1	446	419.2379182	7.32	7.88
DR-14	19 Dec 2015	31.5	88.5	94	86.20689655	7.22	7.22
DR-14	30 Dec 2015	82.8	76.5	74	76.35492564	7.37	7.43
DR-14	31 Dec 2015	74	100.1	95	98.05073954	7.53	7.66
DR-14	01 Jan 2016	69.1	167.2	155	161.6708567	7.48	7.89
DR-14	02 Jan 2016	75.3	63.6	63	64.33340077	7.52	7.51
DR-14	03 Jan 2016	80.5	181.7	167	178.6451676	7.35	7.75
DR-14	04 Jan 2016	73	237	217	229.5844231	7.47	8.01
DR-14	05 Jan 2016	62	295	262	282.1346595	7.61	8.09
DR-14	07 Jan 2016	81.1	350	322	327.5926619	7.9	8.27
DR-14	08 Jan 2016	94.3	376.2	345	352.742616	8.07	8.36
DR-14	09 Jan 2016	76.2	403.7	371	375.1858736	7.87	8.37
DR-14	10 Jan 2016	77.9	476.8	392	406.5137693	7.08	8.19

DR-14	11 Jan 2016	52.9	458.3	398	416.3714	7.82	8.19
DR-14	12 Jan 2016	71	157	163	149.8806683	7.58	7.83
DR-14	16 Jan 2016	52	253		234.7156508	7.85	
DR-14	31 Jan 2016	48	556	475	489.0921886	7.94	8.34
DR-14	14 Feb 2016	54	458	448	424.900269	8.03	8.07
DR-14	05 Mar 2016	21	63	69	63.48246675	8.05	7.58
DR-14	06 Mar 2016	21.1	137.5	140	129.1564907	7.62	7.91
DR-14	07 Mar 2016	20.3	155.7	151	146.5135974	7.73	7.92
DR-14	08 Mar 2016	54.4	181	155	157.6380422	7.78	7.7
DR-14	09 Mar 2016	43.5	168.3	146	150.053495	7.82	7.62
DR-14	10 Mar 2016	37.5	169	151	157.8996543	7.63	7.72
DR-14	11 Mar 2016	35	183.2	164	169.6610483	7.64	7.86
DR-14	12 Mar 2016	58	91.3	90	88.60636646	7.76	7.58
DR-14	13 Mar 2016	51	124	115	118.3770883	7.52	7.71
DR-14	14 Mar 2016	68	100.4	93	95.50080852	7.54	7.73
DR-14	15 Mar 2016	58	121	109	112.2553113	7.54	7.84
DR-14	16 Mar 2016	50	126.7	120	120.0834044	7.28	7.87
DR-14	17 Mar 2016	64	126	156	116.6882756	7.5	8.06
DR-14	18 Mar 2016	63	141	157	131.9730438	8	8.07
DR-14	19 Mar 2016	66.7	194	156	161.4782753	8.28	8.07
DR-14	20 Mar 2016	55	148	157	135.8670706	8.1	8.08
DR-14	21 Mar 2016	50	165.3	178	165.3	7.88	8.07
DR-14	23 May 2016	50.3	60.7	66	63.47380529	8.12	7.08
DR-14	24 May 2016	19.7	76.7	75	81.33616119	7.85	7.18
DR-14	25 May 2016	20.4	85.7	84	88.90963793	6.46	7.34
DR-14	08 Mar 2017	74	57.4	54	56.54058314	7.61	6.97
DR-14	09 Mar 2017			94	0		7.44
DR-14	10 Mar 2017	70.9	160.7	131	140.6564551	8.68	7.57
DR-14	11 Mar 2017			154			7.72
DR-14	12 Mar 2017			178			7.87
DR-14	13 Mar 2017			198			8.03
DR-14	14 Mar 2017			210			7.79
DR-14	16 Mar 2017			218			7.9
DR-14	17 Mar 2017			223			7.88
DR-14	18 Mar 2017			229			7.91
DR-14	19 Mar 2017			234			7.94
DR-14	20 Mar 2017			235			7.99
DR-14	20 Mar 2017			240			7.99
DR-14	21 Mar 2017	53	267.8	240	251.1017346	6.2	7.99
DR-14	04 Mar 2018	18.5	79.6	66	80.05632103	7.69	7.18
DR-14	05 Mar 2018	18	145	127	141.5048307	7.74	7.34
DR-14	06 Mar 2018	22.8	272.2	172	262.7159541	7.93	7.22
DR-14	07 Mar 2018	24.6	145.2	135	143.833581	7.75	7.64
DR-14	08 Mar 2018	27.8	82	75	83.26563769	7.85	7.23
DR-14	09 Mar 2018	15.6	130.6	126	131.3486875	7.68	7.47
DR-14	10 Mar 2018	18.5	156.2	133	155.0218341	7.82	7.59
DR-14	11 Mar 2018	16.6	184.9	152	175.2440527	7.82	7.69
DR-14	12 Mar 2018			176			7.77
DR-14	13 Mar 2018	58.8	230.6	193	212.4366651	8.93	7.92
DR-14	15 Mar 2018	62.6	287	252	266.2584655	8.31	7.87

DR-14	17 Mar 2018	72	326.5	285	306.6879579	8.2	7.96
DR-14	18 Mar 2018	37.8	346.7	312	335.2349642	8.29	7.83
DR-14	19 Mar 2018	42.8	370.6	335	359.6661491	8.36	7.89
DR-14	20 Mar 2018	38.5	392.3	364	384.9852797	8.7	7.74
DR-14	21 Mar 2018	42	420.7	381	408.2880435	8.77	7.86
DR-14	22 Mar 2018	644.6	470.6	404	418.1624311	7.99	8.1
DR-14	23 Mar 2018	301.7	454.9	409	422.7695167	7.92	8.05
DR-14	31 Jan 2019	58.2	41.9	59	40.44011196	7.57	6.84
DR-14	01 Feb 2019	112.4	81.3	52	76.23066104	7.44	6.74
DR-14	02 Feb 2019	139.7	116.7	53	115.1682621	8.13	6.81
DR-14	03 Feb 2019	31.4	106.3	48	107.3195356	7.75	6.84
DR-14	04 Feb 2019	65.1	74.1	80	74.81070167	7.87	7.01
DR-14	05 Feb 2019	66.2	131.6	289	136.2600953	7.57	7.12
DR-14	06 Feb 2019	74	164.4	144	165.9767794	7.68	7.67
DR-14	07 Feb 2019	72.5	234.8	7.87	236.5981459	7.78	7.87
DR-14	08 Feb 2019	67	331.9	270	310.6514414	7.57	7.9
DR-14	09 Feb 2019	59	411	313	370.8382207	7.6	7.92
DR-14	10 Feb 2019	70.4	412.4	342	385.9977537	7.83	7.92
DR-14	11 Feb 2019	76.2	475.8	366	427.1095153	8.08	8.18
DR-14	12 Feb 2019	75.1	458.7	391	420.3629032	7.94	8.02
DR-14	13 Feb 2019	74	540	419	487.2326987	8.08	7.96
DR-14	14 Feb 2019	96	576	447	520.6073753	8	8.08
DR-14	15 Feb 2019	73	585	459	553.4531693	7.87	8.14
DR-14	16 Feb 2019	60	573	492	539.1926226	7.91	8.19
DR-14	17 Feb 2019	66.6	689	530	634.7305389	7.88	8.19
DR-14	18 Feb 2019	46.9	702	539	647.8405316	7.9	8.15
DR-14	19 Feb 2019	73.6	775	573	692.149683	8.1	8.13
DR-14	20 Feb 2019	62	695	580	623.8779174	8.08	8.19
DR-14	21 Feb 2019	87.3	852	616	742.0310051	8.1	8.15
DR-14	22 Feb 2019	84.5	863	629	769.4365193	8.14	8.36
DR-14	23 Feb 2019	68.2	791	650	732.5430635	8.08	8.31
DR-14	24 Feb 2019	65.4	868	649	805.2695055	8.06	8.21
DR-14	25 Feb 2019	64.4	912	663	824.2950108	8.08	8.19
DR-14	26 Feb 2019	64.9	928	692	843.0998456	8.04	8.19
DR-14	27 Feb 2019	72	1,010	703	881.0956992	8.12	8.28
DR-14	28 Feb 2019	69.3	1,010	718	884.0262582	8.17	8.26
DR-14	01 Mar 2019	73.5	1,012	732	893.2038835	8.18	8.25
DR-14	02 Mar 2019	59	1,027	760	928.2357195	8.16	8.21
DR-14	26 Jan 2020	80	75			7.6	
DR-14	26 Jan 2020			77			6.84
DR-14	27 Jan 2020	79	64.5			7.72	
DR-14	27 Jan 2020			66			6.9
DR-14	28 Jan 2020	79	120			7.5	
DR-14	28 Jan 2020			116			7.19
DR-14	29 Jan 2020	90.7	103.6			7.6	
DR-14	29 Jan 2020			100			7.12
DR-14	30 Jan 2020	90.9	101.5			7.35	
DR-14	30 Jan 2020			94			7.1
DR-14	31 Jan 2020	91.1	123.6			7.61	
DR-14	31 Jan 2020			113			7.44

DR-14	01 Feb 2020	86.1	171.3		7.63	
DR-14	01 Feb 2020			157		7.74
DR-14	02 Feb 2020	87.3	203		7.58	
DR-14	02 Feb 2020			182		7.85
DR-14	03 Feb 2020	104.8	226		7.88	
DR-14	03 Feb 2020			208		8.04
DR-14	04 Feb 2020			130		7.73
DR-14	05 Feb 2020	85.3	109.7		7.7	
DR-14	05 Feb 2020			110		7.79
DR-14	06 Feb 2020	84.2	86.6		7.45	
DR-14	06 Feb 2020			88		7.61
DR-14	07 Feb 2020	82.2	75.1		7.5	
DR-14	07 Feb 2020			99		7.69
DR-14	08 Feb 2020	82.2	145.2		7.7	
DR-14	08 Feb 2020			141		7.91
DR-14	09 Feb 2020	70	152.9		8.5	
DR-14	09 Feb 2020			146		7.91
DR-14	10 Feb 2020	73.8	190		7.9	
DR-14	10 Feb 2020			184		8.07
DR-14	11 Feb 2020	98.9	227.8		8.04	
DR-14	11 Feb 2020			216		7.85
DR-14	12 Feb 2020	91.1	239		7.9	
DR-14	12 Feb 2020			228		7.9
DR-14	13 Feb 2020	66.2	244.6		7.72	
DR-14	13 Feb 2020			233		7.86
DR-14	14 Feb 2020	60.1	257		7.72	
DR-14	14 Feb 2020			248		7.84
DR-14	15 Feb 2020	56.7	267.1		7.98	
DR-14	15 Feb 2020			255		7.89
DR-14	16 Feb 2020	55.8	276.9		7.92	
DR-14	16 Feb 2020			271		7.97
DR-14	06 Mar 2020			104		7.55
DR-14	07 Mar 2020			142		7.78
DR-14	08 Mar 2020			155		7.97
DR-14	09 Mar 2020			172		8.01
DR-14	10 Mar 2020	105.6	189.8		8.18	
DR-14	10 Mar 2020			178		7.92
DR-14	11 Mar 2020	80.5	197.4		7.78	
DR-14	11 Mar 2020			188		7.78
DR-14	12 Mar 2020	72.8	206.6		7.72	
DR-14	12 Mar 2020			198		7.84
DR-14	13 Mar 2020	64.5	214		7.68	
DR-14	13 Mar 2020			204		7.92
DR-14	04 Apr 2020	77.6	88		7.5	
DR-14	23 Apr 2020			298		8.26
DR-14	23 Dec 2020	85.8	82.8		7.37	
DR-14	23 Dec 2020			40		6.75
DR-14	24 Dec 2020	83.8	134.3		7.39	
DR-14	24 Dec 2020			122		7.14
DR-14	25 Dec 2020	76.3	161.6		7.7	

DR-14	25 Dec 2020			151		7.47
DR-14	26 Dec 2020	75.8	185.1		7.75	
DR-14	26 Dec 2020			171		7.6
DR-14	27 Dec 2020	72.7	116.9		7.58	
DR-14	27 Dec 2020			111		7.09
DR-14	28 Dec 2020	85.5	98.6		7.69	
DR-14	28 Dec 2020			90		7.16
DR-14	29 Dec 2020	79.1	106.5		7.77	
DR-14	29 Dec 2020			109		7.22
DR-14	30 Dec 2020	89.8	113.1		7.81	
DR-14	30 Dec 2020			108		7.31
DR-14	31 Dec 2020	76.1	126.7		7.43	
DR-14	31 Dec 2020			122		7.42
DR-14	03 Feb 2021	56.3	95.9		7.41	
DR-14	03 Feb 2021			90		6.81
DR-14	04 Feb 2021	55.7	95.9		7.3	
DR-14	04 Feb 2021			90		6.82
DR-14	05 Feb 2021	82	115.4		7.89	
DR-14	05 Feb 2021			105		6.92
DR-14	06 Feb 2021	54.4	116.8		7.44	
DR-14	06 Feb 2021			116		7.1
DR-14	07 Feb 2021	87.4	68.1		7.7	
DR-14	07 Feb 2021			70		6.72
DR-14	08 Feb 2021	88.5	90.6		7.42	
DR-14	08 Feb 2021			88		6.83
DR-14	09 Feb 2021	77.2	100.1		7.58	
DR-14	09 Feb 2021			95		7.05
DR-14	10 Feb 2021	78.8	116.2		7.63	
DR-14	10 Feb 2021			109		7.12
DR-14	11 Feb 2021	77.8	63		7.69	
DR-14	11 Feb 2021			120		7.15
DR-14	12 Feb 2021	76.6	71.2		7.83	
DR-14	12 Feb 2021			135		7.25
DR-14	13 Feb 2021	68.5	73.3		7.73	
DR-14	13 Feb 2021			144		7.31
DR-14	14 Feb 2021	75.8	157.3		7.83	
DR-14	14 Feb 2021			148		7.33
DR-14	15 Feb 2021	87.9	64.7		7.65	
DR-14	15 Feb 2021			60		6.82
DR-14	16 Feb 2021	91.9	108.9		7.81	
DR-14	16 Feb 2021			101		7.14
DR-14	17 Feb 2021	92.5	133.6		7.9	
DR-14	17 Feb 2021			37		7.4
DR-14	18 Feb 2021	102.2	150.5		8	
DR-14	18 Feb 2021			138		7.56
DR-14	19 Feb 2021	96.4	156.4		8.21	
DR-14	19 Feb 2021			144		7.47
DR-14	20 Feb 2021	101.1	161.9		8.24	
DR-14	20 Feb 2021			148		7.55
DR-14	21 Feb 2021	101.3	169.9		7.9	

DR-14	21 Feb 2021				157			7.79
DR-14	22 Feb 2021	102.1		175.7			8.13	
DR-14	22 Feb 2021				166			7.79
DR-14	23 Feb 2021	75.8		177.3			7.92	
DR-14	23 Feb 2021				168			7.53
DR-14	19 May 2021				280			7.62
DR-14	19 May 2021							
DR-14	03 Sep 2021		55.3		69	64	7.06	7.09
DR-14	30 Sep 2021				282			8.13
DR-14	21 Jan 2022				143			7.35
DR-14	22 Jan 2022	87.1		126.4			7.54	
DR-14	22 Jan 2022				103			7.38
DR-14	23 Jan 2022	70		138.8			7.39	
DR-14	23 Jan 2022				112			7.39
DR-14	27 Jan 2022	88.7		106.2			7.73	
DR-14	27 Jan 2022				116			7.59
DR-14	28 Jan 2022	83.3		129.2			7.69	
DR-14	28 Jan 2022				126			7.79
DR-14	29 Jan 2022	89.7		91.7			7.73	
DR-14	29 Jan 2022				95			7.56
DR-14	30 Jan 2022	97.5		91.1			7.75	
DR-14	30 Jan 2022				88			7.54
DR-14	31 Jan 2022	95.2		71.3			7.62	
DR-14	31 Jan 2022				75			7.53
DR-14	01 Feb 2022	94.5		106.9			7.62	
DR-14	01 Feb 2022				107			7.74
DR-14	02 Feb 2022	98.4		148.6			7.71	
DR-14	02 Feb 2022				141			7.89
DR-14	03 Feb 2022	104.6		171.4			7.91	
DR-14	03 Feb 2022				163			7.81
DR-14	04 Feb 2022	98.6		225.9			7.9	
DR-14	04 Feb 2022				178			8.01
DR-14	05 Feb 2022	94		237.9			7.75	
DR-14	05 Feb 2022				188			7.89
DR-14	06 Feb 2022	98.2		263.3			7.8	
DR-14	06 Feb 2022				194			7.95
DR-14 R1	31 Mar 2022				184			7.9
DR-14 R2 (Field_B)	31 Mar 2022				107			7.27
DR-14	28 Sep 2022				135			7.78
DR-14	28 Nov 2022				63			7.12
DR-14	25 Dec 2022	92.8		72.5			7.43	
DR-14	25 Dec 2022				71			7.16
DR-14	27 Dec 2022				72			7.23
DR-14	14 Jan 2023				92			7.35
DR-14	07 Feb 2023				60			7
DR-14	08 Feb 2023				94			7.32
DR-14	07 Mar 2023				82			7.31
DR-14	09 Mar 2023				77			7.4
DR-14	10 Mar 2023				98			7.27
DR-14	11 Mar 2023				158			7.84

DR-14	12 Mar 2023	148	7.99
DR-14	13 Mar 2023	242	8.18
DR-14	14 Mar 2023	337	8.03
DR-14	15 Mar 2023	358	8.2
DR-14	16 Mar 2023	396	8.18
DR-14	17 Mar 2023	469	8.21
DR-14	18 Mar 2023	498	8.23
DR-14	19 Mar 2023	502	8.3
DR-14	20 Mar 2023	562	8.29
DR-14	21 Mar 2023	555	8.29
DR-14	22 Mar 2023	601	8.14
DR-14	23 Mar 2023	641	8.16

ll be treated as a blank in Power BI. Column can be added if indicator is not present. Column can be deleted

Temp (Field) °C	Temperature °C	Redox Potential (Field) (mV)	Flow Rate (m/sec)	Redox Potential (Lab) (mV)	Turbidity (Field) (NTU)	Turbidity (NTU)	Total Dissolved Solids (mg/L)	Suspended Solids (mg/L)	Aluminium (filtered) (mg/L)	Aluminium (mg/L)	Arsenic (filtered) (mg/L)	Arsenic (mg/L)
							119	545	1.02	15.3	<0.001	0.002
26.5		156					159	10	<0.01	0.5	<0.001	<0.001
28.8		135					176	<5	<0.01	0.09	<0.001	<0.001
29.8		131					180	12	<0.01	0.1	<0.001	<0.001
33.8		89.5					56	<5	0.02	0.02	<0.001	<0.001
30.1		45					228	<5	<0.01	<0.01	<0.001	<0.001
30.4		155					100	7	0.01	0.75	<0.001	<0.001
29		141					163	5	<0.01	0.14	<0.001	<0.001
34		47.9					125	42	0.01	1.61	<0.001	0.001
30.2		36.1					52	22	0.07	2.19	<0.001	<0.001
28.6		37					87	43	0.04	4.06	<0.001	<0.001
26.2		-10.8					190	<5	<0.01	0.02	<0.001	<0.001
29.1		-23.3					178	<5	<0.01	0.02	<0.001	<0.001
29.2		-14					182	8	<0.01	0.05	<0.001	<0.001
27		120.4				1.7	253	<5	<0.01	0.07	<0.001	<0.001
33		85				0.7	238	6	<0.01	0.02	<0.001	<0.001
33.5		79				0.9	274	<5	<0.01	0.02	<0.001	<0.001
28.9		151.5	0.5		92.6							
						100	46	67	0.29	3.4	<0.001	<0.001
30.8		106.8	0.1		96							
						132	91	55	0.37	3.32	<0.001	<0.001
30.6		56	0.1		4.3							
						2.9	126	<5	0.05	0.11	<0.001	<0.001
31.3		68.9	0.3		29.6							
						18.7	94	19	0.19	0.56	<0.001	<0.001
30.5		201	0.5		32							
						38.9	122	9	0.07	1.09	<0.001	<0.001
						12.7	125	9	0.17	0.7	<0.001	<0.001
						2.5	196	7	0.03	0.08	<0.001	<0.001
34.4		288.6	1		60.06							
						141	96	108	0.36	3.97	<0.001	0.001
						85.2	80	50	<0.01	1.61	<0.001	<0.001
						5.6	286	5	<0.01	0.2	<0.001	<0.001
						3.8	307	8	<0.01	0.14	<0.001	<0.001
						1.6	329	<5	<0.01	0.06	<0.001	<0.001
						0.7	351	5	<0.01	0.04	<0.001	<0.001
						0.9	323	8	<0.01	0.03	<0.001	<0.001
25.1		98.6					135	62	0.16	5.54	<0.001	<0.001

26.3	143	82	78	0.1	4.33	<0.001	<0.001
26.7	154.5	141	23	0.02	1.25	<0.001	<0.001
26.5	139	86	142	0.04	3.94	<0.001	<0.001
25.8	165	70	30	<0.01	1.58	<0.001	<0.001
26.5	151	135	10	<0.01	0.28	<0.001	<0.001
27.4	153	158	10	<0.01	0.37	<0.001	<0.001
28.2	133	175	6	<0.01	<0.01	<0.001	<0.001
27.4	97	216	<5	<0.01	<0.01	<0.001	<0.001
28.2	79			<0.01	<0.01	<0.001	<0.001
28.8	86.6	209	<5	<0.01	<0.01	<0.001	<0.001
30.1	57.2	259	<5	<0.01	<0.01	<0.001	<0.001
30.1	44.9	247	<5	<0.01	<0.01	<0.001	<0.001
26.9	67.2	114	148	0.01	4.49	<0.001	<0.001
29.2	114						
31.7	151	282	8	<0.01	0.03	<0.001	<0.001
29.2	138	248	<5	<0.01	0.06	<0.001	<0.001
24	39.3	112	558	0.23	18.3	<0.001	0.001
27.3	63.3	108	44	0.21	2.75	<0.001	<0.001
27.2	71.8	106	19	0.31	1.73	<0.001	<0.001
27.8	-26	108	24	0.03	1.57	<0.001	<0.001
33.4	-6	94	118	0.02	3.48	<0.001	0.001
27.6	58	114	23	0.01	0.72	<0.001	0.001
28.9	62	111	20	0.02	1	<0.001	0.001
26.1	123	85	140	0.14	4.29	<0.001	0.001
27.5	123	104	109	0.04	3.3	<0.001	<0.001
27.6	144	90	52	0.12	1.61	<0.001	<0.001
29.1	138	65	10	0.05	1.14	<0.001	<0.001
27.4	161	82	8	0.04	1.26	<0.001	<0.001
28.8	119	105	5	<0.01	0.53	<0.001	<0.001
29.2	142	103	<5	<0.01	0.72	<0.001	<0.001
28.1	127	105	<5	<0.01	0.59	<0.001	<0.001
27.9	72	94	<5	<0.01	0.62	<0.001	<0.001
26.2	206	114	6	<0.01	0.24	<0.001	<0.001
22.7	38.7	67		0.23	7.24	<0.001	0.002
22.3	147.5	59	71	0.19	2.98	<0.001	<0.001
22.6	64.7	74	29	0.16	1.29	<0.001	0.003
30.6	43.1	116	59	0.11	4.3	<0.001	<0.001
		146	21	0.25	2.63	<0.001	<0.001
		160	8	<0.01	1.81	<0.001	<0.001
		194	<5	<0.01	1.39	<0.001	<0.001
		131	12	0.22	1.02	<0.001	<0.001
		135	6	<0.01	0.8	<0.001	<0.001
		115	6	<0.01	0.72	<0.001	<0.001
		120	9	<0.01	0.73	<0.001	<0.001
		129	9	<0.01	0.56	<0.001	<0.001
		123	7	<0.01	0.56	<0.001	<0.001
		126	15	<0.01	0.53	<0.001	<0.001
		125	10	<0.01	0.46	<0.001	<0.001
29	116.8	135	6	<0.01	0.53	<0.001	<0.001
30.8		114	<5	0.01	0.55	<0.001	<0.001

25.9	49.1				173	<5	0.03	0.08	<0.001	<0.001
28.3	16.2				185	5	<0.01	0.03	<0.001	<0.001
27.7	2.2				186	<5	<0.01	0.08	<0.001	<0.001
27.9	-7.7				206	<5	<0.01	0.04	<0.001	<0.001
27.3	-12.6				184	<5	<0.01	0.03	<0.001	<0.001
27.5	-16.5				189	<5	<0.01	0.04	<0.001	<0.001
30.7	-53.8				204	5	0.04	0.04	<0.001	<0.001
29.8	-61.7				210	<5	<0.01	0.02	<0.001	<0.001
31.1	122			0.5	373	<5	0.01	0.02	<0.001	<0.001
31	84				363	<5	<0.01	0.02	<0.001	<0.001
32.5	106.8			0.7	392	<5	0.03	0.02	<0.001	<0.001
32.5	101.7			0.7	382	<5	0.01	0.01	<0.001	<0.001
33	84.4			1	382	<5	<0.01	0.02	<0.001	<0.001
32.5	63.3			4.2	374	<5	0.01	0.12	<0.001	<0.001
28.9	75.2			1.9	432	<5	<0.01	0.03	0.001	<0.001
33.1	48.7			1.8	404	<5	0.01	0.03	0.001	<0.001
33.1	63.9			7.4	434	18	<0.01	0.03	<0.001	<0.001
31.8	71.4			3.1	436	<5	0.01	0.02	0.001	<0.001
32.7	60			2.4	494	<5	<0.01	0.04	0.001	<0.001
26.3	171	0.8	500							
				806	48	702	0.29	19.3	<0.001	0.002
27.3	102.5	0.25	122							
				125	106	74	0.46	3.99	<0.001	0.001
33	44.9	0.05	13.1							
				9.6	103	8	0.15	0.48	<0.001	<0.001
35.3	36.7	0.05	6.8							
				4.2	121	<5	0.11	0.32	<0.001	<0.001
31	55.1	0.25	164							
				170	98	257	0.35	3.96	<0.001	0.001
31.5	57	0.2	150							
				190	96	158	0.31	5.25	<0.001	<0.001
28.8	43.6	5	340.4							
				354	101	334	0.52	11.5	<0.001	0.001
31.2	142	0.2	179							
				212	101	114	0.17	5.27	<0.001	<0.001
33.9	89	0.05	76							
				85.5	115	20	0.19	2.17	<0.001	<0.001
29.2	116	0.05	275							
				253	112	132	0.13	7.28	<0.001	<0.001
30.9	89	0.1	26							
				24.8	128	10	0.07	0.75	<0.001	<0.001
35.6	75.5	0.02	15.7							
				15	144	11	0.06	0.47	<0.001	0.001
34.9	51.4	0.02	12.8							
				13.8	156	8	0.06	0.4	<0.001	<0.001
28.4	83	0.02	14.2							
				12.3	152	8	0.04	0.42	<0.001	<0.001
27.6	65.7	0.02	10.7							
				8.3	156	6	0.03	0.31	<0.001	<0.001
28.8	59.9	0.02	8.4							

				6.1	154	7	0.02	0.3	<0.001	<0.001
28.5	68.7	0.02	5.9							
				9	151	<5	0.02	0.25	<0.001	<0.001
				30.5	101	30	0.42	1.93	<0.001	<0.001
				68.9	110	26	0.38	1.99	<0.001	<0.001
				41.3	133	17	0.32	0.46	<0.001	<0.001
				29.4	127	12	0.24	1.01	<0.001	<0.001
35	11.4	0.02	24.9							
				28.1	113	6	0.18	0.82	<0.001	<0.001
29	37.5	0.02	22.5							
				26.5	132	9	0.14	0.81	<0.001	<0.001
29.8	63.8	0.01	17.2							
				21	129	7	0.13	0.69	<0.001	<0.001
28	67.8	0.01	14.3							
				15.3	142	7	0.12	0.61	<0.001	<0.001
				7.9	163	8	<0.01	0.22	<0.001	<0.001
32.9	309.3	0.2	89.81							
				104	110	32	0.38	3.35	<0.001	<0.001
28.3	295.3	0.1	64.7							
				60.6	109	15	0.24	2.19	<0.001	<0.001
28.5	296.6	0.01	41.9							
				28.7	126	<5	0.13	1.04	<0.001	<0.001
29.3	261.5	0.01	274.3							
				393	99	279	0.44	12.6	<0.001	0.002
29	261.9	0.01	184.4							
				153	64	76	0.57	3.84	<0.001	0.001
28.7	256.7	0.01	69.66							
				79.3	116	16	0.42	1.61	<0.001	0.001
33.9	276.6	0.01	101.7							
				135	118	32	0.32	3.6	<0.001	0.001
29.5	280.1	0.01	55.4							
				64.2	109	14	<0.01	1.6	<0.001	<0.001
27.3	307.3	0.1	116.8							
				97.8	78	30	0.29	2.44	<0.001	0.001
29.8	223.5	0.01	80.6							
				99.6	99	29	0.3	2.56	<0.001	0.001
33.1	249.1	0.01	50.1							
				53.2	77	11	0.26	1.42	<0.001	<0.001
30	269.7	0.01	36.3							
				37.7	101	8	0.25	1.11	<0.001	<0.001
27	306.1	1	433.8							
				632	54	552	0.42	38.4	<0.001	0.003
31.6	288	0.1	192.38							
				226	95	107	0.25	6.04	<0.001	0.001
28.7	305.9	0.01	138.2							
				149	91	55	0.01	4.15	<0.001	0.002
29	295.6	0.01	99.8							
				108	100	33	<0.01	2.92	<0.001	0.001
30.9	281.7	0.01	71.8							
				73.9	95	17	<0.01	2.25	<0.001	<0.001

30.7	289.5	0.01		57.3							
					54.9	90	15	<0.01	1.93	<0.001	<0.001
30.4	270.3	0.01		49.75							
					51.5	106	15	<0.01	1.43	<0.001	<0.001
30.4	263.6	0.01		44.58							
					43.7	119	11	<0.01	1.33	<0.001	<0.001
28.8	274.4	0.7		254.3							
					361	126	252	0.04	12.1	<0.001	<0.001
32.3	302	0.7		101.9							
					120	81	38	<0.01	3.36	<0.001	<0.001
31.3	291.2	0.7		74.4							
					83.6	101	24	<0.01	2.22	<0.001	0.002
31.1	270.9	0.1		72.4							
					83.7	87	31	<0.01	2.8	<0.001	<0.001
32.3	283.5	0.1		56.4							
					61.1	146	25	<0.01	1.97	<0.001	<0.001
33.8	253.4	0.01		54.9							
					60.8	121	9	<0.01	1.96	<0.001	<0.001
33.3	295.7	0.001		48.2							
					48.7	100	11	<0.01	1.68	<0.001	<0.001
34	282.4	0.001		44.4							
					45.4	96	11	<0.01	1.73	<0.001	<0.001
29.1	253.7	0.001		40							
					45	107	9	<0.01	1.57	<0.001	<0.001
					110	110	91	0.009	0.99	<0.0005	0.00082
						120					
	23.5		101.1	255.6	386	168	180	0.05	29.1	<0.001	0.005
					44.8	118	10	<0.01	1.77	<0.001	0.001
					0.2	<10	<5	<0.01	<0.01	<0.001	<0.001
26.8	95.9	2		377.8							
					431	160	522	0.01	29.3	<0.001	0.003
30.3	105.7	0.1		155.4							
					171	108	76	0.02	7.25	<0.001	0.002
28.9	143	0.01		94.5							
					71.9	110	27	0.01	7.85	<0.001	0.002
30	168			123.3							
					160	81	72	<0.01	15.3	<0.001	0.002
26.8	222.5			270.56							
					184	90	334	0.01	12.8	<0.001	0.002
28.2	210.8	0.01		74.03							
					54.1	96	32	<0.01	4.98	<0.001	0.002
27.9	256.3	0.3		247.2							
					172	74	300	<0.01	15.7	<0.001	0.002
29.6	235.7	0.2		182.91							
					183	52	140	<0.01	11.7	<0.001	0.002
28.7	232.5	0.9		300.01							
					514	262	400	0.03	26.8	<0.001	0.002
29.4	241.9	0.1		52.7							
					70.3	80	30	<0.01	1.8	<0.001	<0.001
33.2	145.2	0.001		28.7							

				36.5	101	9	<0.01	1.2	<0.001	<0.001
32.7	159.8	0.01	10.79							
				14.9	109	6	<0.01	0.51	<0.001	<0.001
30	163.2	0.02	7.88							
				10.3	124	<5	<0.01	0.45	<0.001	<0.001
30.8	151.8	0.01	13.81							
				9.8	120	6	<0.01	0.34	<0.001	<0.001
33.3	121.3	0.01	4.46							
				7	125	<5	<0.01	0.25	<0.001	<0.001
				19.4	77	20	<0.01	0.44	<0.001	<0.001
				4.6	97	10	<0.01	0.52	<0.001	<0.001
				0.1	<10	<5	<0.01	<0.01	<0.001	<0.001
				420	140	179	0.03	12.5	<0.001	0.002
27.9		0.2	236.4							
				287	96	175	0.13	8.24	<0.001	0.001
				535	128	336	0.06	14.7	<0.001	0.002
				483	133	268	<0.01	9.82	<0.001	0.001
				293	97	262	0.08	4.8	<0.001	0.001
				74.6	104	19	0.01	1.78	<0.001	<0.001
				269	140	187	0.01	8.32	<0.001	<0.001
				29	136	12	<0.01	1.36	<0.001	<0.001
				61.5	126	34	<0.01	2.02	<0.001	<0.001
				30.8	185	12	<0.01	1.46	<0.001	<0.001
				9.4	223	<5	<0.01	0.43	<0.001	<0.001
				5.5	260	8	<0.01	0.4	<0.001	<0.001
				4.2	276	6	<0.01	0.18	<0.001	<0.001
				2.4	307	<5	<0.01	0.09	<0.001	<0.001
				3.1	348	<5	<0.01	0.05	<0.001	<0.001
				2.4	342	<5	<0.01	0.05	<0.001	<0.001
				3.1	384	6	<0.01	0.03	<0.001	<0.001
				3.3	373	<5	<0.01	0.04	<0.001	<0.001
				4.8	359	<5	<0.01	0.07	<0.001	<0.001
				4	363	<5	<0.01	0.05	<0.001	<0.001
							0.18	0.22	<0.001	<0.001
27.5	97.7				60	211	0.52	5.69	<0.001	<0.001
31.9	86.1				212	<5	<0.01	0.02	<0.001	<0.001
28.5	51.3				136	62	0.52	1.06	<0.001	<0.001
29	160.5				230	<5	0.05	0.39	0.001	0.001
26.4	95.8				156	60	0.19	3.98	<0.001	<0.001
25.1	183				94	337	0.18	8.1	<0.001	<0.001
26.1	139				84	89	0.09	3.26	<0.001	<0.001
26.8	149.3				121	26	0.02	1.57	<0.001	<0.001
24.4	151				57	278	0.14	8.88	<0.001	0.001
25.9	246				116	25	0.01	1.19	<0.001	<0.001
26.7	165				129	7	<0.01	0.27	<0.001	<0.001
27.4	165				157	11	<0.01	0.33	<0.001	<0.001
28.6	117				214	<5	<0.01	<0.01	<0.001	<0.001
28.5	84.9				227	<5	<0.01	<0.01	<0.001	<0.001
29	107.2				217	<5	<0.01	<0.01	<0.001	<0.001
34.1	67.7				218	<5	<0.01	0.02	<0.001	<0.001

30.3	46.8	293	<5	<0.01	<0.01	<0.001	<0.001
27.5	85	126	98	<0.01	3.05	<0.001	<0.001
29.1	124						
32.2	140	267	<5	<0.01	0.1	<0.001	<0.001
29.1	143	291	<5	<0.01	0.05	<0.001	<0.001
24.6	41.8	117	492	0.53	13.3	<0.001	0.001
28.4	62.2	132	61	0.3	3.25	<0.001	<0.001
28.3	65.2	125	21	0.24	2.03	<0.001	<0.001
32.8	35.2	125	16	0.02	1.4	<0.001	<0.001
31.4	28.5	107	73	0.01	2.31	<0.001	0.001
28.7	66.8	122	28	0.01	1.37	<0.001	0.001
29.2	71	153	11	<0.01	0.93	<0.001	0.001
26.6	135	81	189	0.15	3.08	<0.001	0.001
27.5	133	105	98	0.06	2.7	<0.001	<0.001
27.7	150	80	52	0.1	2.13	<0.001	0.001
29.1	149	64	9	0.06	1	<0.001	<0.001
27.9	161	77	9	0.05	1.18	<0.001	<0.001
29.2	103	91	6	0.18	0.47	<0.001	<0.001
28.6	148	94	5	0.01	0.53	<0.001	0.001
35.6	109	97	<5	0.01	0.48	<0.001	<0.001
29.7	124	96	<5	<0.01	0.51	<0.001	<0.001
25	182	108	6	<0.01	0.39	<0.001	<0.001
22.7	42	63	218	0.29	6.92	<0.001	0.002
22	139.4	66	61	0.16	2.42	<0.001	<0.001
23.1	109	76	24	0.1	1.16	<0.001	0.002
25.8	32	88	394	0.27	13.6	<0.001	0.002
		113	63	0.11	4.23	<0.001	<0.001
32.5	-80.4	137	19	0.03	2.37	<0.001	<0.001
		159	9	0.02	1.78	<0.001	<0.001
		174	7	<0.01	1.35	<0.001	<0.001
		128	14	0.25	1	<0.001	<0.001
		124	7	<0.01	0.96	<0.001	<0.001
		126	7	<0.01	0.75	<0.001	<0.001
		126	10	<0.01	0.63	<0.001	<0.001
		144	7	<0.01	0.55	<0.001	<0.001
		129	<5	<0.01	0.35	<0.001	<0.001
		136	6	<0.01	0.37	<0.001	<0.001
		145	<5	<0.01	0.24	<0.001	<0.001
28.5	160.4	145	<5	<0.01	0.24	<0.001	<0.001
24.7	21.1	76	218	0.22	14.8	<0.001	0.002
26.3	12.2	88	30	0.14	1.15	<0.001	<0.001
26.9	9.1	121	12	<0.01	0.54	<0.001	<0.001
25.5	10	126	191	0.11	9.64	<0.001	0.001
24.2	11.8	100	215	0.22	9.59	<0.001	0.001
24.7	8.5	94	22	0.09	2.36	<0.001	<0.001
25.4	5.7	100	16	0.04	1.39	<0.001	<0.001
27.9	12.9	110	<5	0.02	0.59	<0.001	<0.001
		130	6	<0.01	<0.01	<0.001	<0.001
29.5	7.5	118	<5	<0.01	0.39	<0.001	0.001
29.1	47.3	164	<5	0.03	0.12	<0.001	<0.001

28.4	9.5				196	<5	<0.01	0.03	<0.001	<0.001
26.8	16.7				216	<5	<0.01	0.03	<0.001	<0.001
26.6	3.1				216	<5	<0.01	0.1	<0.001	<0.001
26	-18.9				221	<5	<0.01	0.07	<0.001	0.001
26.6	-20				224	<5	<0.01	0.04	<0.001	<0.001
31.6	-59.4				248	<5	<0.01	0.03	<0.001	<0.001
29	-55.2				259	5	<0.01	0.02	<0.001	<0.001
26.9	-52.2			310	57	234	0.64	9.36	<0.001	0.001
28.5	-45.2			289	50	433	0.3	12.1	<0.001	0.001
25.7	-86.4			485	50	1,030	0.32	20.8	<0.001	0.002
24.5	-63.1			132	44	187	0.2	5.83	<0.001	<0.001
24.5	95.9			73.7	58	79	0.17	2.65	<0.001	<0.001
23.2	99.7			46.3	205	80	0.02	2.29	0.001	0.001
24.5	124.4			31.3	119	61	0.1	1.59	0.001	<0.001
24.6	240			18.1	118	16	0.06	0.68	<0.001	<0.001
28.6	96.7			6.3	163	8	0.03	0.31	<0.001	<0.001
30.7	155			3	178	<5	0.02	0.14	<0.001	<0.001
28.6	242.6			1.5	192	<5	0.01	0.1	<0.001	<0.001
31	82.1			1.4	218	<5	<0.01	0.03	<0.001	<0.001
29.8	95			1.5	230	6	<0.01	0.02	<0.001	<0.001
30.7	206			2	274	<5	<0.01	0.03	<0.001	<0.001
30.6	102			1.2	282	<5	<0.01	0.02	<0.001	<0.001
28	80			1.4	296	6	<0.01	0.03	<0.001	<0.001
28.3	84.5			2.6	316	8	<0.01	0.11	<0.001	<0.001
29.5	166.3			1.4	338	12	<0.01	0.03	<0.001	<0.001
29.4	115.1			1.8	318	<5	<0.01	0.03	<0.001	<0.001
31.3	114			0.9	351	<5	0.01	0.02	<0.001	<0.001
31	96.3			0.4	338	<5	<0.01	0.02	<0.001	<0.001
32.8	95.2				366	<5	<0.01	0.07	<0.001	<0.001
31.4	68.6			0.8	390	<5	0.02	0.04	<0.001	<0.001
29.2	94.1			1.2	375	8	<0.01	0.02	<0.001	<0.001
29.1	88.3			1	402	<5	0.01	0.04	<0.001	<0.001
30.6	61.1			2.1	400	<5	0.01	0.05	<0.001	<0.001
30.3	78.3			3.4	392	<5	<0.01	0.07	0.001	<0.001
32.7	80.5			2.1	466	<5	<0.01	0.03	0.001	<0.001
32.5	89.9			2.2	410	8	<0.01	0.04	0.001	<0.001
32	54.9			2.8	424	8	0.01	0.02	0.001	<0.001
30.6	71			2.4	472	10	<0.01	0.02	0.001	<0.001
26.6	114	0.4	390							
				249	66	410	0.43	15	<0.001	0.002
26.5	121	0.3	469							
				733	49	593	0.3	18.4	<0.001	0.002
27.4	130.1	0.1	119							
				134	111	67	0.39	3.03	<0.001	0.001
27	114.3	0.75	115.38							
				149	111	96	0.33	4.54	<0.001	<0.001
30.3	65.1	0.2	132.1							
				91.3	75	160	0.45	5.61	<0.001	0.001
28.9	80.7	0.3	116.1							
				147	98	83	0.29	4.65	<0.001	<0.001

31.5	59.5	0.2	25.8							
				25.1	95	11	0.18	0.85	<0.001	<0.001
32.5	56	0.2	13.6							
				10	106	<5	0.14	0.52	<0.001	<0.001
35	35.6	0.2	7							
				4.6	131	<5	0.1	0.3	<0.001	<0.001
				134	105	117	0.28	3.27	<0.001	0.001
31.8	56.2	0.4	72							
				73.5	87	54	0.29	1.84	<0.001	<0.001
29	55	5	354							
				382	100	358	0.16	12.6	<0.001	0.001
30.8	81	0.15	185							
				199	117	93	0.19	5.12	<0.001	<0.001
33.1	95	0.1	78							
				86.1	104	21	0.17	2.31	<0.001	<0.001
30.8	133	0.1	132							
				160	116	89	0.15	4.94	<0.001	<0.001
30.9	114	0.1	33							
				39.2	123	14	0.08	1.24	<0.001	<0.001
35.9	74.7	0.02	16.4							
				15.8	133	13	0.06	0.53	<0.001	<0.001
36.3	44.5	0.02	15.5							
				13.1	141	9	0.06	0.29	<0.001	<0.001
28.4	77.9	0.02	13.9							
				12.1	143	6	0.04	0.4	<0.001	<0.001
27.6	63.6	0.02	11.3							
				11.8	149	5	0.03	0.34	<0.001	<0.001
29.5	58.2	0.02	8.9							
				9.4	150	9	0.03	0.28	<0.001	<0.001
28.2	71.7	0.01	8.8							
				3.2	161	<5	0.02	0.2	<0.001	<0.001
				42.3	113	29	0.33	1.74	<0.001	<0.001
				59.4	98	13	0.26	1.26	<0.001	<0.001
				31.9	127	18	0.28	0.86	<0.001	<0.001
				24.9	128	12	0.25	0.81	<0.001	<0.001
33.6	12.8	0.05	26.4							
				30.4	122	13	0.19	0.88	<0.001	<0.001
30.8	27.7	0.05	22.5							
				27.6	123	14	0.13	0.74	<0.001	<0.001
30.6	62.8	0.02	17.5							
				19.8	132	<5	0.14	0.68	<0.001	<0.001
28.4	74.2	0.01	14.3							
				17.2	134	7	0.11	0.57	<0.001	<0.001
31.2	55.3	0.3	116							
				11.7	191	22	<0.01	0.4	<0.001	<0.001
28.7	282.2	2	215.2							
				268	67	206	0.39	8	<0.001	<0.001
32.4	297.4	0.6	89.5							
				98.1	110	35	0.39	3.3	<0.001	<0.001
28.6	265.1	0.2	57.7							

				64.1	138	15	0.25	2.09	<0.001	<0.001
29.7	266.7	0.1	26.6							
				34.6	138	8	0.15	1.25	<0.001	<0.001
31.5	275.4	0.1	191.4							
				265	82	151	0.44	7.32	<0.001	0.001
30.6	259	0.1	113.6							
				134	63	57	0.55	3.06	<0.001	0.001
29.3	274.1	0.05	72.75							
				87.9	134	15	0.43	1.72	<0.001	0.001
32.9	294.7	0.03	148.2							
				214	103	104	0.32	5.43	<0.001	0.001
29.4	274.3	0.01	75.04							
				96.1	113	22	<0.01	2.21	<0.001	<0.001
31.5	268.3	0.5	99.4							
				128	84	45	0.33	3.11	<0.001	0.001
31.1	246.1	0.5	99.7							
				124	91	47	0.35	3.18	<0.001	0.002
35	262.4	0.1	54.3							
				56.7	84	14	0.26	1.62	<0.001	0.001
30.1	286.5	0.1	42.1							
				37	95	12	0.22	1.35	<0.001	0.001
26.9	246.2	1	492.8							
				899	16	654	0.36	41.9	<0.001	0.004
31.3	291.4	0.1	178.4							
				193	66	101	0.25	6.21	<0.001	0.001
28.4	275.6	0.01	131.8							
				171	89	75	0.02	4.8	<0.001	0.002
29.7	271.8	0.01	103.8							
				115	96	39	0.01	3.47	<0.001	0.001
30.8	286.7	0.01	78.6							
				84.2	79	20	<0.01	2.43	<0.001	<0.001
30.7	291.4	0.01	58.14							
				61.2	92	18	<0.01	1.81	<0.001	<0.001
30.6	314.4	0.01	49.42							
				53	113	17	<0.01	1.62	<0.001	<0.001
30.2	242.3	0.01	42.43							
				43	127	16	<0.01	1.36	<0.001	<0.001
29.1	327.1	0.5	268.7							
				359	58	244	0.04	9.18	<0.001	<0.001
33.3	305.4	0.5	101.9							
				121	89	51	0.01	3.55	<0.001	<0.001
31.5	284.7	0.5	72.9							
				79.6	90	17	<0.01	2.38	<0.001	0.001
31.4	260.8	0.01	58.4							
				60	101	17	<0.01	1.94	<0.001	<0.001
31.8	283.4	0.05	55.8							
				57.8	105	17	<0.01	2.02	<0.001	<0.001
34.2	272.8	0.05	64.5							
				47.9	108	15	<0.01	1.51	<0.001	<0.001
34.1	283.1	0.01	38.7							

					44.1	98	11	<0.01	1.22	<0.001	<0.001
35.1		269.1	0.001		35						
					31.1	123	11	<0.01	1.34	0.001	<0.001
29		238.9	0.001		33.3						
					28.8	97	13	<0.01	1.2	<0.001	<0.001
					66	140	62	<0.005	0.6	0.00061	0.0009
						160					
	25.2			170.3	260	335	212	160	0.05	19.7	<0.001	0.003
						37.8	161	18	<0.01	1.23	<0.001	0.001
						499	86	530	0.03	21.7	<0.001	0.003
31		135.6	0.5		166.3						
					89.1	100	99	0.02	9.86	<0.001	0.002
29.1		146.1	0.05		102						
					73.5	100	45	<0.01	7.77	<0.001	0.002
27.1		204.8			184.2						
					144	126	220	<0.01	8.38	<0.001	0.002
27.5		224.6	0.1		7,567						
					48.2	90	32	<0.01	7.03	<0.001	0.002
27.6		260.7	0.25		238.6						
					203	96	266	<0.01	15.1	<0.001	0.002
29.9		238	0.4		207.19						
					254	72	232	<0.01	15	<0.001	0.002
28.9		237.2	1.1		342.35						
					515	130	410	0.02	32.2	<0.001	0.003
29.9		295.3	0.12		55.3						
					72.2	79	31	<0.01	1.73	<0.001	<0.001
33.2		162.5	0.3		33.8						
					40.8	98	12	<0.01	2.53	<0.001	<0.001
32.8		210.8	0.02		13.01						
					19	117	10	<0.01	0.61	<0.001	<0.001
30.9		161	0.01		10.02						
					13.5	98	6	<0.01	0.5	<0.001	<0.001
31.1		154.8	0.01		8.44						
					11.4	118	6	<0.01	0.45	<0.001	<0.001
33.6		140.3	0.01		6.99						
					8.8	113	<5	<0.01	0.31	<0.001	<0.001
					21.3	103	16	<0.01	0.59	<0.001	<0.001
					0.3	62	<5	<0.01	<0.01	<0.001	<0.001
					169	170	22	<0.01	5.8	<0.001	<0.001
					439	132	167	0.04	12.4	<0.001	0.002
29.4			0.3		230.2						
					286	88	160	0.14	8.01	<0.001	0.001
					423	96	276	0.07	12.5	<0.001	0.002
					243	109	140	<0.01	7.71	<0.001	0.001
					287	121	190	0.09	6.31	<0.001	0.001
					77.7	112	24	0.01	1.82	<0.001	<0.001
					244	176	163	0.03	9.18	<0.001	0.001
					93	78	78	0.03	3.7	<0.001	<0.001
					50.3	94	25	0.03	1.45	<0.001	<0.001
					30.4	146	8	<0.01	1.75	<0.001	<0.001

65.8	122	40	<0.01	2.09	<0.001	<0.001
29.5	187	12	<0.01	1.15	<0.001	<0.001
5.5	237	<5	<0.01	0.36	<0.001	<0.001
7.1	263	6	<0.01	0.3	<0.001	<0.001
5.6	289	9	<0.01	0.42	<0.001	<0.001
2.8	333	<5	<0.01	0.1	<0.001	<0.001
2.8	357	6	<0.01	0.06	<0.001	<0.001
2.3	346	5	<0.01	0.06	<0.001	<0.001
3.2	381	5	<0.01	0.04	<0.001	<0.001
3.8	372	<5	<0.01	0.04	<0.001	<0.001
5.2	365	10	<0.01	0.07	<0.001	<0.001
5	354	<5	<0.01	0.07	<0.001	<0.001

if no data. DATA IN THIS SHEET ARE EXACTLY AS RECORDED BY MMG (units as supplied - mg/L)

Cadmium (filtered) (mg/L)	Cadmium (mg/L)	Copper (filtered) (mg/L)	Copper (mg/L)	Iron (filtered) (mg/L)	Iron (mg/L)	Lead (filtered) (mg/L)	Lead (mg/L)	Manganese (filtered) (mg/L)	Manganese (mg/L)	Nickel (filtered) (mg/L)
<0.0001	0.0001	0.002	0.03			<0.001	0.012	0.013	0.99	0.001
<0.0001	<0.0001	0.002	0.002			<0.001	<0.001	0.017	0.043	<0.001
<0.0001	<0.0001	<0.001	0.002			<0.001	<0.001	0.028	0.042	<0.001
<0.0001	<0.0001	<0.001	0.002			<0.001	<0.001	0.035	0.059	<0.001
<0.0001	<0.0001	<0.001	<0.001			<0.001	<0.001	0.002	0.003	<0.001
<0.0001	<0.0001	<0.001	0.001			<0.001	<0.001	0.03	0.031	<0.001
<0.0001	<0.0001	0.002	0.003			<0.001	<0.001	0.009	0.054	<0.001
<0.0001	<0.0001	<0.001	<0.001			<0.001	<0.001	0.009	0.063	<0.001
<0.0001	<0.0001	0.002	0.004			<0.001	<0.001	0.007	0.079	<0.001
<0.0001	<0.0001	0.002	0.004			<0.001	0.001	0.012	0.078	<0.001
<0.0001	<0.0001	0.001	0.006			<0.001	0.002	0.023	0.147	<0.001
<0.0001	<0.0001	0.002	0.001			<0.001	<0.001	0.005	0.021	<0.001
<0.0001	<0.0001	0.001	0.002			<0.001	<0.001	0.01	0.03	<0.001
<0.0001	<0.0001	0.001	0.005			<0.001	<0.001	0.009	0.046	<0.001
<0.0001	<0.0001	0.001	<0.001			<0.001	<0.001	0.108	0.12	<0.001
<0.0001	<0.0001	0.001	0.001			<0.001	<0.001	0.11	0.116	<0.001
<0.0001	<0.0001	0.001	0.001			<0.001	<0.001	0.031	0.048	<0.001
<0.0001	<0.0001	0.003	0.008			<0.001	0.001	0.01	0.08	<0.001
<0.0001	<0.0001	0.002	0.008			<0.001	0.002	0.012	0.082	<0.001
<0.0001	<0.0001	0.001	0.002			<0.001	<0.001	0.028	0.058	<0.001
<0.0001	<0.0001	0.002	0.003			<0.001	<0.001	0.007	0.052	<0.001
<0.0001	<0.0001	0.002	0.003			<0.001	<0.001	0.025	0.068	<0.001
<0.0001	<0.0001	0.002	0.003			<0.001	<0.001	0.017	0.042	<0.001
<0.0001	<0.0001	0.002	0.002			<0.001	<0.001	0.028	0.048	<0.001
<0.0001	<0.0001	0.002	0.007			<0.001	0.002	0.03	0.226	<0.001
<0.0001	<0.0001	0.002	0.006			<0.001	0.002	<0.001	0.105	<0.001
<0.0001	<0.0001	<0.001	0.001			<0.001	<0.001	0.008	0.043	<0.001
<0.0001	<0.0001	<0.001	0.001			<0.001	<0.001	<0.001	0.039	<0.001
<0.0001	<0.0001	<0.001	<0.001			<0.001	<0.001	<0.001	0.04	<0.001
<0.0001	<0.0001	0.001	0.001			<0.001	<0.001	<0.001	0.021	<0.001
<0.0001	<0.0001	0.001	0.001			<0.001	<0.001	<0.001	0.029	<0.001
<0.0001	<0.0001	0.003	0.012			<0.001	0.002	0.006	0.13	<0.001

<0.0001	<0.0001	0.002	0.005	<0.001	0.002	0.006	0.124	<0.001
<0.0001	<0.0001	0.002	0.004	<0.001	<0.001	0.013	0.075	<0.001
<0.0001	<0.0001	0.002	0.011	<0.001	0.002	0.005	0.17	<0.001
<0.0001	<0.0001	0.002	0.003	<0.001	<0.001	0.011	0.069	<0.001
<0.0001	<0.0001	<0.001	0.002	<0.001	<0.001	0.034	0.068	<0.001
<0.0001	<0.0001	<0.001	0.002	<0.001	<0.001	0.053	0.064	<0.001
<0.0001	<0.0001	<0.001	0.002	<0.001	<0.001	0.043	0.046	<0.001
<0.0001	<0.0001	<0.001	0.002	<0.001	<0.001	0.022	0.021	<0.001
<0.0001	<0.0001	<0.001	0.002	<0.001	<0.001	0.046	0.044	<0.001
<0.0001	<0.0001	<0.001	0.001	<0.001	<0.001	0.031	0.031	<0.001
<0.0001	<0.0001	0.002	0.002	<0.001	<0.001	0.053	0.031	<0.001
<0.0001	<0.0001	0.002	0.001	<0.001	<0.001	0.043	0.012	<0.001
<0.0001	<0.0001	0.002	0.011	<0.001	0.002	<0.001	0.161	<0.001
<0.0001	<0.0001	0.001	0.002	<0.001	<0.001	0.016	0.14	<0.001
<0.0001	<0.0001	0.001	0.008	<0.001	<0.001	0.011	0.065	<0.001
<0.0001	<0.0001	0.002	0.059	<0.001	0.007	0.002	0.777	<0.001
<0.0001	<0.0001	0.004	0.018	<0.001	0.001	0.003	0.134	<0.001
<0.0001	<0.0001	0.005	0.012	<0.001	<0.001	0.003	0.146	0.001
<0.0001	<0.0001	0.006	0.01	<0.001	<0.001	<0.001	0.076	<0.001
<0.0001	<0.0001	0.004	0.016	<0.001	0.001	0.005	0.156	<0.001
<0.0001	<0.0001	0.004	0.007	<0.001	<0.001	0.019	0.063	<0.001
<0.0001	<0.0001	0.004	0.008	<0.001	<0.001	0.001	0.053	<0.001
<0.0001	<0.0001	0.002	0.011	<0.001	0.003	0.004	0.35	<0.001
<0.0001	<0.0001	0.002	0.009	<0.001	0.002	0.001	0.16	<0.001
<0.0001	<0.0001	0.002	0.007	<0.001	<0.001	0.002	0.101	<0.001
<0.0001	<0.0001	0.002	0.004	<0.001	<0.001	0.015	0.065	<0.001
<0.0001	<0.0001	0.002	0.005	<0.001	0.001	0.017	0.089	<0.001
<0.0001	<0.0001	0.002	0.003	<0.001	<0.001	<0.001	0.11	<0.001
<0.0001	<0.0001	0.002	0.003	<0.001	<0.001	<0.001	0.116	<0.001
<0.0001	<0.0001	0.002	0.003	<0.001	<0.001	<0.001	0.11	<0.001
<0.0001	<0.0001	0.002	0.005	<0.001	<0.001	<0.001	0.109	<0.001
<0.0001	<0.0001	0.002	0.003	<0.001	<0.001	<0.001	0.144	<0.001
<0.0001	0.0006	0.005	0.022	<0.001	0.007	0.005	0.388	<0.001
<0.0001	<0.0001	0.005	0.01	0.001	0.003	0.004	0.171	<0.001
<0.0001	0.0013	0.004	0.009	<0.001	0.004	0.016	0.076	<0.001
<0.0001	<0.0001	0.003	0.01	<0.001	0.002	0.001	0.107	<0.001
<0.0001	<0.0001	0.002	0.007	<0.001	0.001	0.001	0.076	<0.001
<0.0001	<0.0001	0.002	0.005	<0.001	<0.001	0.003	0.075	<0.001
<0.0001	<0.0001	0.002	0.004	<0.001	<0.001	0.005	0.076	<0.001
<0.0001	<0.0001	0.002	0.004	<0.001	<0.001	0.02	0.101	<0.001
<0.0001	<0.0001	0.001	0.004	<0.001	<0.001	0.001	0.133	<0.001
<0.0001	<0.0001	0.002	0.004	<0.001	<0.001	0.018	0.119	<0.001
<0.0001	<0.0001	0.004	0.054	<0.001	0.002	0.008	0.089	<0.001
<0.0001	<0.0001	0.001	0.003	<0.001	<0.001	0.007	0.087	<0.001
<0.0001	<0.0001	0.001	0.003	<0.001	<0.001	0.01	0.081	<0.001
<0.0001	<0.0001	0.001	0.003	<0.001	<0.001	0.003	0.077	<0.001
<0.0001	<0.0001	0.001	0.003	<0.001	<0.001	0.031	0.117	<0.001
<0.0001	<0.0001	0.001	0.003	<0.001	<0.001	0.003	0.077	<0.001
<0.0001	<0.0001	0.002	0.003	<0.001	0.001	0.023	0.045	<0.001

<0.0001	<0.0001	0.002	0.004		<0.001	<0.001	0.036	0.078	<0.001
<0.0001	<0.0001	0.002	0.003		<0.001	<0.001	0.026	0.104	<0.001
<0.0001	<0.0001	0.002	0.002		<0.001	<0.001	0.026	0.252	<0.001
<0.0001	<0.0001	0.002	0.003		<0.001	<0.001	0.016	0.168	<0.001
<0.0001	<0.0001	0.002	0.002		<0.001	<0.001	0.006	0.133	<0.001
<0.0001	<0.0001	0.001	0.002		<0.001	<0.001	0.006	0.133	<0.001
<0.0001	<0.0001	0.002	0.002		<0.001	<0.001	0.122	0.103	<0.001
<0.0001	<0.0001	0.003	0.002		0.003	<0.001	0.005	0.066	<0.001
<0.0001	<0.0001	0.002	0.003		<0.001	<0.001	0.056	0.097	<0.001
<0.0001	<0.0001	0.001	0.02		<0.001	<0.001	0.061	<0.0001	<0.001
<0.0001	<0.0001	0.002	0.002		<0.001	<0.001	0.078	0.11	<0.001
<0.0001	<0.0001	0.003	0.001		<0.001	<0.001	0.079	0.119	<0.001
<0.0001	<0.0001	0.002	0.001		<0.001	<0.001	0.078	0.117	<0.001
<0.0001	<0.0001	0.001	0.003		<0.001	<0.001	0.073	0.143	<0.001
<0.0001	0.0001	0.001	0.002		<0.001	<0.001	0.104	0.17	<0.001
<0.0001	<0.0001	0.001	0.002		<0.001	<0.001	0.052	0.093	<0.001
0.0003	<0.0001	0.001	0.002		<0.001	<0.001	0.056	0.107	<0.001
<0.0001	<0.0001	0.002	0.002		<0.001	<0.001	0.053	0.092	<0.001
<0.0001	0.0008	0.001	0.002		<0.001	<0.001	0.076	0.207	<0.001
<0.0001	<0.0001	<0.001	0.044		<0.001	0.011	0.006	0.632	<0.001
<0.0001	<0.0001	0.003	0.016		<0.001	0.001	0.008	0.127	<0.001
<0.0001	<0.0001	0.002	0.003		<0.001	<0.001	0.03	0.047	<0.001
<0.0001	<0.0001	0.002	0.007		<0.001	<0.001	0.034	0.046	<0.001
<0.0001	<0.0001	0.006	0.013		0.005	0.006	0.018	0.183	0.001
<0.0001	<0.0001	0.003	0.013		<0.001	0.003	0.006	0.208	<0.001
<0.0001	<0.0001	0.002	0.024		<0.001	0.007	0.004	0.345	<0.001
<0.0001	<0.0001	0.002	0.013		<0.001	0.004	0.007	0.135	<0.001
<0.0001	<0.0001	0.002	0.005		<0.001	0.001	0.012	0.071	<0.001
<0.0001	<0.0001	0.003	0.026		<0.001	0.003	0.004	0.232	<0.001
<0.0001	<0.0001	0.002	0.003		<0.001	<0.001	0.014	0.048	<0.001
<0.0001	<0.0001	0.002	0.003		<0.001	<0.001	0.021	0.053	<0.001
<0.0001	<0.0001	0.002	0.003		<0.001	<0.001	0.011	0.054	<0.001
<0.0001	<0.0001	0.002	0.003		<0.001	<0.001	0.003	0.053	<0.001
<0.0001	<0.0001	0.002	0.003		<0.001	<0.001	0.002	0.054	<0.001

<0.0001	<0.0001	0.002	0.003			<0.001	<0.001	0.002	0.053	<0.001
<0.0001	<0.0001	0.002	0.003			<0.001	<0.001	0.046	0.128	<0.001
<0.0001	<0.0001	0.002	0.005			<0.001	<0.001	0.005	0.061	<0.001
<0.0001	<0.0001	0.002	0.006			<0.001	<0.001	0.009	0.083	<0.001
<0.0001	<0.0001	0.002	0.003			<0.001	<0.001	0.01	0.03	<0.001
<0.0001	<0.0001	0.002	0.003			<0.001	<0.001	0.011	0.049	<0.001
<0.0001	<0.0001	0.002	0.003			<0.001	<0.001	0.009	0.051	0.019
<0.0001	<0.0001	0.002	0.003			<0.001	<0.001	0.01	0.061	<0.001
<0.0001	<0.0001	0.002	0.003			<0.001	<0.001	0.005	0.051	<0.001
<0.0001	<0.0001	0.002	0.003			<0.001	<0.001	0.004	0.048	<0.001
<0.0001	<0.0001	0.002	0.003	<0.05	0.34	<0.001	<0.001	<0.001	0.091	<0.001
<0.0001	<0.0001	0.003	0.008			<0.001	0.001	0.014	0.114	<0.001
<0.0001	<0.0001	0.003	0.006			<0.001	<0.001	0.008	0.08	<0.001
<0.0001	<0.0001	0.003	0.006			<0.001	<0.001	0.02	0.064	<0.001
<0.0001	<0.0001	0.005	0.062			<0.001	0.005	0.007	0.496	<0.001
<0.0001	<0.0001	0.002	0.009			<0.001	0.001	0.007	0.157	<0.001
<0.0001	<0.0001	0.002	0.005			<0.001	<0.001	0.007	0.07	<0.001
<0.0001	<0.0001	0.002	0.008			<0.001	0.002	0.017	0.16	<0.001
<0.0001	<0.0001	0.001	0.005			<0.001	0.001	<0.001	0.095	<0.001
<0.0001	<0.0001	0.003	0.008			<0.001	0.002	0.006	0.089	<0.001
<0.0001	<0.0001	0.003	0.009			<0.001	0.003	0.005	0.088	<0.001
<0.0001	<0.0001	0.003	0.007			<0.001	0.002	0.01	0.096	<0.001
<0.0001	<0.0001	0.003	0.006			<0.001	0.004	0.004	0.063	0.008
<0.0001	0.0002	0.004	0.109			<0.001	0.022	0.011	1.82	<0.001
<0.0001	<0.0001	0.003	0.012			<0.001	0.002	0.005	0.133	<0.001
<0.0001	<0.0001	0.002	0.008			<0.001	0.002	<0.001	0.108	<0.001
<0.0001	<0.0001	0.001	0.007			<0.001	0.001	<0.001	0.119	<0.001
<0.0001	<0.0001	0.001	0.005			<0.001	<0.001	<0.001	0.098	<0.001

<0.0001	<0.0001	0.001	0.004	<0.001	<0.001	<0.001	0.074	<0.001
<0.0001	<0.0001	0.001	0.004	<0.001	<0.001	<0.001	0.088	<0.001
<0.0001	<0.0001	0.001	0.004	<0.001	<0.001	<0.001	0.084	<0.001
<0.0001	<0.0001	0.002	0.025	<0.001	0.006	0.001	0.305	<0.001
<0.0001	<0.0001	0.001	0.007	<0.001	0.002	<0.001	0.084	<0.001
<0.0001	<0.0001	0.001	0.006	<0.001	0.001	<0.001	0.065	<0.001
<0.0001	<0.0001	0.001	0.006	<0.001	0.001	<0.001	0.1	<0.001
<0.0001	<0.0001	0.001	0.004	<0.001	<0.001	<0.001	0.056	<0.001
<0.0001	<0.0001	0.001	0.004	<0.001	<0.001	<0.001	0.058	<0.001
<0.0001	<0.0001	0.002	0.004	<0.001	<0.001	<0.001	0.066	<0.001
<0.0001	<0.0001	0.001	0.005	<0.001	<0.001	<0.001	0.059	<0.001
<0.0001	<0.0001	0.001	0.005	<0.001	<0.001	<0.001	0.05	<0.001
<0.0001	<0.0001	0.0035	0.0079	<0.0001	0.0014	0.0063	0.12	0.00073
<0.0001	<0.0001	0.003	0.032	<0.001	0.015	0.001	0.67	<0.001
<0.0001	<0.0001	0.002	0.006	<0.001	0.001	<0.001	0.155	<0.001
<0.0001	<0.0001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
<0.0001	0.0003	0.002	0.119	<0.001	0.041	<0.001	1.4	<0.001
<0.0001	<0.0001	0.002	0.012	<0.001	0.006	<0.001	0.137	<0.001
<0.0001	<0.0001	0.002	0.01	<0.001	0.004	<0.001	0.091	<0.001
<0.0001	<0.0001	<0.001	0.015	<0.001	0.004	<0.001	0.222	<0.001
<0.0001	<0.0001	0.002	0.04	<0.001	0.008	<0.001	0.499	<0.001
<0.0001	<0.0001	0.002	0.01	<0.001	0.002	<0.001	0.112	<0.001
<0.0001	<0.0001	0.001	0.036	<0.001	0.006	<0.001	0.436	<0.001
<0.0001	<0.0001	<0.001	0.025	<0.001	0.005	<0.001	0.332	<0.001
<0.0001	<0.0001	0.001	0.034	<0.001	0.006	<0.001	0.432	<0.001
<0.0001	<0.0001	0.001	0.006	<0.001	0.001	<0.001	0.087	<0.001

<0.0001	<0.0001	0.002	0.004	<0.001	<0.001	<0.001	0.061	<0.001
<0.0001	<0.0001	0.001	0.002	<0.001	<0.001	<0.001	0.062	<0.001
<0.0001	<0.0001	0.001	0.002	<0.001	<0.001	<0.001	0.067	<0.001
<0.0001	<0.0001	0.001	0.006	<0.001	<0.001	<0.001	0.064	<0.001
<0.0001	<0.0001	0.002	0.001	<0.001	<0.001	<0.001	0.063	<0.001
<0.0001	<0.0001	0.002	0.002	<0.001	<0.001	<0.001	0.144	<0.001
<0.0001	<0.0001	0.002	0.003	<0.001	<0.001	<0.001	0.048	<0.001
<0.0001	<0.0001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001	<0.001
<0.0001	<0.0001	0.002	0.029	<0.001	0.005	<0.001	0.366	<0.001
<0.0001	<0.0001	0.002	0.018	<0.001	0.004	0.001	0.179	<0.001
<0.0001	<0.0001	0.002	0.037	<0.001	0.005	0.001	0.379	<0.001
<0.0001	<0.0001	0.002	0.028	<0.001	0.003	<0.001	0.265	<0.001
<0.0001	<0.0001	0.002	0.017	<0.001	0.004	0.001	0.241	<0.001
<0.0001	<0.0001	0.002	0.006	<0.001	<0.001	<0.001	0.054	<0.001
<0.0001	<0.0001	0.002	0.018	<0.001	0.003	<0.001	0.225	<0.001
<0.0001	<0.0001	<0.001	0.004	<0.001	<0.001	<0.001	0.075	<0.001
<0.0001	<0.0001	<0.001	0.007	<0.001	0.001	<0.001	0.128	<0.001
<0.0001	<0.0001	0.001	0.004	<0.001	<0.001	<0.001	0.102	<0.001
<0.0001	<0.0001	0.001	0.002	<0.001	<0.001	<0.001	0.094	<0.001
<0.0001	<0.0001	<0.001	0.002	<0.001	<0.001	<0.001	0.1	<0.001
<0.0001	<0.0001	0.001	0.002	<0.001	<0.001	<0.001	0.127	<0.001
<0.0001	0.0002	0.001	<0.001	<0.001	<0.001	0.06	0.123	<0.001
<0.0001	<0.0001	0.001	0.002	<0.001	<0.001	<0.001	0.148	<0.001
<0.0001	<0.0001	0.001	0.001	<0.001	<0.001	<0.001	0.135	<0.001
<0.0001	<0.0001	0.001	0.001	<0.001	<0.001	<0.001	0.157	<0.001
<0.0001	<0.0001	0.001	0.002	<0.001	<0.001	<0.001	0.184	<0.001
<0.0001	<0.0001	0.001	<0.001	<0.001	<0.001	<0.001	0.157	<0.001
<0.0001	<0.0001	0.001	0.001	<0.001	<0.001	<0.001	0.157	<0.001
<0.0001	<0.0001	<0.001	<0.001	<0.001	<0.001	<0.001	0.002	<0.001
<0.0001	<0.0001	0.002	0.015	<0.001	0.003	0.007	0.224	<0.001
<0.0001	<0.0001	0.002	0.002	<0.001	<0.001	0.057	0.091	<0.001
<0.0001	<0.0001	0.004	0.008	<0.001	<0.001	0.079	0.127	0.001
<0.0001	<0.0001	0.002	0.016	<0.001	<0.001	0.329	0.389	<0.001
<0.0001	<0.0001	0.002	0.01	<0.001	0.002	0.001	0.145	<0.001
<0.0001	<0.0001	0.002	0.013	<0.001	0.003	0.004	0.346	<0.001
<0.0001	<0.0001	0.002	0.007	<0.001	0.001	0.002	0.138	<0.001
<0.0001	<0.0001	0.002	0.004	<0.001	0.003	0.016	0.085	<0.001
<0.0001	<0.0001	0.002	0.02	<0.001	0.006	0.006	0.297	<0.001
<0.0001	<0.0001	0.002	0.004	<0.001	<0.001	0.017	0.081	<0.001
<0.0001	<0.0001	<0.001	0.002	<0.001	<0.001	0.05	0.077	<0.001
<0.0001	<0.0001	<0.001	0.002	<0.001	<0.001	0.071	0.087	<0.001
<0.0001	<0.0001	<0.001	0.004	<0.001	<0.001	0.091	0.091	<0.001
<0.0001	<0.0001	<0.001	0.002	<0.001	<0.001	0.052	0.052	<0.001
<0.0001	<0.0001	<0.001	0.002	<0.001	<0.001	0.036	0.037	<0.001
<0.0001	<0.0001	0.002	0.001	<0.001	<0.001	0.045	0.033	<0.001

<0.0001	<0.0001	0.002	0.001		<0.001	<0.001	0.049	0.018	<0.001
<0.0001	<0.0001	0.002	0.009		<0.001	0.001	0.001	0.119	<0.001
<0.0001	<0.0001	0.001	0.003		<0.001	<0.001	0.006	0.099	<0.001
<0.0001	<0.0001	0.001	<0.001		<0.001	<0.001	0.005	0.05	<0.001
<0.0001	<0.0001	0.003	0.053		<0.001	0.005	0.004	0.692	<0.001
<0.0001	<0.0001	0.004	0.019		<0.001	0.001	0.002	0.155	<0.001
<0.0001	<0.0001	0.004	0.013		<0.001	<0.001	0.002	0.159	<0.001
<0.0001	<0.0001	0.005	0.009		<0.001	<0.001	<0.001	0.106	0.001
<0.0001	<0.0001	0.004	0.012		<0.001	0.001	0.006	0.122	<0.001
<0.0001	<0.0001	0.004	0.009		<0.001	<0.001	0.008	0.11	<0.001
<0.0001	<0.0001	0.003	0.006		<0.001	<0.001	0.002	0.097	<0.001
<0.0001	<0.0001	0.002	0.01		<0.001	0.004	0.004	0.439	<0.001
<0.0001	<0.0001	0.002	0.008		<0.001	0.002	0.002	0.186	<0.001
<0.0001	<0.0001	0.002	0.006		<0.001	0.001	0.002	0.116	<0.001
<0.0001	<0.0001	0.002	0.004		<0.001	<0.001	0.045	0.116	<0.001
<0.0001	0.0003	0.002	0.016		<0.001	<0.001	0.072	0.173	<0.001
<0.0001	<0.0001	0.002	0.009		<0.001	<0.001	0.004	0.191	<0.001
<0.0001	<0.0001	0.002	0.003		<0.001	<0.001	0.002	0.194	<0.001
<0.0001	<0.0001	0.002	0.003		<0.001	<0.001	0.002	0.193	<0.001
<0.0001	<0.0001	0.002	0.003		<0.001	<0.001	0.001	0.178	<0.001
<0.0001	<0.0001	0.002	0.003		<0.001	<0.001	<0.001	0.16	<0.001
<0.0001	0.0004	0.005	0.025		<0.001	0.005	0.006	0.388	<0.001
<0.0001	<0.0001	0.005	0.01		<0.001	0.003	0.003	0.156	<0.001
<0.0001	0.0004	0.004	0.008		<0.001	0.002	0.009	0.071	0.001
<0.0001	<0.0001	0.004	0.035		0.005	0.006	0.006	0.425	<0.001
<0.0001	<0.0001	0.002	0.01		<0.001	0.002	0.001	0.098	<0.001
<0.0001	<0.0001	0.002	0.006		<0.001	<0.001	0.006	0.088	<0.001
<0.0001	<0.0001	0.002	0.006		<0.001	<0.001	0.01	0.104	<0.001
<0.0001	<0.0001	0.002	0.004		<0.001	<0.001	0.016	0.124	<0.001
<0.0001	<0.0001	0.002	0.004		<0.001	<0.001	0.061	0.164	<0.001
<0.0001	<0.0001	0.002	0.004		<0.001	<0.001	0.001	0.126	<0.001
<0.0001	<0.0001	0.002	0.003		<0.001	<0.001	0.019	0.107	<0.001
<0.0001	<0.0001	0.001	0.003		<0.001	<0.001	0.01	0.087	<0.001
<0.0001	<0.0001	0.002	0.003		<0.001	<0.001	0.003	0.062	<0.001
<0.0001	<0.0001	0.002	0.002		<0.001	<0.001	0.001	0.045	<0.001
<0.0001	<0.0001	0.002	0.003		<0.001	<0.001	0.002	0.038	<0.001
<0.0001	<0.0001	0.002	0.002		<0.001	<0.001	<0.001	0.031	<0.001
<0.0001	<0.0001	0.002	0.002		<0.001	<0.001	<0.001	0.031	<0.001
<0.0001	<0.0001	0.002	0.029		<0.001	0.004	0.005	0.378	<0.001
<0.0001	<0.0001	0.005	0.009		<0.001	<0.001	0.05	0.123	<0.001
<0.0001	<0.0001	0.002	0.004		<0.001	<0.001	0.27	0.371	<0.001
<0.0001	<0.0001	0.003	0.037		<0.001	0.003	0.012	0.304	<0.001
<0.0001	<0.0001	0.002	0.019		<0.001	0.004	0.002	0.268	<0.001
<0.0001	<0.001	0.003	0.007		<0.001	<0.001	0.012	0.084	<0.001
<0.0001	<0.0001	0.002	0.004		<0.001	<0.001	0.024	0.068	<0.001
<0.0001	<0.0001	0.002	0.004		<0.001	<0.001	0.053	0.072	<0.001
<0.0001	<0.0001	0.002	0.003		<0.001	<0.001	0.05	0.076	<0.001
<0.0001	<0.0001	0.002	0.003		<0.001	<0.001	0.047	0.047	<0.001
<0.0001	<0.0001	0.002	0.003		<0.001	<0.001	0.105	0.166	<0.001

<0.0001	<0.0001	0.002	0.003		<0.001	<0.001	0.059	0.148	<0.001
<0.0001	<0.0001	0.002	0.002		<0.001	<0.001	0.066	0.183	<0.001
<0.0001	<0.0001	0.002	0.004		<0.001	<0.001	0.061	0.24	<0.001
<0.0001	<0.0001	0.003	0.002		<0.001	<0.001	0.013	0.212	<0.001
<0.0001	<0.0001	0.001	0.001		<0.001	<0.001	0.011	0.134	<0.001
<0.0001	<0.0001	0.002	0.002		<0.001	<0.001	0.024	0.154	<0.001
<0.0001	<0.0001	0.002	0.002		<0.001	<0.001	0.043	0.146	<0.001
<0.0001	<0.0001	0.004	0.027		<0.001	0.004	0.006	0.33	<0.001
<0.0001	<0.0001	0.003	0.037		<0.001	0.006	0.013	0.536	<0.001
<0.0001	0.0001	0.002	0.061		<0.001	0.018	0.004	0.871	<0.001
<0.0001	<0.0001	0.002	0.016		<0.001	0.002	0.004	0.238	<0.001
<0.0001	<0.0001	0.002	0.009		<0.001	0.001	0.049	0.132	<0.001
<0.0001	<0.0001	0.01	0.01		0.001	0.001	0.69	0.69	0.003
<0.0001	<0.0001	0.003	0.008		<0.001	<0.001	0.033	0.105	<0.001
<0.0001	<0.0001	0.002	0.004		<0.001	<0.001	0.028	0.07	<0.001
<0.0001	<0.0001	0.003	0.003		<0.001	<0.001	0.057	0.076	<0.001
<0.0001	<0.0001	0.002	0.002		<0.001	<0.001	0.068	0.079	<0.001
<0.0001	<0.0001	0.002	0.003		<0.001	<0.001	0.086	0.108	<0.001
<0.0001	<0.0001	0.002	0.002		<0.001	<0.001	0.073	0.084	<0.001
<0.0001	<0.0001	0.002	0.002		<0.001	<0.001	0.074	0.106	<0.001
<0.0001	<0.0001	0.002	0.003		<0.001	<0.001	0.08	0.117	<0.001
<0.0001	<0.0001	0.002	0.002		<0.001	<0.001	0.076	0.104	<0.001
<0.0001	<0.0001	0.002	0.002		<0.001	<0.001	0.044	0.132	<0.001
<0.0001	<0.0001	0.002	0.003		<0.001	<0.001	0.062	0.125	<0.001
<0.0001	<0.0001	0.002	0.002		<0.001	<0.001	0.058	0.125	<0.001
<0.0001	<0.0001	0.001	0.002		<0.001	<0.001	0.074	0.116	<0.001
<0.0001	<0.0001	0.002	0.002		<0.001	<0.001	0.052	0.107	<0.001
<0.0001	<0.0001	0.002	0.002		<0.001	<0.001	0.046	0.104	<0.001
<0.0001	<0.0001	0.001	0.07		<0.001	<0.001	0.065	<0.0001	<0.001
<0.0001	<0.0001	0.003	0.002		<0.001	0.002	0.072	0.122	<0.001
<0.0001	<0.0001	0.002	0.002		<0.001	<0.001	0.085	0.135	<0.001
<0.0001	<0.0001	0.002	0.002		<0.001	<0.001	0.076	0.15	<0.001
<0.0001	<0.0001	0.002	0.002		<0.001	0.006	0.061	0.156	<0.001
<0.0001	<0.0001	0.002	0.002		<0.001	<0.001	0.051	0.167	<0.001
<0.0001	<0.0001	0.002	0.002		0.001	<0.001	0.094	0.15	<0.001
<0.0001	<0.0001	0.002	0.002		<0.001	<0.001	0.084	0.153	<0.001
<0.0001	<0.0001	0.002	0.002		<0.001	<0.001	0.036	0.106	<0.001
<0.0001	<0.0001	0.002	0.001		<0.001	<0.001	0.018	0.162	<0.001
<0.0001	<0.0001	0.002	0.033		<0.001	0.006	0.012	0.464	<0.001
<0.0001	<0.0001	0.001	0.037		<0.001	0.011	0.006	0.566	<0.001
<0.0001	<0.0001	0.004	0.01		<0.001	<0.001	0.008	0.118	<0.001
<0.0001	<0.0001	0.002	0.013		<0.001	0.003	0.023	0.156	<0.001
<0.0001	<0.0001	0.005	0.025		<0.001	0.005	0.137	0.343	<0.001
<0.0001	<0.0001	0.002	0.008		<0.001	0.003	0.013	0.129	<0.001

<0.0001	<0.0001	0.002	0.003			<0.001	<0.001	0.024	0.066	<0.001
<0.0001	<0.0001	0.002	0.003			<0.001	<0.001	0.043	0.062	<0.001
<0.0001	<0.0001	0.002	0.003			0.003	<0.001	0.037	0.051	<0.001
<0.0001	<0.0001	0.002	0.01			<0.001	0.006	0.005	0.108	<0.001
<0.0001	<0.0001	0.002	0.007			<0.001	0.002	0.008	0.113	<0.001
<0.0001	<0.0001	0.002	0.025			<0.001	0.007	0.005	0.369	<0.001
<0.0001	<0.0001	0.002	0.012			<0.001	0.003	0.028	0.14	<0.001
<0.0001	<0.0001	0.002	0.007			<0.001	0.004	0.014	0.091	<0.001
<0.0001	<0.0001	0.003	0.017			<0.001	0.002	0.006	0.163	<0.001
<0.0001	<0.0001	0.002	0.005			<0.001	<0.001	0.021	0.085	<0.001
<0.0001	<0.0001	0.002	0.003			<0.001	<0.001	0.025	0.067	<0.001
<0.0001	<0.0001	0.002	0.003			<0.001	<0.001	0.025	0.086	<0.001
<0.0001	<0.0001	0.002	0.003			<0.001	<0.001	0.009	0.102	<0.001
<0.0001	<0.0001	0.002	0.003			<0.001	<0.001	0.046	0.125	<0.001
<0.0001	<0.0001	0.002	0.003			<0.001	<0.001	0.052	0.122	<0.001
<0.0001	<0.0001	0.002	0.002			<0.001	<0.001	0.003	0.047	<0.001
<0.0001	<0.0001	0.002	0.005			<0.001	<0.001	0.005	0.053	<0.001
<0.0001	<0.0001	0.002	0.004			<0.001	<0.001	0.009	0.056	<0.001
<0.0001	<0.0001	0.002	0.004			<0.001	<0.001	0.012	0.052	<0.001
<0.0001	<0.0001	0.002	0.004			<0.001	<0.001	0.013	0.052	<0.001
<0.0001	<0.0001	0.002	0.003			<0.001	<0.001	0.022	0.08	0.019
<0.0001	<0.0001	0.002	0.003			<0.001	<0.001	0.025	0.089	<0.001
<0.0001	<0.0001	0.002	0.003			<0.001	<0.001	0.034	0.102	<0.001
<0.0001	<0.0001	0.002	0.003			<0.001	<0.001	0.035	0.11	<0.001
<0.0001	<0.0001	0.002	0.004	<0.05	0.8	<0.001	<0.001	<0.001	0.284	<0.001
<0.0001	<0.0001	0.003	0.019			<0.001	0.003	0.008	0.262	<0.001
<0.0001	<0.0001	0.003	0.007			<0.001	0.001	0.014	0.107	<0.001

<0.0001	<0.0001	0.003	0.006		<0.001	<0.001	0.019	0.083	<0.001
<0.0001	<0.0001	0.003	0.005		<0.001	<0.001	0.028	0.083	<0.001
<0.0001	<0.0001	0.006	0.032		<0.001	0.003	0.04	0.338	<0.001
<0.0001	<0.0001	0.002	0.007		<0.001	0.001	0.012	0.118	<0.001
<0.0001	<0.0001	0.003	0.006		<0.001	<0.001	0.019	0.096	<0.001
<0.0001	<0.0001	0.002	0.01		<0.001	0.002	0.013	0.238	<0.001
<0.0001	<0.0001	0.001	0.006		<0.001	0.001	<0.001	0.156	<0.001
<0.0001	<0.0001	0.003	0.01		<0.001	0.003	0.01	0.129	<0.001
<0.0001	<0.0001	0.003	0.01		<0.001	0.003	0.01	0.138	<0.001
<0.0001	<0.0001	0.003	0.006		<0.001	0.002	0.015	0.109	<0.001
<0.0001	<0.0001	0.003	0.006		<0.001	0.001	0.014	0.1	<0.001
<0.0001	0.0007	0.004	0.121		<0.001	0.016	0.01	1.99	<0.001
<0.0001	<0.0001	0.003	0.013		<0.001	0.003	0.005	0.14	0.001
<0.0001	<0.0001	0.002	0.01		<0.001	0.002	<0.001	0.174	<0.001
<0.0001	<0.0001	0.001	0.007		<0.001	0.001	<0.001	0.185	<0.001
<0.0001	<0.0001	0.001	0.005		<0.001	<0.001	<0.001	0.186	<0.001
<0.0001	<0.0001	0.001	0.004		<0.001	<0.001	<0.001	0.234	<0.001
<0.0001	<0.0001	0.001	0.005		<0.001	<0.001	<0.001	0.154	<0.001
0.0001	<0.0001	0.001	0.004		<0.001	<0.001	<0.001	0.133	<0.001
<0.0001	<0.0001	0.001	0.02		<0.001	0.005	0.001	0.268	<0.001
<0.0001	<0.0001	0.001	0.007		<0.001	0.001	<0.001	0.091	<0.001
<0.0001	<0.0001	0.001	0.006		<0.001	0.001	<0.001	0.072	<0.001
<0.0001	<0.0001	0.001	0.005		<0.001	<0.001	<0.001	0.072	<0.001
<0.0001	<0.0001	0.001	0.004		<0.001	<0.001	<0.001	0.079	<0.001
<0.0001	<0.0001	0.001	0.004		<0.001	<0.001	<0.001	0.102	<0.001

<0.0001	<0.0001	0.002	0.003	<0.001	<0.001	<0.001	0.083	<0.001
<0.0001	<0.0001	0.001	0.004	<0.001	<0.001	<0.001	0.066	<0.001
<0.0001	<0.0001	0.001	0.004	<0.001	<0.001	<0.001	0.077	<0.001
<0.0001	<0.0001	0.002	0.0049	<0.0001	0.0009	0.071	0.43	0.0011
<0.0001	<0.0001	0.002	0.024	<0.001	0.018	0.004	0.8	<0.001
<0.0001	<0.0001	0.004	0.008	<0.001	<0.001	<0.001	0.137	<0.001
<0.0001	0.0001	0.002	0.071	<0.001	0.021	<0.001	0.774	<0.001
<0.0001	<0.0001	0.002	0.014	<0.001	0.006	<0.001	0.165	<0.001
<0.0001	<0.0001	0.002	0.01	<0.001	0.003	<0.001	0.133	<0.001
<0.0001	<0.0001	0.002	0.024	<0.001	0.005	<0.001	0.31	<0.001
<0.0001	<0.0001	0.002	0.01	<0.001	0.002	0.001	0.115	<0.001
<0.0001	<0.0001	0.001	0.03	<0.001	0.006	<0.001	0.367	<0.001
<0.0001	<0.0001	<0.001	0.024	<0.001	0.005	<0.001	0.344	<0.001
<0.0001	<0.0001	0.001	0.038	<0.001	0.006	<0.001	0.453	<0.001
<0.0001	<0.0001	0.001	0.006	<0.001	<0.001	<0.001	0.086	<0.001
<0.0001	<0.0001	0.001	0.004	<0.001	<0.001	<0.001	0.073	<0.001
<0.0001	<0.0001	0.001	0.002	<0.001	<0.001	<0.001	0.094	<0.001
<0.0001	<0.0001	0.001	0.002	<0.001	<0.001	<0.001	0.114	<0.001
<0.0001	<0.0001	0.001	0.002	<0.001	<0.001	<0.001	0.144	<0.001
<0.0001	<0.0001	0.001	0.001	<0.001	<0.001	<0.001	0.136	<0.001
<0.0001	<0.0001	0.002	0.004	<0.001	<0.001	<0.001	0.18	<0.001
<0.0001	<0.0001	0.003	0.004	<0.001	<0.001	0.001	0.001	<0.001
<0.0001	<0.0001	0.004	0.018	<0.001	0.002	0.002	0.116	<0.001
<0.0001	<0.0001	0.002	0.032	<0.001	0.005	<0.001	0.358	<0.001
<0.0001	<0.0001	0.002	0.017	<0.001	0.004	0.002	0.168	<0.001
<0.0001	<0.0001	0.002	0.034	<0.001	0.005	0.001	0.334	<0.001
<0.0001	<0.0001	0.002	0.025	<0.001	0.002	<0.001	0.243	<0.001
<0.0001	<0.0001	0.002	0.018	<0.001	0.003	0.002	0.223	<0.001
<0.0001	<0.0001	0.002	0.008	<0.001	<0.001	0.001	0.059	<0.001
<0.0001	<0.0001	0.002	0.021	<0.001	0.003	<0.001	0.202	<0.001
<0.0001	<0.0001	<0.001	0.011	<0.001	0.002	<0.001	0.2	<0.001
<0.0001	<0.0001	<0.001	0.005	<0.001	<0.001	<0.001	0.056	<0.001
<0.0001	<0.0001	<0.001	0.005	<0.001	<0.001	<0.001	0.082	<0.001

<0.0001	<0.0001	<0.001	0.006		<0.001	0.001	<0.001	0.128	<0.001
<0.0001	<0.0001	0.001	0.005		<0.001	<0.001	<0.001	0.129	<0.001
<0.0001	<0.0001	0.001	0.002		<0.001	<0.001	<0.001	0.123	<0.001
<0.0001	<0.0001	0.002	<0.001		<0.001	<0.001	<0.001	0.115	<0.001
<0.0001	<0.0001	0.001	0.003		<0.001	<0.001	<0.001	0.171	<0.001
<0.0001	<0.0001	0.001	<0.001		<0.001	<0.001	0.051	0.185	<0.001
<0.0001	<0.0001	0.001	0.001		<0.001	<0.001	<0.001	0.144	<0.001
<0.0001	<0.0001	0.001	0.001		<0.001	<0.001	<0.001	0.143	<0.001
<0.0001	<0.0001	0.001	0.002		<0.001	<0.001	<0.001	0.158	<0.001
0.0001	<0.0001	0.002	0.001		<0.001	<0.001	<0.001	0.164	0.008
<0.0001	<0.0001	0.001	0.001		<0.001	<0.001	<0.001	0.203	<0.001
<0.0001	<0.0001	0.001	<0.001		<0.001	<0.001	<0.001	0.231	<0.001

Nickel (mg/L)	Zinc (filtered) (mg/L)	Zinc (mg/L)
0.018	<0.005	0.038
<0.001	<0.005	<0.005
<0.001	<0.005	<0.005
<0.001	<0.005	0.006
<0.001	<0.005	<0.005
<0.001	<0.005	<0.005
0.001	<0.005	<0.005
<0.001	<0.005	<0.005
0.001	<0.005	0.006
0.002	<0.005	0.019
0.003	<0.005	0.011
<0.001	<0.005	0.02
0.001	<0.005	0.011
<0.001	<0.005	0.012
<0.001	<0.005	<0.005
<0.001	<0.005	<0.005
<0.001	<0.005	<0.005
0.003	0.008	<0.005
0.003	<0.005	<0.005
<0.001	<0.005	<0.005
0.001	<0.005	0.03
0.002	<0.005	<0.005
<0.001	<0.005	<0.005
0.013	<0.005	<0.005
0.004	<0.005	0.007
0.002	<0.005	<0.005
<0.001	<0.005	<0.005
<0.001	<0.005	<0.005
<0.001	<0.005	0.01
<0.001	<0.005	<0.005
<0.001	<0.005	<0.005
0.005	<0.005	0.007

0.002	<0.005	<0.005
0.001	<0.005	<0.005
0.004	<0.005	<0.005
<0.001	<0.005	<0.005
<0.001	<0.005	<0.005
<0.001	<0.005	<0.005
<0.001	<0.005	<0.005
<0.001	<0.005	<0.005
<0.001	<0.005	<0.005
<0.001	<0.005	<0.005
<0.001	<0.005	<0.005
<0.001	<0.005	<0.005
0.004	<0.005	0.007

<0.001	<0.005	<0.005
<0.001	<0.005	<0.005
0.02	<0.005	0.024
0.004	<0.005	0.005
0.003	<0.005	<0.005
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DO NOT change column headings. Values in the Data columns must be a number. Copy the data from the Raw

Monitoring Point	Date	DO % Saturation (Field)	Dissolved Oxygen - % Saturation	Electrical Conductivity (field) (µS/cm)	Electrical Conductivity (Lab) (µS/cm)	Electrical Conductivity @ 25oC (µS/cm)
CC-05	11 Jan 2015				126	
CC-05	03 Jan 2016	73		197.3	234	191.8327662
CC-05	04 Jan 2016	73		320.7	280	299.1046447
CC-05	05 Jan 2016	78		360	312	329.9120235
CC-05	07 Jan 2016	202.5		380.7	51	326.1651816
CC-05	08 Jan 2016	126.6		339.1	350	309.1439511
CC-05	01 Feb 2016	49.2		182	159	165.0643933
CC-05	14 Feb 2016	58		253	229	235.1301115
CC-05	10 Mar 2016	41.5		149	122	127.2416738
CC-05	05 Mar 2018	15		122.3	92	111.3032399
CC-05	06 Mar 2018	21.6		137.7	106	128.884313
CC-05	18 Mar 2018	37.7		300.8	274	294.0946422
CC-05	19 Mar 2018	88.7		321.8	272	298.5434641
CC-05	20 Mar 2018	81.2		322	281	298.203371
CC-05	11 Feb 2019	61		502	433	483.6223507
CC-05	12 Feb 2019	101		495	376	429.6875
CC-05	13 Feb 2019	140		541	377	465.7770125
CC-05	27 Jan 2020	78.3		84.4		
CC-05	27 Jan 2020				80	
CC-05	28 Jan 2020	86.2		106		
CC-05	28 Jan 2020				98	
CC-05	02 Feb 2020	98.2		227.1		
CC-05	02 Feb 2020				194	
CC-05	03 Feb 2020	89.6		163.3		
CC-05	03 Feb 2020				149	
CC-05	08 Feb 2020	84		191.9		
CC-05	08 Feb 2020				183	
CC-05	06 Mar 2020				139	
CC-05	08 Mar 2020				223	
CC-05	24 Dec 2020	85.4		105.8		
CC-05	24 Dec 2020				98	
CC-05	07 Feb 2023				97	
CC-05	15 Mar 2023				400	
CC-05	16 Mar 2023				445	
CC-05	17 Mar 2023				479	
CC-05	18 Mar 2023				516	
CC-05	19 Mar 2023				516	
DR-10	19 Dec 2015	42.6		87.2	94	87.0346342
DR-10	31 Dec 2015	77		111.7	112	109.0075144
DR-10	01 Jan 2016	65		169	158	163.7120992

DR-10	02 Jan 2016	84.7	109	103	105.9795819
DR-10	03 Jan 2016	81	145	171	142.8289992
DR-10	04 Jan 2016	63	241	219	234.3218279
DR-10	05 Jan 2016	58	297	261	284.0474369
DR-10	06 Jan 2016	61.3	324.7	302	306.0897436
DR-10	07 Jan 2016	63	347.7	325	332.5363428
DR-10	08 Jan 2016	55	368.5		347.3793363
DR-10	09 Jan 2016	56.3	397.7	369	370.9196046
DR-10	10 Jan 2016	46.5	444	392	404.7770991
DR-10	11 Jan 2016	28	456.3	396	415.9905187
DR-10	12 Jan 2016	71.9	137	139	132.2266191
DR-10	16 Jan 2016	41	257		238.0070383
DR-10	31 Jan 2016	34.2	569	492	504.7458529
DR-10	14 Feb 2016	50.4	449	400	415.817744
DR-10	05 Mar 2016	20	104.8	116	106.8297655
DR-10	06 Mar 2016	14.6	139.4	119	133.5632845
DR-10	07 Mar 2016	8.3	142.1	136	136.398541
DR-10	08 Mar 2016	3.8	155.3	141	147.4553741
DR-10	09 Mar 2016	85.4	171	152	147.464643
DR-10	10 Mar 2016	8.5	290	136	276.3483896
DR-10	11 Mar 2016	39	202	138	188.064426
DR-10	12 Mar 2016	55	111	93	108.7275933
DR-10	13 Mar 2016	48	130	116	124.1050119
DR-10	14 Mar 2016	55	98.2	90	93.57728226
DR-10	15 Mar 2016	47	124.5	110	115.5023657
DR-10	16 Mar 2016	44	134	124	128.1560826
DR-10	17 Mar 2016	54	158	170	147.3605671
DR-10	18 Mar 2016	46	111	173	102.7968142
DR-10	19 Mar 2016	22.7	185	168	174.7096043
DR-10	20 Mar 2016	42	159	169	150.6966164
DR-10	21 Mar 2016	44	178.6	182	174.6186938
DR-10	23 May 2016	40.4	62.2	71	65.04235073
DR-10	24 May 2016	23.9	77.7	63	81.90154949
DR-10	25 May 2016	0.5	89.3	77	93.56663873
DR-10	09 Mar 2017	60.1	147.6	96	133.4056399
DR-10	10 Mar 2017			136	0
DR-10	11 Mar 2017			160	
DR-10	12 Mar 2017			175	
DR-10	13 Mar 2017			200	
DR-10	14 Mar 2017			209	
DR-10	16 Mar 2017			207	
DR-10	17 Mar 2017			212	
DR-10	18 Mar 2017			215	
DR-10	19 Mar 2017			217	
DR-10	20 Mar 2017			221	
DR-10	20 Mar 2017			222	
DR-10	21 Mar 2017	41	250.6	209	232.8996283
DR-10	12 Mar 2018		191.9	162	172.8517384
DR-10	15 Mar 2018	60.9	260.7	243	256.3169796
DR-10	17 Mar 2018	56.9	306.6	266	288.510398

DR-10	18 Mar 2018	40.9	323.9	286	308.0947398
DR-10	19 Mar 2018	45	340.5	299	322.7182258
DR-10	20 Mar 2018	47.4	345.1	308	330.6505701
DR-10	21 Mar 2018	46.5	359.9	328	343.5799523
DR-10	22 Mar 2018	480.8	379.5	330	342.4163133
DR-10	23 Mar 2018	461.4	343.2	328	314.516129
DR-10	20 Feb 2019	70	784	572	702.571915
DR-10	21 Feb 2019	90.5	803	602	720.8258528
DR-10	22 Feb 2019	93.6	862	610	754.4857768
DR-10	23 Feb 2019	88.8	888	634	777.2428884
DR-10	24 Feb 2019	88.2	878	640	762.1527778
DR-10	25 Feb 2019	85.2	877	649	767.6148796
DR-10	26 Feb 2019	65.7	888	701	826.7386649
DR-10	27 Feb 2019	94	1,000	697	866.6262241
DR-10	28 Feb 2019	81.7	5.92	701	5.130427247
DR-10	01 Mar 2019	63.4	900	730	797.0244421
DR-10	02 Mar 2019	64.1	709	745	618.5117334
DR-10	27 Jan 2020	81	59.5		
DR-10	27 Jan 2020			64	
DR-10	28 Jan 2020	78.3	116.6		
DR-10	28 Jan 2020			113	
DR-10	02 Feb 2020	94	203.8		
DR-10	02 Feb 2020			179	
DR-10	03 Feb 2020	100.7	230.8		
DR-10	03 Feb 2020			209	
DR-10	04 Feb 2020	80.9	121.7		
DR-10	04 Feb 2020			118	
DR-10	05 Feb 2020	85.9	109.8		
DR-10	05 Feb 2020			105	
DR-10	06 Feb 2020	85.6	85.7		
DR-10	06 Feb 2020			84	
DR-10	07 Feb 2020	84	94.9		
DR-10	07 Feb 2020			90	
DR-10	08 Feb 2020	79.9	151.7		
DR-10	08 Feb 2020			145	
DR-10	09 Feb 2020	68	119.7		
DR-10	09 Feb 2020			117	
DR-10	10 Feb 2020	78.8	210.2		
DR-10	10 Feb 2020			202	
DR-10	11 Feb 2020	101.3	245.9		
DR-10	11 Feb 2020			234	
DR-10	12 Feb 2020	90	258.9		
DR-10	12 Feb 2020			223	
DR-10	13 Feb 2020	68.9	261		
DR-10	13 Feb 2020			253	
DR-10	14 Feb 2020	63	268.7		
DR-10	14 Feb 2020			262	
DR-10	15 Feb 2020	59.2	273.2		
DR-10	15 Feb 2020			264	
DR-10	16 Feb 2020	57.1	281.5		

DR-10	16 Feb 2020			265
DR-10	06 Mar 2020			106
DR-10	07 Mar 2020			143
DR-10	08 Mar 2020			165
DR-10	09 Mar 2020			185
DR-10	10 Mar 2020	98.1	207.2	
DR-10	10 Mar 2020			195
DR-10	11 Mar 2020	77	208	
DR-10	11 Mar 2020			199
DR-10	12 Mar 2020	74.4	214.5	
DR-10	12 Mar 2020			206
DR-10	13 Mar 2020	68.8	217.2	
DR-10	13 Mar 2020			208
DR-10	25 Apr 2020			296
DR-10	24 Dec 2020	82.1	133.8	
DR-10	24 Dec 2020			122
DR-10	25 Dec 2020	77	161.2	
DR-10	25 Dec 2020			150
DR-10	26 Dec 2020	73.9	192.9	
DR-10	26 Dec 2020			180
DR-10	27 Dec 2020	80.7	92.5	
DR-10	27 Dec 2020			88
DR-10	28 Dec 2020	87.7	89.2	
DR-10	28 Dec 2020			81
DR-10	29 Dec 2020	82.7	107.1	
DR-10	29 Dec 2020			102
DR-10	30 Dec 2020	99.2	118.8	
DR-10	30 Dec 2020			114
DR-10	31 Dec 2020	76	132.4	
DR-10	31 Dec 2020			127
DR-10	03 Feb 2021	9.8	88	
DR-10	03 Feb 2021			94
DR-10	04 Feb 2021	59.2	100	
DR-10	04 Feb 2021			94
DR-10	05 Feb 2021	79.8	113.3	
DR-10	05 Feb 2021			108
DR-10	06 Feb 2021	69.4	113.8	
DR-10	06 Feb 2021			109
DR-10	07 Feb 2021	86.5	71	
DR-10	07 Feb 2021			70
DR-10	08 Feb 2021	91	90.4	
DR-10	08 Feb 2021			87
DR-10	09 Feb 2021	80	99.3	
DR-10	09 Feb 2021			94
DR-10	10 Feb 2021	79	117.6	
DR-10	10 Feb 2021			110
DR-10	11 Feb 2021	83.1	136.8	
DR-10	11 Feb 2021			126
DR-10	12 Feb 2021	84.6	140.4	
DR-10	12 Feb 2021			135

DR-10	13 Feb 2021	80.8		44.9	
DR-10	13 Feb 2021				140
DR-10	14 Feb 2021	78.3		153.4	
DR-10	14 Feb 2021				140
DR-10	15 Feb 2021	89.5		65.1	
DR-10	15 Feb 2021				60
DR-10	16 Feb 2021	91.4		110.6	
DR-10	16 Feb 2021				103
DR-10	17 Feb 2021	93.6		135.7	
DR-10	17 Feb 2021				127
DR-10	18 Feb 2021	103.1		150.3	
DR-10	18 Feb 2021				138
DR-10	19 Feb 2021	99.6		150.6	
DR-10	19 Feb 2021				140
DR-10	20 Feb 2021	94.4		154.8	
DR-10	20 Feb 2021				141
DR-10	21 Feb 2021	90		158.1	
DR-10	21 Feb 2021				145
DR-10	22 Feb 2021	91.5		161.7	
DR-10	22 Feb 2021				152
DR-10	23 Feb 2021	79.3		162.1	
DR-10	23 Feb 2021				154
DR-10	18 May 2021				210
DR-10	18 May 2021				
DR-10	03 Sep 2021		59		60
DR-10 R1	30 Sep 2021				149
DR-10 R2 (Field_B)	30 Sep 2021				1
DR-10	21 Jan 2022	82.8		156.3	
DR-10	21 Jan 2022				143
DR-10	22 Jan 2022	88.8		119.8	
DR-10	22 Jan 2022				99
DR-10	23 Jan 2022	84.4		134.9	
DR-10	23 Jan 2022				110
DR-10	26 Jan 2022	106.3		100.7	
DR-10	26 Jan 2022				88
DR-10	27 Jan 2022	89.9		104.2	
DR-10	27 Jan 2022				116
DR-10	28 Jan 2022	89.7		125.5	
DR-10	28 Jan 2022				127
DR-10	29 Jan 2022	91.3		92.6	
DR-10	29 Jan 2022				98
DR-10	30 Jan 2022	98		92	
DR-10	30 Jan 2022				86
DR-10	31 Jan 2022	95.4		70.1	
DR-10	31 Jan 2022				74
DR-10	01 Feb 2022	95		106.9	
DR-10	01 Feb 2022				112
DR-10	02 Feb 2022	101.2		152.4	
DR-10	02 Feb 2022				144
DR-10	03 Feb 2022	104.2		176.4	

DR-10	03 Feb 2022			167	
DR-10	04 Feb 2022	98.7	225.7		
DR-10	04 Feb 2022			181	
DR-10	05 Feb 2022	98.5	239.3		
DR-10	05 Feb 2022			188	
DR-10	06 Feb 2022	98.9	255.7		
DR-10	06 Feb 2022			194	
DR-10	30 Mar 2022			138	
DR-10 R1	29 Sep 2022			134	
DR-10 R2	29 Sep 2022			<1	
DR-10	28 Nov 2022			60	
DR-10	25 Dec 2022	93.6	71.1		
DR-10	25 Dec 2022			71	
DR-10	27 Dec 2022			73	
DR-10	14 Jan 2023			74	
DR-10	07 Feb 2023			60	
DR-10	08 Feb 2023			97	
DR-10	07 Mar 2023			84	
DR-10	11 Mar 2023			153	
DR-10	12 Mar 2023			146	
DR-10	13 Mar 2023			240	
DR-10	14 Mar 2023			322	
DR-10	15 Mar 2023			350	
DR-10	16 Mar 2023			389	
DR-10	17 Mar 2023			434	
DR-10	18 Mar 2023			496	
DR-10	19 Mar 2023			501	
DR-10	20 Mar 2023			561	
DR-10	21 Mar 2023			559	
DR-10	22 Mar 2023			600	
DR-10	23 Mar 2023			632	
DR-10 (Duplicate01)	17 Jan 2015				
DR-14	17 Jan 2015	69.3	78.4	91	74.84486874
DR-14	24 Jan 2015	4.2	363.2	360	321.1033507
DR-14	26 Jan 2015	39.4	169.1	173	158.5560244
DR-14	31 Jan 2015	3	451.1	446	419.2379182
DR-14	19 Dec 2015	31.5	88.5	94	86.20689655
DR-14	30 Dec 2015	82.8	76.5	74	76.35492564
DR-14	31 Dec 2015	74	100.1	95	98.05073954
DR-14	01 Jan 2016	69.1	167.2	155	161.6708567
DR-14	02 Jan 2016	75.3	63.6	63	64.33340077
DR-14	03 Jan 2016	80.5	181.7	167	178.6451676
DR-14	04 Jan 2016	73	237	217	229.5844231
DR-14	05 Jan 2016	62	295	262	282.1346595
DR-14	07 Jan 2016	81.1	350	322	327.5926619
DR-14	08 Jan 2016	94.3	376.2	345	352.742616
DR-14	09 Jan 2016	76.2	403.7	371	375.1858736
DR-14	10 Jan 2016	77.9	476.8	392	406.5137693
DR-14	11 Jan 2016	52.9	458.3	398	416.3714
DR-14	12 Jan 2016	71	157	163	149.8806683

DR-14	16 Jan 2016	52	253		234.7156508
DR-14	31 Jan 2016	48	556	475	489.0921886
DR-14	14 Feb 2016	54	458	448	424.900269
DR-14	05 Mar 2016	21	63	69	63.48246675
DR-14	06 Mar 2016	21.1	137.5	140	129.1564907
DR-14	07 Mar 2016	20.3	155.7	151	146.5135974
DR-14	08 Mar 2016	54.4	181	155	157.6380422
DR-14	09 Mar 2016	43.5	168.3	146	150.053495
DR-14	10 Mar 2016	37.5	169	151	157.8996543
DR-14	11 Mar 2016	35	183.2	164	169.6610483
DR-14	12 Mar 2016	58	91.3	90	88.60636646
DR-14	13 Mar 2016	51	124	115	118.3770883
DR-14	14 Mar 2016	68	100.4	93	95.50080852
DR-14	15 Mar 2016	58	121	109	112.2553113
DR-14	16 Mar 2016	50	126.7	120	120.0834044
DR-14	17 Mar 2016	64	126	156	116.6882756
DR-14	18 Mar 2016	63	141	157	131.9730438
DR-14	19 Mar 2016	66.7	194	156	161.4782753
DR-14	20 Mar 2016	55	148	157	135.8670706
DR-14	21 Mar 2016	50	165.3	178	165.3
DR-14	23 May 2016	50.3	60.7	66	63.47380529
DR-14	24 May 2016	19.7	76.7	75	81.33616119
DR-14	25 May 2016	20.4	85.7	84	88.90963793
DR-14	08 Mar 2017	74	57.4	54	56.54058314
DR-14	09 Mar 2017			94	0
DR-14	10 Mar 2017	70.9	160.7	131	140.6564551
DR-14	11 Mar 2017			154	
DR-14	12 Mar 2017			178	
DR-14	13 Mar 2017			198	
DR-14	14 Mar 2017			210	
DR-14	16 Mar 2017			218	
DR-14	17 Mar 2017			223	
DR-14	18 Mar 2017			229	
DR-14	19 Mar 2017			234	
DR-14	20 Mar 2017			235	
DR-14	20 Mar 2017			240	
DR-14	21 Mar 2017	53	267.8	240	251.1017346
DR-14	04 Mar 2018	18.5	79.6	66	80.05632103
DR-14	05 Mar 2018	18	145	127	141.5048307
DR-14	06 Mar 2018	22.8	272.2	172	262.7159541
DR-14	07 Mar 2018	24.6	145.2	135	143.833581
DR-14	08 Mar 2018	27.8	82	75	83.26563769
DR-14	09 Mar 2018	15.6	130.6	126	131.3486875
DR-14	10 Mar 2018	18.5	156.2	133	155.0218341
DR-14	11 Mar 2018	16.6	184.9	152	175.2440527
DR-14	12 Mar 2018			176	
DR-14	13 Mar 2018	58.8	230.6	193	212.4366651
DR-14	15 Mar 2018	62.6	287	252	266.2584655
DR-14	17 Mar 2018	72	326.5	285	306.6879579
DR-14	18 Mar 2018	37.8	346.7	312	335.2349642

DR-14	19 Mar 2018	42.8	370.6	335	359.6661491
DR-14	20 Mar 2018	38.5	392.3	364	384.9852797
DR-14	21 Mar 2018	42	420.7	381	408.2880435
DR-14	22 Mar 2018	644.6	470.6	404	418.1624311
DR-14	23 Mar 2018	301.7	454.9	409	422.7695167
DR-14	31 Jan 2019	58.2	41.9	59	40.44011196
DR-14	01 Feb 2019	112.4	81.3	52	76.23066104
DR-14	02 Feb 2019	139.7	116.7	53	115.1682621
DR-14	03 Feb 2019	31.4	106.3	48	107.3195356
DR-14	04 Feb 2019	65.1	74.1	80	74.81070167
DR-14	05 Feb 2019	66.2	131.6	289	136.2600953
DR-14	06 Feb 2019	74	164.4	144	165.9767794
DR-14	07 Feb 2019	72.5	234.8	7.87	236.5981459
DR-14	08 Feb 2019	67	331.9	270	310.6514414
DR-14	09 Feb 2019	59	411	313	370.8382207
DR-14	10 Feb 2019	70.4	412.4	342	385.9977537
DR-14	11 Feb 2019	76.2	475.8	366	427.1095153
DR-14	12 Feb 2019	75.1	458.7	391	420.3629032
DR-14	13 Feb 2019	74	540	419	487.2326987
DR-14	14 Feb 2019	96	576	447	520.6073753
DR-14	15 Feb 2019	73	585	459	553.4531693
DR-14	16 Feb 2019	60	573	492	539.1926226
DR-14	17 Feb 2019	66.6	689	530	634.7305389
DR-14	18 Feb 2019	46.9	702	539	647.8405316
DR-14	19 Feb 2019	73.6	775	573	692.149683
DR-14	20 Feb 2019	62	695	580	623.8779174
DR-14	21 Feb 2019	87.3	852	616	742.0310051
DR-14	22 Feb 2019	84.5	863	629	769.4365193
DR-14	23 Feb 2019	68.2	791	650	732.5430635
DR-14	24 Feb 2019	65.4	868	649	805.2695055
DR-14	25 Feb 2019	64.4	912	663	824.2950108
DR-14	26 Feb 2019	64.9	928	692	843.0998456
DR-14	27 Feb 2019	72	1,010	703	881.0956992
DR-14	28 Feb 2019	69.3	1,010	718	884.0262582
DR-14	01 Mar 2019	73.5	1,012	732	893.2038835
DR-14	02 Mar 2019	59	1,027	760	928.2357195
DR-14	26 Jan 2020	80	75		
DR-14	26 Jan 2020			77	
DR-14	27 Jan 2020	79	64.5		
DR-14	27 Jan 2020			66	
DR-14	28 Jan 2020	79	120		
DR-14	28 Jan 2020			116	
DR-14	29 Jan 2020	90.7	103.6		
DR-14	29 Jan 2020			100	
DR-14	30 Jan 2020	90.9	101.5		
DR-14	30 Jan 2020			94	
DR-14	31 Jan 2020	91.1	123.6		
DR-14	31 Jan 2020			113	
DR-14	01 Feb 2020	86.1	171.3		
DR-14	01 Feb 2020			157	

DR-14	02 Feb 2020	87.3	203	
DR-14	02 Feb 2020			182
DR-14	03 Feb 2020	104.8	226	
DR-14	03 Feb 2020			208
DR-14	04 Feb 2020			130
DR-14	05 Feb 2020	85.3	109.7	
DR-14	05 Feb 2020			110
DR-14	06 Feb 2020	84.2	86.6	
DR-14	06 Feb 2020			88
DR-14	07 Feb 2020	82.2	75.1	
DR-14	07 Feb 2020			99
DR-14	08 Feb 2020	82.2	145.2	
DR-14	08 Feb 2020			141
DR-14	09 Feb 2020	70	152.9	
DR-14	09 Feb 2020			146
DR-14	10 Feb 2020	73.8	190	
DR-14	10 Feb 2020			184
DR-14	11 Feb 2020	98.9	227.8	
DR-14	11 Feb 2020			216
DR-14	12 Feb 2020	91.1	239	
DR-14	12 Feb 2020			228
DR-14	13 Feb 2020	66.2	244.6	
DR-14	13 Feb 2020			233
DR-14	14 Feb 2020	60.1	257	
DR-14	14 Feb 2020			248
DR-14	15 Feb 2020	56.7	267.1	
DR-14	15 Feb 2020			255
DR-14	16 Feb 2020	55.8	276.9	
DR-14	16 Feb 2020			271
DR-14	06 Mar 2020			104
DR-14	07 Mar 2020			142
DR-14	08 Mar 2020			155
DR-14	09 Mar 2020			172
DR-14	10 Mar 2020	105.6	189.8	
DR-14	10 Mar 2020			178
DR-14	11 Mar 2020	80.5	197.4	
DR-14	11 Mar 2020			188
DR-14	12 Mar 2020	72.8	206.6	
DR-14	12 Mar 2020			198
DR-14	13 Mar 2020	64.5	214	
DR-14	13 Mar 2020			204
DR-14	04 Apr 2020	77.6	88	
DR-14	23 Apr 2020			298
DR-14	23 Dec 2020	85.8	82.8	
DR-14	23 Dec 2020			40
DR-14	24 Dec 2020	83.8	134.3	
DR-14	24 Dec 2020			122
DR-14	25 Dec 2020	76.3	161.6	
DR-14	25 Dec 2020			151
DR-14	26 Dec 2020	75.8	185.1	

DR-14	26 Dec 2020			171
DR-14	27 Dec 2020	72.7	116.9	
DR-14	27 Dec 2020			111
DR-14	28 Dec 2020	85.5	98.6	
DR-14	28 Dec 2020			90
DR-14	29 Dec 2020	79.1	106.5	
DR-14	29 Dec 2020			109
DR-14	30 Dec 2020	89.8	113.1	
DR-14	30 Dec 2020			108
DR-14	31 Dec 2020	76.1	126.7	
DR-14	31 Dec 2020			122
DR-14	03 Feb 2021	56.3	95.9	
DR-14	03 Feb 2021			90
DR-14	04 Feb 2021	55.7	95.9	
DR-14	04 Feb 2021			90
DR-14	05 Feb 2021	82	115.4	
DR-14	05 Feb 2021			105
DR-14	06 Feb 2021	54.4	116.8	
DR-14	06 Feb 2021			116
DR-14	07 Feb 2021	87.4	68.1	
DR-14	07 Feb 2021			70
DR-14	08 Feb 2021	88.5	90.6	
DR-14	08 Feb 2021			88
DR-14	09 Feb 2021	77.2	100.1	
DR-14	09 Feb 2021			95
DR-14	10 Feb 2021	78.8	116.2	
DR-14	10 Feb 2021			109
DR-14	11 Feb 2021	77.8	63	
DR-14	11 Feb 2021			120
DR-14	12 Feb 2021	76.6	71.2	
DR-14	12 Feb 2021			135
DR-14	13 Feb 2021	68.5	73.3	
DR-14	13 Feb 2021			144
DR-14	14 Feb 2021	75.8	157.3	
DR-14	14 Feb 2021			148
DR-14	15 Feb 2021	87.9	64.7	
DR-14	15 Feb 2021			60
DR-14	16 Feb 2021	91.9	108.9	
DR-14	16 Feb 2021			101
DR-14	17 Feb 2021	92.5	133.6	
DR-14	17 Feb 2021			37
DR-14	18 Feb 2021	102.2	150.5	
DR-14	18 Feb 2021			138
DR-14	19 Feb 2021	96.4	156.4	
DR-14	19 Feb 2021			144
DR-14	20 Feb 2021	101.1	161.9	
DR-14	20 Feb 2021			148
DR-14	21 Feb 2021	101.3	169.9	
DR-14	21 Feb 2021			157
DR-14	22 Feb 2021	102.1	175.7	

DR-14	22 Feb 2021				166
DR-14	23 Feb 2021	75.8		177.3	
DR-14	23 Feb 2021				168
DR-14	19 May 2021				280
DR-14	19 May 2021				
DR-14	03 Sep 2021		55.3		69
DR-14	30 Sep 2021				282
DR-14	21 Jan 2022				143
DR-14	22 Jan 2022	87.1		126.4	
DR-14	22 Jan 2022				103
DR-14	23 Jan 2022	70		138.8	
DR-14	23 Jan 2022				112
DR-14	27 Jan 2022	88.7		106.2	
DR-14	27 Jan 2022				116
DR-14	28 Jan 2022	83.3		129.2	
DR-14	28 Jan 2022				126
DR-14	29 Jan 2022	89.7		91.7	
DR-14	29 Jan 2022				95
DR-14	30 Jan 2022	97.5		91.1	
DR-14	30 Jan 2022				88
DR-14	31 Jan 2022	95.2		71.3	
DR-14	31 Jan 2022				75
DR-14	01 Feb 2022	94.5		106.9	
DR-14	01 Feb 2022				107
DR-14	02 Feb 2022	98.4		148.6	
DR-14	02 Feb 2022				141
DR-14	03 Feb 2022	104.6		171.4	
DR-14	03 Feb 2022				163
DR-14	04 Feb 2022	98.6		225.9	
DR-14	04 Feb 2022				178
DR-14	05 Feb 2022	94		237.9	
DR-14	05 Feb 2022				188
DR-14	06 Feb 2022	98.2		263.3	
DR-14	06 Feb 2022				194
DR-14 R1	31 Mar 2022				184
DR-14 R2 (Field_B)	31 Mar 2022				107
DR-14	28 Sep 2022				135
DR-14	28 Nov 2022				63
DR-14	25 Dec 2022	92.8		72.5	
DR-14	25 Dec 2022				71
DR-14	27 Dec 2022				72
DR-14	14 Jan 2023				92
DR-14	07 Feb 2023				60
DR-14	08 Feb 2023				94
DR-14	07 Mar 2023				82
DR-14	09 Mar 2023				77
DR-14	10 Mar 2023				98
DR-14	11 Mar 2023				158
DR-14	12 Mar 2023				148
DR-14	13 Mar 2023				242

DR-14	14 Mar 2023	337
DR-14	15 Mar 2023	358
DR-14	16 Mar 2023	396
DR-14	17 Mar 2023	469
DR-14	18 Mar 2023	498
DR-14	19 Mar 2023	502
DR-14	20 Mar 2023	562
DR-14	21 Mar 2023	555
DR-14	22 Mar 2023	601
DR-14	23 Mar 2023	641

v Data sheet. Delete outliers from the Data columns and highlight cell. See user guide for details.

Electrical Conductivity (Non Compensated) (µS/cm)	pH (Field)	pH (Lab)	Temp (Field) °C	Temperature °C	Redox Potential (Field) (mV)	Flow Rate (m/sec)
		7.94				
	7.53	7.99	26.5		156	
	7.66	8.17	28.8		135	
	7.95	8.24	29.8		131	
	8.15	7.61	33.8		89.5	
	8.24	8.44	30.1		45	
	7.78	8.05	30.4		155	
	8.08	7.89	29		141	
	8.01	7.78	34		47.9	
	7.21	7.43	30.2		36.1	
	7.06	7.5	28.6		37	
	8.66	8.07	26.2		-10.8	
	8.95	8.41	29.1		-23.3	
	8.85	8.43	29.2		-14	
	7.8	8.1	27		120.4	
	8.2	8.2	33		85	
	8.33	8.1	33.5		79	
	7.37		28.9		151.5	0.5
		6.92				
	7.5		30.8		106.8	0.1
		7.34				
	7.9		30.6		56	0.1
		8.07				
	7.71		31.3		68.9	0.3
		7.86				
	8.1		30.5		201	0.5
		8.05				
		7.75				
		8.19				
	7.61		34.4		288.6	1
		7.03				
		7.26				
		8.11				
		8.16				
		8.33				
		8.31				
		8.36				
	7.16	7.26	25.1		98.6	
	7.49	7.65	26.3		143	
	7.61	7.88	26.7		154.5	

7.54	7.76	26.5	139
7.51	7.95	25.8	165
7.59	7.89	26.5	151
7.73	8.09	27.4	153
7.6	8.23	28.2	133
7.6	8.5	27.4	97
7.8		28.2	79
7.75	8.36	28.8	86.6
7.49	8.16	30.1	57.2
7.28	8.18	30.1	44.9
7.63	7.82	26.9	67.2
7.61		29.2	114
7.57	8.23	31.7	151
7.63	7.99	29.2	138
8.03	7.75	24	39.3
7.64	7.81	27.3	63.3
7.9	7.83	27.2	71.8
7.46	7.63	27.8	-26
8.12	7.72	33.4	-6
7.75	7.65	27.6	58
7.91	7.8	28.9	62
8.2	7.61	26.1	123
7.72	7.74	27.5	123
7.46	7.69	27.6	144
7.48	7.85	29.1	138
6.99	7.89	27.4	161
7.6	8.08	28.8	119
7.3	8.08	29.2	142
7.55	8.07	28.1	127
7.2	8.09	27.9	72
7.64	8.08	26.2	206
8.45	7.06	22.7	38.7
8.43	7.11	22.3	147.5
6.4	7.25	22.6	64.7
7.91	7.46	30.6	43.1
	7.66		
	7.85		
	8.01		
	8.01		
	7.67		
	7.83		
	7.82		
	7.82		
	7.87		
	7.91		
	7.8		
7.26	7.67	29	116.8
7.53	7.78	30.8	
8.17	7.93	25.9	49.1
8.18	7.94	28.3	16.2

8.41	7.84	27.7	2.2	
8.46	7.92	27.9	-7.7	
8.67	7.83	27.3	-12.6	
8.7	7.89	27.5	-16.5	
7.9	8.06	30.7	-53.8	
7.9	8.03	29.8	-61.7	
8	8.26	31.1	122	
8	8.13	31	84	
8.19	8.32	32.5	106.8	
8.13	8.34	32.5	101.7	
8.16	8.25	33	84.4	
8.16	8.19	32.5	63.3	
8.08	8.18	28.9	75.2	
8.2	8.33	33.1	48.7	
8.18	8.35	33.1	63.9	
8.06	8.24	31.8	71.4	
8.13	8.23	32.7	60	
7.58		26.3	171	0.8
	6.91			
7.6		27.3	102.5	0.25
	7.17			
7.7		33	44.9	0.05
	7.95			
7.87		35.3	36.7	0.05
	8.03			
7.5		31	55.1	0.25
	7.68			
7.7		31.5	57	0.2
	7.76			
7.69		28.8	43.6	5
	7.59			
7.7		31.2	142	0.2
	7.71			
7.8		33.9	89	0.05
	7.95			
7.8		29.2	116	0.05
	7.72			
8.4		30.9	89	0.1
	8.14			
7.98		35.6	75.5	0.02
	7.93			
7.77		34.9	51.4	0.02
	7.94			
7.82		28.4	83	0.02
	7.93			
8.02		27.6	65.7	0.02
	7.94			
8.13		28.8	59.9	0.02
	7.9			
8.05		28.5	68.7	0.02

	7.92			
	7.56			
	7.78			
	7.95			
	7.99			
8.04		35	11.4	0.02
	7.9			
7.82		29	37.5	0.02
	7.83			
7.82		29.8	63.8	0.01
	7.74			
7.78		28	67.8	0.01
	7.94			
	8.23			
7.43		32.9	309.3	0.2
	7.17			
7.76		28.3	295.3	0.1
	7.32			
7.72		28.5	296.6	0.01
	7.65			
7.9		29.3	261.5	0.01
	6.97			
7.7		29	261.9	0.01
	7.12			
7.8		28.7	256.7	0.01
	7.22			
7.91		33.9	276.6	0.01
	7.44			
7.42		29.5	280.1	0.01
	7.37			
7.31		27.3	307.3	0.1
	6.81			
7.25		29.8	223.5	0.01
	6.83			
8.09		33.1	249.1	0.01
	6.92			
7.58		30	269.7	0.01
	6.94			
7.69		27	306.1	1
	6.73			
7.55		31.6	288	0.1
	6.91			
7.6		28.7	305.9	0.01
	7.07			
7.6		29	295.6	0.01
	7.11			
7.8		30.9	281.7	0.01
	7.29			
7.98		30.7	289.5	0.01
	7.32			

	7.9		30.4	270.3	0.01
		7.47			
	7.88		30.4	263.6	0.01
		7.36			
	7.83		28.8	274.4	0.7
		6.84			
	7.97		32.3	302	0.7
		7.11			
	7.87		31.3	291.2	0.7
		7.33			
	8.01		31.1	270.9	0.1
		7.61			
	8.2		32.3	283.5	0.1
		7.5			
	8.26		33.8	253.4	0.01
		7.49			
	7.82		33.3	295.7	0.001
		7.49			
	8.09		34	282.4	0.001
		7.6			
	8.1		29.1	253.7	0.001
		7.49			
		7.35			
81	7.3	7.05		23.5	
		7.87			
		5.89			
	7.67		26.8	95.9	2
		7.37			
	7.66		30.3	105.7	0.1
		7.37			
	7.59		28.9	143	0.01
		7.51			
	7.62		30	168	
		7.44			
	7.75		26.8	222.5	
		7.53			
	7.79		28.2	210.8	0.01
		7.74			
	7.78		27.9	256.3	0.3
		7.64			
	7.78		29.6	235.7	0.2
		7.62			
	7.63		28.7	232.5	0.9
		7.49			
	7.66		29.4	241.9	0.1
		7.77			
	7.83		33.2	145.2	0.001
		7.94			
	7.96		32.7	159.8	0.01

	8.02			
7.97		30	163.2	0.02
	8.04			
7.98		30.8	151.8	0.01
	7.97			
7.89		33.3	121.3	0.01
	7.99			
	7.89			
	7.7			
	5.99			
	7.14			
7.4		27.9		0.2
	7.13			
	7.34			
	7.24			
	6.97			
	7.34			
	7.39			
	7.77			
	7.98			
	8.15			
	8.28			
	8.19			
	8.2			
	8.19			
	8.25			
	8.3			
	8.26			
	8.28			
	8.15			
	8.18			
7.52	7.66	27.5	97.7	
7.67	8.5	31.9	86.1	
7.42	8.03	28.5	51.3	
7.32	7.88	29	160.5	
7.22	7.22	26.4	95.8	
7.37	7.43	25.1	183	
7.53	7.66	26.1	139	
7.48	7.89	26.8	149.3	
7.52	7.51	24.4	151	
7.35	7.75	25.9	246	
7.47	8.01	26.7	165	
7.61	8.09	27.4	165	
7.9	8.27	28.6	117	
8.07	8.36	28.5	84.9	
7.87	8.37	29	107.2	
7.08	8.19	34.1	67.7	
7.82	8.19	30.3	46.8	
7.58	7.83	27.5	85	

7.85		29.1	124
7.94	8.34	32.2	140
8.03	8.07	29.1	143
8.05	7.58	24.6	41.8
7.62	7.91	28.4	62.2
7.73	7.92	28.3	65.2
7.78	7.7	32.8	35.2
7.82	7.62	31.4	28.5
7.63	7.72	28.7	66.8
7.64	7.86	29.2	71
7.76	7.58	26.6	135
7.52	7.71	27.5	133
7.54	7.73	27.7	150
7.54	7.84	29.1	149
7.28	7.87	27.9	161
7.5	8.06	29.2	103
8	8.07	28.6	148
8.28	8.07	35.6	109
8.1	8.08	29.7	124
7.88	8.07	25	182
8.12	7.08	22.7	42
7.85	7.18	22	139.4
6.46	7.34	23.1	109
7.61	6.97	25.8	32
	7.44		
8.68	7.57	32.5	-80.4
	7.72		
	7.87		
	8.03		
	7.79		
	7.9		
	7.88		
	7.91		
	7.94		
	7.99		
	7.99		
6.2	7.99	28.5	160.4
7.69	7.18	24.7	21.1
7.74	7.34	26.3	12.2
7.93	7.22	26.9	9.1
7.75	7.64	25.5	10
7.85	7.23	24.2	11.8
7.68	7.47	24.7	8.5
7.82	7.59	25.4	5.7
7.82	7.69	27.9	12.9
	7.77		
8.93	7.92	29.5	7.5
8.31	7.87	29.1	47.3
8.2	7.96	28.4	9.5
8.29	7.83	26.8	16.7

8.36	7.89	26.6	3.1	
8.7	7.74	26	-18.9	
8.77	7.86	26.6	-20	
7.99	8.1	31.6	-59.4	
7.92	8.05	29	-55.2	
7.57	6.84	26.9	-52.2	
7.44	6.74	28.5	-45.2	
8.13	6.81	25.7	-86.4	
7.75	6.84	24.5	-63.1	
7.87	7.01	24.5	95.9	
7.57	7.12	23.2	99.7	
7.68	7.67	24.5	124.4	
7.78	7.87	24.6	240	
7.57	7.9	28.6	96.7	
7.6	7.92	30.7	155	
7.83	7.92	28.6	242.6	
8.08	8.18	31	82.1	
7.94	8.02	29.8	95	
8.08	7.96	30.7	206	
8	8.08	30.6	102	
7.87	8.14	28	80	
7.91	8.19	28.3	84.5	
7.88	8.19	29.5	166.3	
7.9	8.15	29.4	115.1	
8.1	8.13	31.3	114	
8.08	8.19	31	96.3	
8.1	8.15	32.8	95.2	
8.14	8.36	31.4	68.6	
8.08	8.31	29.2	94.1	
8.06	8.21	29.1	88.3	
8.08	8.19	30.6	61.1	
8.04	8.19	30.3	78.3	
8.12	8.28	32.7	80.5	
8.17	8.26	32.5	89.9	
8.18	8.25	32	54.9	
8.16	8.21	30.6	71	
7.6		26.6	114	0.4
	6.84			
7.72		26.5	121	0.3
	6.9			
7.5		27.4	130.1	0.1
	7.19			
7.6		27	114.3	0.75
	7.12			
7.35		30.3	65.1	0.2
	7.1			
7.61		28.9	80.7	0.3
	7.44			
7.63		31.5	59.5	0.2
	7.74			

7.58		32.5	56	0.2
	7.85			
7.88		35	35.6	0.2
	8.04			
	7.73			
7.7		31.8	56.2	0.4
	7.79			
7.45		29	55	5
	7.61			
7.5		30.8	81	0.15
	7.69			
7.7		33.1	95	0.1
	7.91			
8.5		30.8	133	0.1
	7.91			
7.9		30.9	114	0.1
	8.07			
8.04		35.9	74.7	0.02
	7.85			
7.9		36.3	44.5	0.02
	7.9			
7.72		28.4	77.9	0.02
	7.86			
7.72		27.6	63.6	0.02
	7.84			
7.98		29.5	58.2	0.02
	7.89			
7.92		28.2	71.7	0.01
	7.97			
	7.55			
	7.78			
	7.97			
	8.01			
8.18		33.6	12.8	0.05
	7.92			
7.78		30.8	27.7	0.05
	7.78			
7.72		30.6	62.8	0.02
	7.84			
7.68		28.4	74.2	0.01
	7.92			
7.5		31.2	55.3	0.3
	8.26			
7.37		28.7	282.2	2
	6.75			
7.39		32.4	297.4	0.6
	7.14			
7.7		28.6	265.1	0.2
	7.47			
7.75		29.7	266.7	0.1

7.6			
7.58	31.5	275.4	0.1
7.09			
7.69	30.6	259	0.1
7.16			
7.77	29.3	274.1	0.05
7.22			
7.81	32.9	294.7	0.03
7.31			
7.43	29.4	274.3	0.01
7.42			
7.41	31.5	268.3	0.5
6.81			
7.3	31.1	246.1	0.5
6.82			
7.89	35	262.4	0.1
6.92			
7.44	30.1	286.5	0.1
7.1			
7.7	26.9	246.2	1
6.72			
7.42	31.3	291.4	0.1
6.83			
7.58	28.4	275.6	0.01
7.05			
7.63	29.7	271.8	0.01
7.12			
7.69	30.8	286.7	0.01
7.15			
7.83	30.7	291.4	0.01
7.25			
7.73	30.6	314.4	0.01
7.31			
7.83	30.2	242.3	0.01
7.33			
7.65	29.1	327.1	0.5
6.82			
7.81	33.3	305.4	0.5
7.14			
7.9	31.5	284.7	0.5
7.4			
8	31.4	260.8	0.01
7.56			
8.21	31.8	283.4	0.05
7.47			
8.24	34.2	272.8	0.05
7.55			
7.9	34.1	283.1	0.01
7.79			
8.13	35.1	269.1	0.001

		7.79			
	7.92		29	238.9	0.001
		7.53			
		7.62			
64	7.06	7.09	25.2		
		8.13			
		7.35			
	7.54		31	135.6	0.5
		7.38			
	7.39		29.1	146.1	0.05
		7.39			
	7.73		27.1	204.8	
		7.59			
	7.69		27.5	224.6	0.1
		7.79			
	7.73		27.6	260.7	0.25
		7.56			
	7.75		29.9	238	0.4
		7.54			
	7.62		28.9	237.2	1.1
		7.53			
	7.62		29.9	295.3	0.12
		7.74			
	7.71		33.2	162.5	0.3
		7.89			
	7.91		32.8	210.8	0.02
		7.81			
	7.9		30.9	161	0.01
		8.01			
	7.75		31.1	154.8	0.01
		7.89			
	7.8		33.6	140.3	0.01
		7.95			
		7.9			
		7.27			
		7.78			
		7.12			
	7.43		29.4		0.3
		7.16			
		7.23			
		7.35			
		7			
		7.32			
		7.31			
		7.4			
		7.27			
		7.84			
		7.99			
		8.18			

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Redox Potential (Lab) (mV)	Turbidity (Field) (NTU)	Turbidity (NTU)	Total Dissolved Solids (mg/L)	Suspended Solids (mg/L)	Aluminium (dissolved) (µg/L)	Aluminium (µg/L)
			119	545	1020	15300
			159	10	5	500
			176	2.5	5	90
			180	12	5	100
			56	2.5	20	20
			228	2.5	5	5
			100	7	10	750
			163	5	5	140
			125	42	10	1610
			52	22	70	2190
			87	43	40	4060
			190	2.5	5	20
			178	2.5	5	20
			182	8	5	50
		1.7	253	2.5	5	70
		0.7	238	6	5	20
		0.9	274	2.5	5	20
	92.6				0	0
		100	46	67	290	3400
	96				0	0
		132	91	55	370	3320
	4.3				0	0
		2.9	126	2.5	50	110
	29.6				0	0
		18.7	94	19	190	560
	32				0	0
		38.9	122	9	70	1090
		12.7	125	9	170	700
		2.5	196	7	30	80
	60.06				0	0
		141	96	108	360	3970
		85.2	80	50	5	1610
		5.6	286	5	5	200
		3.8	307	8	5	140
		1.6	329	2.5	5	60
		0.7	351	5	5	40
		0.9	323	8	5	30
			135	62	160	5540
			82	78	100	4330
			141	23	20	1250

86	142	40	3940
70	30	5	1580
135	10	5	280
158	10	5	370
175	6	5	5
216	2.5	5	5
		5	5
209	2.5	5	5
259	2.5	5	5
247	2.5	5	5
114	148	10	4490
		0	0
282	8	5	30
248	2.5	5	60
112	558	230	18300
108	44	210	2750
106	19	310	1730
108	24	30	1570
94	118	20	3480
114	23	10	720
111	20	20	1000
85	140	140	4290
104	109	40	3300
90	52	120	1610
65	10	50	1140
82	8	40	1260
105	5	5	530
103	2.5	5	720
105	2.5	5	590
94	2.5	5	620
114	6	5	240
67		230	7240
59	71	190	2980
74	29	160	1290
116	59	110	4300
146	21	250	2630
160	8	5	1810
194	2.5	5	1390
131	12	220	1020
135	6	5	800
115	6	5	720
120	9	5	730
129	9	5	560
123	7	5	560
126	15	5	530
125	10	5	460
135	6	5	530
114	2.5	10	550
173	2.5	30	80
185	5	5	30

		186	2.5	5	80
		206	2.5	5	40
		184	2.5	5	30
		189	2.5	5	40
		204	5	40	40
		210	2.5	5	20
	0.5	373	2.5	10	20
		363	2.5	5	20
	0.7	392	2.5	30	20
	0.7	382	2.5	10	10
	1	382	2.5	5	20
	4.2	374	2.5	10	120
	1.9	432	2.5	5	30
	1.8	404	2.5	10	30
	7.4	434	18	5	30
	3.1	436	2.5	10	20
	2.4	494	2.5	5	40
500				0	0
	806	48	702	290	19300
122				0	0
	125	106	74	460	3990
13.1				0	0
	9.6	103	8	150	480
6.8				0	0
	4.2	121	2.5	110	320
164				0	0
	170	98	257	350	3960
150				0	0
	190	96	158	310	5250
340.4				0	0
	354	101	334	520	11500
179				0	0
	212	101	114	170	5270
76				0	0
	85.5	115	20	190	2170
275				0	0
	253	112	132	130	7280
26				0	0
	24.8	128	10	70	750
15.7				0	0
	15	144	11	60	470
12.8				0	0
	13.8	156	8	60	400
14.2				0	0
	12.3	152	8	40	420
10.7				0	0
	8.3	156	6	30	310
8.4				0	0
	6.1	154	7	20	300
5.9				0	0

	9	151	2.5	20	250
	30.5	101	30	420	1930
	68.9	110	26	380	1990
	41.3	133	17	320	460
	29.4	127	12	240	1010
24.9				0	0
	28.1	113	6	180	820
22.5				0	0
	26.5	132	9	140	810
17.2				0	0
	21	129	7	130	690
14.3				0	0
	15.3	142	7	120	610
	7.9	163	8	5	220
89.81				0	0
	104	110	32	380	3350
64.7				0	0
	60.6	109	15	240	2190
41.9				0	0
	28.7	126	2.5	130	1040
274.3				0	0
	393	99	279	440	12600
184.4				0	0
	153	64	76	570	3840
69.66				0	0
	79.3	116	16	420	1610
101.7				0	0
	135	118	32	320	3600
55.4				0	0
	64.2	109	14	5	1600
116.8				0	0
	97.8	78	30	290	2440
80.6				0	0
	99.6	99	29	300	2560
50.1				0	0
	53.2	77	11	260	1420
36.3				0	0
	37.7	101	8	250	1110
433.8				0	0
	632	54	552	420	38400
192.38				0	0
	226	95	107	250	6040
138.2				0	0
	149	91	55	10	4150
99.8				0	0
	108	100	33	5	2920
71.8				0	0
	73.9	95	17	5	2250
57.3				0	0
	54.9	90	15	5	1930

	49.75				0	0
		51.5	106	15	5	1430
	44.58				0	0
		43.7	119	11	5	1330
	254.3				0	0
		361	126	252	40	12100
	101.9				0	0
		120	81	38	5	3360
	74.4				0	0
		83.6	101	24	5	2220
	72.4				0	0
		83.7	87	31	5	2800
	56.4				0	0
		61.1	146	25	5	1970
	54.9				0	0
		60.8	121	9	5	1960
	48.2				0	0
		48.7	100	11	5	1680
	44.4				0	0
		45.4	96	11	5	1730
	40				0	0
		45	107	9	5	1570
		110	110	91	9	990
			120		0	0
101.1	255.6	386	168	180	50	29100
		44.8	118	10	5	1770
		0.2	<10	2.5	5	5
	377.8				0	0
		431	160	522	10	29300
	155.4				0	0
		171	108	76	20	7250
	94.5				0	0
		71.9	110	27	10	7850
	123.3				0	0
		160	81	72	5	15300
	270.56				0	0
		184	90	334	10	12800
	74.03				0	0
		54.1	96	32	5	4980
	247.2				0	0
		172	74	300	5	15700
	182.91				0	0
		183	52	140	5	11700
	300.01				0	0
		514	262	400	30	26800
	52.7				0	0
		70.3	80	30	5	1800
	28.7				0	0
		36.5	101	9	5	1200
	10.79				0	0

	14.9	109	6	5	510
7.88				0	0
	10.3	124	2.5	5	450
13.81				0	0
	9.8	120	6	5	340
4.46				0	0
	7	125	2.5	5	250
	19.4	77	20	5	440
	4.6	97	10	5	520
	0.1	<10	2.5	5	5
	420	140	179	30	12500
236.4				0	0
	287	96	175	130	8240
	535	128	336	60	14700
	483	133	268	5	9820
	293	97	262	80	4800
	74.6	104	19	10	1780
	269	140	187	10	8320
	29	136	12	5	1360
	61.5	126	34	5	2020
	30.8	185	12	5	1460
	9.4	223	2.5	5	430
	5.5	260	8	5	400
	4.2	276	6	5	180
	2.4	307	2.5	5	90
	3.1	348	2.5	5	50
	2.4	342	2.5	5	50
	3.1	384	6	5	30
	3.3	373	2.5	5	40
	4.8	359	2.5	5	70
	4	363	2.5	5	50
				180	220
		60	211	520	5690
		212	2.5	5	20
		136	62	520	1060
		230	2.5	50	390
		156	60	190	3980
		94	337	180	8100
		84	89	90	3260
		121	26	20	1570
		57	278	140	8880
		116	25	10	1190
		129	7	5	270
		157	11	5	330
		214	2.5	5	5
		227	2.5	5	5
		217	2.5	5	5
		218	2.5	5	20
		293	2.5	5	5
		126	98	5	3050

		0	0
267	2.5	5	100
291	2.5	5	50
117	492	530	13300
132	61	300	3250
125	21	240	2030
125	16	20	1400
107	73	10	2310
122	28	10	1370
153	11	5	930
81	189	150	3080
105	98	60	2700
80	52	100	2130
64	9	60	1000
77	9	50	1180
91	6	180	470
94	5	10	530
97	2.5	10	480
96	2.5	5	510
108	6	5	390
63	218	290	6920
66	61	160	2420
76	24	100	1160
88	394	270	13600
113	63	110	4230
137	19	30	2370
159	9	20	1780
174	7	5	1350
128	14	250	1000
124	7	5	960
126	7	5	750
126	10	5	630
144	7	5	550
129	2.5	5	350
136	6	5	370
145	2.5	5	240
145	2.5	5	240
76	218	220	14800
88	30	140	1150
121	12	5	540
126	191	110	9640
100	215	220	9590
94	22	90	2360
100	16	40	1390
110	2.5	20	590
130	6	5	5
118	2.5	5	390
164	2.5	30	120
196	2.5	5	30
216	2.5	5	30

		216	2.5	5	100
		221	2.5	5	70
		224	2.5	5	40
		248	2.5	5	30
		259	5	5	20
	310	57	234	640	9360
	289	50	433	300	12100
	485	50	1,030	320	20800
	132	44	187	200	5830
	73.7	58	79	170	2650
	46.3	205	80	20	2290
	31.3	119	61	100	1590
	18.1	118	16	60	680
	6.3	163	8	30	310
	3	178	2.5	20	140
	1.5	192	2.5	10	100
	1.4	218	2.5	5	30
	1.5	230	6	5	20
	2	274	2.5	5	30
	1.2	282	2.5	5	20
	1.4	296	6	5	30
	2.6	316	8	5	110
	1.4	338	12	5	30
	1.8	318	2.5	5	30
	0.9	351	2.5	10	20
	0.4	338	2.5	5	20
		366	2.5	5	70
	0.8	390	2.5	20	40
	1.2	375	8	5	20
	1	402	2.5	10	40
	2.1	400	2.5	10	50
	3.4	392	2.5	5	70
	2.1	466	2.5	5	30
	2.2	410	8	5	40
	2.8	424	8	10	20
	2.4	472	10	5	20
390				0	0
	249	66	410	430	15000
469				0	0
	733	49	593	300	18400
119				0	0
	134	111	67	390	3030
115.38				0	0
	149	111	96	330	4540
132.1				0	0
	91.3	75	160	450	5610
116.1				0	0
	147	98	83	290	4650
25.8				0	0
	25.1	95	11	180	850

13.6				0	0
	10	106	2.5	140	520
7				0	0
	4.6	131	2.5	100	300
	134	105	117	280	3270
72				0	0
	73.5	87	54	290	1840
354				0	0
	382	100	358	160	12600
185				0	0
	199	117	93	190	5120
78				0	0
	86.1	104	21	170	2310
132				0	0
	160	116	89	150	4940
33				0	0
	39.2	123	14	80	1240
16.4				0	0
	15.8	133	13	60	530
15.5				0	0
	13.1	141	9	60	290
13.9				0	0
	12.1	143	6	40	400
11.3				0	0
	11.8	149	5	30	340
8.9				0	0
	9.4	150	9	30	280
8.8				0	0
	3.2	161	2.5	20	200
	42.3	113	29	330	1740
	59.4	98	13	260	1260
	31.9	127	18	280	860
	24.9	128	12	250	810
26.4				0	0
	30.4	122	13	190	880
22.5				0	0
	27.6	123	14	130	740
17.5				0	0
	19.8	132	2.5	140	680
14.3				0	0
	17.2	134	7	110	570
116				0	0
	11.7	191	22	5	400
215.2				0	0
	268	67	206	390	8000
89.5				0	0
	98.1	110	35	390	3300
57.7				0	0
	64.1	138	15	250	2090
26.6				0	0

	34.6	138	8	150	1250
191.4				0	0
	265	82	151	440	7320
113.6				0	0
	134	63	57	550	3060
72.75				0	0
	87.9	134	15	430	1720
148.2				0	0
	214	103	104	320	5430
75.04				0	0
	96.1	113	22	5	2210
99.4				0	0
	128	84	45	330	3110
99.7				0	0
	124	91	47	350	3180
54.3				0	0
	56.7	84	14	260	1620
42.1				0	0
	37	95	12	220	1350
492.8				0	0
	899	16	654	360	41900
178.4				0	0
	193	66	101	250	6210
131.8				0	0
	171	89	75	20	4800
103.8				0	0
	115	96	39	10	3470
78.6				0	0
	84.2	79	20	5	2430
58.14				0	0
	61.2	92	18	5	1810
49.42				0	0
	53	113	17	5	1620
42.43				0	0
	43	127	16	5	1360
268.7				0	0
	359	58	244	40	9180
101.9				0	0
	121	89	51	10	3550
72.9				0	0
	79.6	90	17	5	2380
58.4				0	0
	60	101	17	5	1940
55.8				0	0
	57.8	105	17	5	2020
64.5				0	0
	47.9	108	15	5	1510
38.7				0	0
	44.1	98	11	5	1220
35				0	0

		31.1	123	11	5	1340
	33.3				0	0
		28.8	97	13	5	1200
		66	140	62	2.5	600
			160		0	0
170.3	260	335	212	160	50	19700
		37.8	161	18	5	1230
		499	86	530	30	21700
	166.3				0	0
		89.1	100	99	20	9860
	102				0	0
		73.5	100	45	5	7770
	184.2				0	0
		144	126	220	5	8380
	7,567				0	0
		48.2	90	32	5	7030
	238.6				0	0
		203	96	266	5	15100
	207.19				0	0
		254	72	232	5	15000
	342.35				0	0
		515	130	410	20	32200
	55.3				0	0
		72.2	79	31	5	1730
	33.8				0	0
		40.8	98	12	5	2530
	13.01				0	0
		19	117	10	5	610
	10.02				0	0
		13.5	98	6	5	500
	8.44				0	0
		11.4	118	6	5	450
	6.99				0	0
		8.8	113	2.5	5	310
		21.3	103	16	5	590
		0.3	62	2.5	5	5
		169	170	22	5	5800
		439	132	167	40	12400
	230.2				0	0
		286	88	160	140	8010
		423	96	276	70	12500
		243	109	140	5	7710
		287	121	190	90	6310
		77.7	112	24	10	1820
		244	176	163	30	9180
		93	78	78	30	3700
		50.3	94	25	30	1450
		30.4	146	8	5	1750
		65.8	122	40	5	2090
		29.5	187	12	5	1150

5.5	237	2.5	5	360
7.1	263	6	5	300
5.6	289	9	5	420
2.8	333	2.5	5	100
2.8	357	6	5	60
2.3	346	5	5	60
3.2	381	5	5	40
3.8	372	2.5	5	40
5.2	365	10	5	70
5	354	2.5	5	70

Arsenic (dissolved) (µg/L)	Arsenic (µg/L)	Cadmium (dissolved) (µg/L)	Cadmium (µg/L)	Copper (dissolved) (µg/L)	Copper (µg/L)	Iron (dissolved) (µg/L)	Iron (µg/L)	Lead (dissolved) (µg/L)
0.5	2	0.05	0.1	2	30	0	0	0.5
0.5	0.5	0.05	0.05	2	2	0	0	0.5
0.5	0.5	0.05	0.05	0.5	2	0	0	0.5
0.5	0.5	0.05	0.05	0.5	2	0	0	0.5
0.5	0.5	0.05	0.05	0.5	0.5	0	0	0.5
0.5	0.5	0.05	0.05	0.5	1	0	0	0.5
0.5	0.5	0.05	0.05	2	3	0	0	0.5
0.5	0.5	0.05	0.05	0.5	0.5	0	0	0.5
0.5	1	0.05	0.05	2	4	0	0	0.5
0.5	0.5	0.05	0.05	2	4	0	0	0.5
0.5	0.5	0.05	0.05	1	6	0	0	0.5
0.5	0.5	0.05	0.05	2	1	0	0	0.5
0.5	0.5	0.05	0.05	1	2	0	0	0.5
0.5	0.5	0.05	0.05	1	5	0	0	0.5
0.5	0.5	0.05	0.05	1	0.5	0	0	0.5
0.5	0.5	0.05	0.05	1	1	0	0	0.5
0.5	0.5	0.05	0.05	1	1	0	0	0.5
0	0	0	0	0	0	0	0	0
0.5	0.5	0.05	0.05	3	8	0	0	0.5
0	0	0	0	0	0	0	0	0
0.5	0.5	0.05	0.05	2	8	0	0	0.5
0	0	0	0	0	0	0	0	0
0.5	0.5	0.05	0.05	1	2	0	0	0.5
0	0	0	0	0	0	0	0	0
0.5	0.5	0.05	0.05	2	3	0	0	0.5
0	0	0	0	0	0	0	0	0
0.5	0.5	0.05	0.05	2	3	0	0	0.5
0.5	0.5	0.05	0.05	2	3	0	0	0.5
0.5	0.5	0.05	0.05	2	2	0	0	0.5
0	0	0	0	0	0	0	0	0
0.5	1	0.05	0.05	2	7	0	0	0.5
0.5	0.5	0.05	0.05	2	6	0	0	0.5
0.5	0.5	0.05	0.05	0.5	1	0	0	0.5
0.5	0.5	0.05	0.05	0.5	1	0	0	0.5
0.5	0.5	0.05	0.05	0.5	0.5	0	0	0.5
0.5	0.5	0.05	0.05	1	1	0	0	0.5
0.5	0.5	0.05	0.05	1	1	0	0	0.5
0.5	0.5	0.05	0.05	3	12	0	0	0.5
0.5	0.5	0.05	0.05	2	5	0	0	0.5
0.5	0.5	0.05	0.05	2	4	0	0	0.5

0.5	0.5	0.05	0.05	2	11	0	0	0.5
0.5	0.5	0.05	0.05	2	3	0	0	0.5
0.5	0.5	0.05	0.05	0.5	2	0	0	0.5
0.5	0.5	0.05	0.05	0.5	2	0	0	0.5
0.5	0.5	0.05	0.05	0.5	2	0	0	0.5
0.5	0.5	0.05	0.05	0.5	2	0	0	0.5
0.5	0.5	0.05	0.05	0.5	2	0	0	0.5
0.5	0.5	0.05	0.05	0.5	1	0	0	0.5
0.5	0.5	0.05	0.05	2	2	0	0	0.5
0.5	0.5	0.05	0.05	2	1	0	0	0.5
0.5	0.5	0.05	0.05	2	11	0	0	0.5
0	0	0	0	0	0	0	0	0
0.5	0.5	0.05	0.05	1	2	0	0	0.5
0.5	0.5	0.05	0.05	1	8	0	0	0.5
0.5	1	0.05	0.05	2	59	0	0	0.5
0.5	0.5	0.05	0.05	4	18	0	0	0.5
0.5	0.5	0.05	0.05	5	12	0	0	0.5
0.5	0.5	0.05	0.05	6	10	0	0	0.5
0.5	1	0.05	0.05	4	16	0	0	0.5
0.5	1	0.05	0.05	4	7	0	0	0.5
0.5	1	0.05	0.05	4	8	0	0	0.5
0.5	1	0.05	0.05	2	11	0	0	0.5
0.5	0.5	0.05	0.05	2	9	0	0	0.5
0.5	0.5	0.05	0.05	2	7	0	0	0.5
0.5	0.5	0.05	0.05	2	4	0	0	0.5
0.5	0.5	0.05	0.05	2	5	0	0	0.5
0.5	0.5	0.05	0.05	2	3	0	0	0.5
0.5	0.5	0.05	0.05	2	3	0	0	0.5
0.5	0.5	0.05	0.05	2	3	0	0	0.5
0.5	0.5	0.05	0.05	2	5	0	0	0.5
0.5	0.5	0.05	0.05	2	3	0	0	0.5
0.5	2	0.05	0.6	5	22	0	0	0.5
0.5	0.5	0.05	0.05	5	10	0	0	1
0.5	3	0.05	1.3	4	9	0	0	0.5
0.5	0.5	0.05	0.05	3	10	0	0	0.5
0.5	0.5	0.05	0.05	2	7	0	0	0.5
0.5	0.5	0.05	0.05	2	5	0	0	0.5
0.5	0.5	0.05	0.05	2	4	0	0	0.5
0.5	0.5	0.05	0.05	2	4	0	0	0.5
0.5	0.5	0.05	0.05	1	4	0	0	0.5
0.5	0.5	0.05	0.05	2	4	0	0	0.5
0.5	0.5	0.05	0.05	4	54	0	0	0.5
0.5	0.5	0.05	0.05	1	3	0	0	0.5
0.5	0.5	0.05	0.05	1	3	0	0	0.5
0.5	0.5	0.05	0.05	1	3	0	0	0.5
0.5	0.5	0.05	0.05	1	3	0	0	0.5
0.5	0.5	0.05	0.05	1	3	0	0	0.5
0.5	0.5	0.05	0.05	2	3	0	0	0.5
0.5	0.5	0.05	0.05	2	4	0	0	0.5
0.5	0.5	0.05	0.05	2	3	0	0	0.5

0.5	0.5	0.05	0.05	2	2	0	0	0.5
0.5	0.5	0.05	0.05	2	3	0	0	0.5
0.5	0.5	0.05	0.05	2	2	0	0	0.5
0.5	0.5	0.05	0.05	1	2	0	0	0.5
0.5	0.5	0.05	0.05	2	2	0	0	0.5
0.5	0.5	0.05	0.05	3	2	0	0	3
0.5	0.5	0.05	0.05	2	3	0	0	0.5
0.5	0.5	0.05	0.05	1	20	0	0	0.5
0.5	0.5	0.05	0.05	2	2	0	0	0.5
0.5	0.5	0.05	0.05	3	1	0	0	0.5
0.5	0.5	0.05	0.05	2	1	0	0	0.5
0.5	0.5	0.05	0.05	1	3	0	0	0.5
1	0.5	0.05	0.1	1	2	0	0	0.5
1	0.5	0.05	0.05	1	2	0	0	0.5
0.5	0.5	0.3	0.05	1	2	0	0	0.5
1	0.5	0.05	0.05	2	2	0	0	0.5
1	0.5	0.05	0.8	1	2	0	0	0.5
0	0	0	0	0	0	0	0	0
0.5	2	0.05	0.05	0.5	44	0	0	0.5
0	0	0	0	0	0	0	0	0
0.5	1	0.05	0.05	3	16	0	0	0.5
0	0	0	0	0	0	0	0	0
0.5	0.5	0.05	0.05	2	3	0	0	0.5
0	0	0	0	0	0	0	0	0
0.5	0.5	0.05	0.05	2	7	0	0	0.5
0	0	0	0	0	0	0	0	0
0.5	1	0.05	0.05	6	13	0	0	5
0	0	0	0	0	0	0	0	0
0.5	0.5	0.05	0.05	3	13	0	0	0.5
0	0	0	0	0	0	0	0	0
0.5	1	0.05	0.05	2	24	0	0	0.5
0	0	0	0	0	0	0	0	0
0.5	0.5	0.05	0.05	2	13	0	0	0.5
0	0	0	0	0	0	0	0	0
0.5	0.5	0.05	0.05	2	5	0	0	0.5
0	0	0	0	0	0	0	0	0
0.5	0.5	0.05	0.05	3	26	0	0	0.5
0	0	0	0	0	0	0	0	0
0.5	0.5	0.05	0.05	2	3	0	0	0.5
0	0	0	0	0	0	0	0	0
0.5	1	0.05	0.05	2	3	0	0	0.5
0	0	0	0	0	0	0	0	0
0.5	0.5	0.05	0.05	2	3	0	0	0.5
0	0	0	0	0	0	0	0	0
0.5	0.5	0.05	0.05	2	3	0	0	0.5
0	0	0	0	0	0	0	0	0
0.5	0.5	0.05	0.05	2	3	0	0	0.5
0	0	0	0	0	0	0	0	0
0.5	0.5	0.05	0.05	2	3	0	0	0.5
0	0	0	0	0	0	0	0	0

0.5	0.5	0.05	0.05	2	3	0	0	0.5
0.5	0.5	0.05	0.05	2	5	0	0	0.5
0.5	0.5	0.05	0.05	2	6	0	0	0.5
0.5	0.5	0.05	0.05	2	3	0	0	0.5
0.5	0.5	0.05	0.05	2	3	0	0	0.5
0	0	0	0	0	0	0	0	0
0.5	0.5	0.05	0.05	2	3	0	0	0.5
0	0	0	0	0	0	0	0	0
0.5	0.5	0.05	0.05	2	3	0	0	0.5
0	0	0	0	0	0	0	0	0
0.5	0.5	0.05	0.05	2	3	0	0	0.5
0	0	0	0	0	0	0	0	0
0.5	0.5	0.05	0.05	2	3	0	0	0.5
0.5	0.5	0.05	0.05	2	3	25	340	0.5
0	0	0	0	0	0	0	0	0
0.5	0.5	0.05	0.05	3	8	0	0	0.5
0	0	0	0	0	0	0	0	0
0.5	0.5	0.05	0.05	3	6	0	0	0.5
0	0	0	0	0	0	0	0	0
0.5	0.5	0.05	0.05	3	6	0	0	0.5
0	0	0	0	0	0	0	0	0
0.5	2	0.05	0.05	5	62	0	0	0.5
0	0	0	0	0	0	0	0	0
0.5	1	0.05	0.05	2	9	0	0	0.5
0	0	0	0	0	0	0	0	0
0.5	1	0.05	0.05	2	5	0	0	0.5
0	0	0	0	0	0	0	0	0
0.5	1	0.05	0.05	2	8	0	0	0.5
0	0	0	0	0	0	0	0	0
0.5	0.5	0.05	0.05	1	5	0	0	0.5
0	0	0	0	0	0	0	0	0
0.5	1	0.05	0.05	3	8	0	0	0.5
0	0	0	0	0	0	0	0	0
0.5	1	0.05	0.05	3	9	0	0	0.5
0	0	0	0	0	0	0	0	0
0.5	0.5	0.05	0.05	3	7	0	0	0.5
0	0	0	0	0	0	0	0	0
0.5	0.5	0.05	0.05	3	6	0	0	0.5
0	0	0	0	0	0	0	0	0
0.5	3	0.05	0.2	4	109	0	0	0.5
0	0	0	0	0	0	0	0	0
0.5	1	0.05	0.05	3	12	0	0	0.5
0	0	0	0	0	0	0	0	0
0.5	2	0.05	0.05	2	8	0	0	0.5
0	0	0	0	0	0	0	0	0
0.5	1	0.05	0.05	1	7	0	0	0.5
0	0	0	0	0	0	0	0	0
0.5	0.5	0.05	0.05	1	5	0	0	0.5
0	0	0	0	0	0	0	0	0
0.5	0.5	0.05	0.05	1	4	0	0	0.5

0	0	0	0	0	0	0	0	0
0.5	0.5	0.05	0.05	1	4	0	0	0.5
0	0	0	0	0	0	0	0	0
0.5	0.5	0.05	0.05	1	4	0	0	0.5
0	0	0	0	0	0	0	0	0
0.5	0.5	0.05	0.05	2	25	0	0	0.5
0	0	0	0	0	0	0	0	0
0.5	0.5	0.05	0.05	1	7	0	0	0.5
0	0	0	0	0	0	0	0	0
0.5	2	0.05	0.05	1	6	0	0	0.5
0	0	0	0	0	0	0	0	0
0.5	0.5	0.05	0.05	1	6	0	0	0.5
0	0	0	0	0	0	0	0	0
0.5	0.5	0.05	0.05	1	4	0	0	0.5
0	0	0	0	0	0	0	0	0
0.5	0.5	0.05	0.05	1	4	0	0	0.5
0	0	0	0	0	0	0	0	0
0.5	0.5	0.05	0.05	2	4	0	0	0.5
0	0	0	0	0	0	0	0	0
0.5	0.5	0.05	0.05	1	5	0	0	0.5
0	0	0	0	0	0	0	0	0
0.5	0.5	0.05	0.05	1	5	0	0	0.5
#VALUE!	0.82	0.05	0.05	3.5	7.9	0	0	0.05
0	0	0	0	0	0	0	0	0
0.5	5	0.05	0.05	3	32	0	0	0.5
0.5	1	0.05	0.05	2	6	0	0	0.5
0.5	0.5	0.05	0.05	0.5	0.5	0	0	0.5
0	0	0	0	0	0	0	0	0
0.5	3	0.05	0.3	2	119	0	0	0.5
0	0	0	0	0	0	0	0	0
0.5	2	0.05	0.05	2	12	0	0	0.5
0	0	0	0	0	0	0	0	0
0.5	2	0.05	0.05	2	10	0	0	0.5
0	0	0	0	0	0	0	0	0
0.5	2	0.05	0.05	0.5	15	0	0	0.5
0	0	0	0	0	0	0	0	0
0.5	2	0.05	0.05	2	40	0	0	0.5
0	0	0	0	0	0	0	0	0
0.5	2	0.05	0.05	2	10	0	0	0.5
0	0	0	0	0	0	0	0	0
0.5	2	0.05	0.05	1	36	0	0	0.5
0	0	0	0	0	0	0	0	0
0.5	2	0.05	0.05	0.5	25	0	0	0.5
0	0	0	0	0	0	0	0	0
0.5	2	0.05	0.05	1	34	0	0	0.5
0	0	0	0	0	0	0	0	0
0.5	0.5	0.05	0.05	1	6	0	0	0.5
0	0	0	0	0	0	0	0	0
0.5	0.5	0.05	0.05	2	4	0	0	0.5
0	0	0	0	0	0	0	0	0

0.5	0.5	0.05	0.05	1	2	0	0	0.5
0	0	0	0	0	0	0	0	0
0.5	0.5	0.05	0.05	1	2	0	0	0.5
0	0	0	0	0	0	0	0	0
0.5	0.5	0.05	0.05	1	6	0	0	0.5
0	0	0	0	0	0	0	0	0
0.5	0.5	0.05	0.05	2	1	0	0	0.5
0.5	0.5	0.05	0.05	2	2	0	0	0.5
0.5	0.5	0.05	0.05	2	3	0	0	0.5
0.5	0.5	0.05	0.05	0.5	0.5	0	0	0.5
0.5	2	0.05	0.05	2	29	0	0	0.5
0	0	0	0	0	0	0	0	0
0.5	1	0.05	0.05	2	18	0	0	0.5
0.5	2	0.05	0.05	2	37	0	0	0.5
0.5	1	0.05	0.05	2	28	0	0	0.5
0.5	1	0.05	0.05	2	17	0	0	0.5
0.5	0.5	0.05	0.05	2	6	0	0	0.5
0.5	0.5	0.05	0.05	2	18	0	0	0.5
0.5	0.5	0.05	0.05	0.5	4	0	0	0.5
0.5	0.5	0.05	0.05	0.5	7	0	0	0.5
0.5	0.5	0.05	0.05	1	4	0	0	0.5
0.5	0.5	0.05	0.05	1	2	0	0	0.5
0.5	0.5	0.05	0.05	0.5	2	0	0	0.5
0.5	0.5	0.05	0.05	1	2	0	0	0.5
0.5	0.5	0.05	0.2	1	0.5	0	0	0.5
0.5	0.5	0.05	0.05	1	2	0	0	0.5
0.5	0.5	0.05	0.05	1	1	0	0	0.5
0.5	0.5	0.05	0.05	1	1	0	0	0.5
0.5	0.5	0.05	0.05	1	2	0	0	0.5
0.5	0.5	0.05	0.05	1	0.5	0	0	0.5
0.5	0.5	0.05	0.05	1	1	0	0	0.5
0.5	0.5	0.05	0.05	0.5	0.5	0	0	0.5
0.5	0.5	0.05	0.05	2	15	0	0	0.5
0.5	0.5	0.05	0.05	2	2	0	0	0.5
0.5	0.5	0.05	0.05	4	8	0	0	0.5
1	1	0.05	0.05	2	16	0	0	0.5
0.5	0.5	0.05	0.05	2	10	0	0	0.5
0.5	0.5	0.05	0.05	2	13	0	0	0.5
0.5	0.5	0.05	0.05	2	7	0	0	0.5
0.5	0.5	0.05	0.05	2	4	0	0	0.5
0.5	1	0.05	0.05	2	20	0	0	0.5
0.5	0.5	0.05	0.05	2	4	0	0	0.5
0.5	0.5	0.05	0.05	0.5	2	0	0	0.5
0.5	0.5	0.05	0.05	0.5	2	0	0	0.5
0.5	0.5	0.05	0.05	0.5	4	0	0	0.5
0.5	0.5	0.05	0.05	0.5	2	0	0	0.5
0.5	0.5	0.05	0.05	0.5	2	0	0	0.5
0.5	0.5	0.05	0.05	2	1	0	0	0.5
0.5	0.5	0.05	0.05	2	1	0	0	0.5
0.5	0.5	0.05	0.05	2	9	0	0	0.5

0	0	0	0	0	0	0	0	0
0.5	0.5	0.05	0.05	1	3	0	0	0.5
0.5	0.5	0.05	0.05	1	0.5	0	0	0.5
0.5	1	0.05	0.05	3	53	0	0	0.5
0.5	0.5	0.05	0.05	4	19	0	0	0.5
0.5	0.5	0.05	0.05	4	13	0	0	0.5
0.5	0.5	0.05	0.05	5	9	0	0	0.5
0.5	1	0.05	0.05	4	12	0	0	0.5
0.5	1	0.05	0.05	4	9	0	0	0.5
0.5	1	0.05	0.05	3	6	0	0	0.5
0.5	1	0.05	0.05	2	10	0	0	0.5
0.5	0.5	0.05	0.05	2	8	0	0	0.5
0.5	1	0.05	0.05	2	6	0	0	0.5
0.5	0.5	0.05	0.05	2	4	0	0	0.5
0.5	0.5	0.05	0.3	2	16	0	0	0.5
0.5	0.5	0.05	0.05	2	9	0	0	0.5
0.5	1	0.05	0.05	2	3	0	0	0.5
0.5	0.5	0.05	0.05	2	3	0	0	0.5
0.5	0.5	0.05	0.05	2	3	0	0	0.5
0.5	0.5	0.05	0.05	2	3	0	0	0.5
0.5	2	0.05	0.4	5	25	0	0	0.5
0.5	0.5	0.05	0.05	5	10	0	0	0.5
0.5	2	0.05	0.4	4	8	0	0	0.5
0.5	2	0.05	0.05	4	35	0	0	5
0.5	0.5	0.05	0.05	2	10	0	0	0.5
0.5	0.5	0.05	0.05	2	6	0	0	0.5
0.5	0.5	0.05	0.05	2	6	0	0	0.5
0.5	0.5	0.05	0.05	2	4	0	0	0.5
0.5	0.5	0.05	0.05	2	4	0	0	0.5
0.5	0.5	0.05	0.05	2	4	0	0	0.5
0.5	0.5	0.05	0.05	2	3	0	0	0.5
0.5	0.5	0.05	0.05	1	3	0	0	0.5
0.5	0.5	0.05	0.05	2	3	0	0	0.5
0.5	0.5	0.05	0.05	2	2	0	0	0.5
0.5	0.5	0.05	0.05	2	3	0	0	0.5
0.5	0.5	0.05	0.05	2	2	0	0	0.5
0.5	0.5	0.05	0.05	2	2	0	0	0.5
0.5	2	0.05	0.05	2	29	0	0	0.5
0.5	0.5	0.05	0.05	5	9	0	0	0.5
0.5	0.5	0.05	0.05	2	4	0	0	0.5
0.5	1	0.05	0.05	3	37	0	0	0.5
0.5	1	0.05	0.05	2	19	0	0	0.5
0.5	0.5	0.05	0.5	3	7	0	0	0.5
0.5	0.5	0.05	0.05	2	4	0	0	0.5
0.5	0.5	0.05	0.05	2	4	0	0	0.5
0.5	0.5	0.05	0.05	2	3	0	0	0.5
0.5	1	0.05	0.05	2	3	0	0	0.5
0.5	0.5	0.05	0.05	2	3	0	0	0.5
0.5	0.5	0.05	0.05	2	3	0	0	0.5
0.5	0.5	0.05	0.05	2	2	0	0	0.5

0.5	0.5	0.05	0.05	2	4	0	0	0.5
0.5	1	0.05	0.05	3	2	0	0	0.5
0.5	0.5	0.05	0.05	1	1	0	0	0.5
0.5	0.5	0.05	0.05	2	2	0	0	0.5
0.5	0.5	0.05	0.05	2	2	0	0	0.5
0.5	1	0.05	0.05	4	27	0	0	0.5
0.5	1	0.05	0.05	3	37	0	0	0.5
0.5	2	0.05	0.1	2	61	0	0	0.5
0.5	0.5	0.05	0.05	2	16	0	0	0.5
0.5	0.5	0.05	0.05	2	9	0	0	0.5
1	1	0.05	0.05	10	10	0	0	1
1	0.5	0.05	0.05	3	8	0	0	0.5
0.5	0.5	0.05	0.05	2	4	0	0	0.5
0.5	0.5	0.05	0.05	3	3	0	0	0.5
0.5	0.5	0.05	0.05	2	2	0	0	0.5
0.5	0.5	0.05	0.05	2	3	0	0	0.5
0.5	0.5	0.05	0.05	2	2	0	0	0.5
0.5	0.5	0.05	0.05	2	2	0	0	0.5
0.5	0.5	0.05	0.05	2	3	0	0	0.5
0.5	0.5	0.05	0.05	2	2	0	0	0.5
0.5	0.5	0.05	0.05	2	2	0	0	0.5
0.5	0.5	0.05	0.05	2	3	0	0	0.5
0.5	0.5	0.05	0.05	2	2	0	0	0.5
0.5	0.5	0.05	0.05	1	2	0	0	0.5
0.5	0.5	0.05	0.05	2	2	0	0	0.5
0.5	0.5	0.05	0.05	2	2	0	0	0.5
0.5	0.5	0.05	0.05	1	70	0	0	0.5
0.5	0.5	0.05	0.05	3	2	0	0	0.5
0.5	0.5	0.05	0.05	2	2	0	0	0.5
0.5	0.5	0.05	0.05	2	2	0	0	0.5
0.5	0.5	0.05	0.05	2	2	0	0	0.5
1	0.5	0.05	0.05	2	2	0	0	0.5
1	0.5	0.05	0.05	2	2	0	0	1
1	0.5	0.05	0.05	2	2	0	0	0.5
1	0.5	0.05	0.05	2	2	0	0	0.5
1	0.5	0.05	0.05	2	1	0	0	0.5
0	0	0	0	0	0	0	0	0
0.5	2	0.05	0.05	2	33	0	0	0.5
0	0	0	0	0	0	0	0	0
0.5	2	0.05	0.05	1	37	0	0	0.5
0	0	0	0	0	0	0	0	0
0.5	1	0.05	0.05	4	10	0	0	0.5
0	0	0	0	0	0	0	0	0
0.5	0.5	0.05	0.05	2	13	0	0	0.5
0	0	0	0	0	0	0	0	0
0.5	1	0.05	0.05	5	25	0	0	0.5
0	0	0	0	0	0	0	0	0
0.5	0.5	0.05	0.05	2	8	0	0	0.5
0	0	0	0	0	0	0	0	0
0.5	0.5	0.05	0.05	2	3	0	0	0.5

0	0	0	0	0	0	0	0	0
0.5	0.5	0.05	0.05	2	3	0	0	0.5
0	0	0	0	0	0	0	0	0
0.5	0.5	0.05	0.05	2	3	0	0	3
0.5	1	0.05	0.05	2	10	0	0	0.5
0	0	0	0	0	0	0	0	0
0.5	0.5	0.05	0.05	2	7	0	0	0.5
0	0	0	0	0	0	0	0	0
0.5	1	0.05	0.05	2	25	0	0	0.5
0	0	0	0	0	0	0	0	0
0.5	0.5	0.05	0.05	2	12	0	0	0.5
0	0	0	0	0	0	0	0	0
0.5	0.5	0.05	0.05	2	7	0	0	0.5
0	0	0	0	0	0	0	0	0
0.5	0.5	0.05	0.05	3	17	0	0	0.5
0	0	0	0	0	0	0	0	0
0.5	0.5	0.05	0.05	2	5	0	0	0.5
0	0	0	0	0	0	0	0	0
0.5	0.5	0.05	0.05	2	3	0	0	0.5
0	0	0	0	0	0	0	0	0
0.5	0.5	0.05	0.05	2	3	0	0	0.5
0	0	0	0	0	0	0	0	0
0.5	0.5	0.05	0.05	2	3	0	0	0.5
0	0	0	0	0	0	0	0	0
0.5	0.5	0.05	0.05	2	3	0	0	0.5
0	0	0	0	0	0	0	0	0
0.5	0.5	0.05	0.05	2	3	0	0	0.5
0	0	0	0	0	0	0	0	0
0.5	0.5	0.05	0.05	2	2	0	0	0.5
0.5	0.5	0.05	0.05	2	5	0	0	0.5
0.5	0.5	0.05	0.05	2	4	0	0	0.5
0.5	0.5	0.05	0.05	2	4	0	0	0.5
0.5	0.5	0.05	0.05	2	4	0	0	0.5
0	0	0	0	0	0	0	0	0
0.5	0.5	0.05	0.05	2	3	0	0	0.5
0	0	0	0	0	0	0	0	0
0.5	0.5	0.05	0.05	2	3	0	0	0.5
0	0	0	0	0	0	0	0	0
0.5	0.5	0.05	0.05	2	3	0	0	0.5
0	0	0	0	0	0	0	0	0
0.5	0.5	0.05	0.05	2	3	0	0	0.5
0	0	0	0	0	0	0	0	0
0.5	0.5	0.05	0.05	2	4	25	800	0.5
0	0	0	0	0	0	0	0	0
0.5	0.5	0.05	0.05	3	19	0	0	0.5
0	0	0	0	0	0	0	0	0
0.5	0.5	0.05	0.05	3	7	0	0	0.5
0	0	0	0	0	0	0	0	0
0.5	0.5	0.05	0.05	3	6	0	0	0.5
0	0	0	0	0	0	0	0	0

0.5	0.5	0.05	0.05	3	5	0	0	0.5
0	0	0	0	0	0	0	0	0
0.5	1	0.05	0.05	6	32	0	0	0.5
0	0	0	0	0	0	0	0	0
0.5	1	0.05	0.05	2	7	0	0	0.5
0	0	0	0	0	0	0	0	0
0.5	1	0.05	0.05	3	6	0	0	0.5
0	0	0	0	0	0	0	0	0
0.5	1	0.05	0.05	2	10	0	0	0.5
0	0	0	0	0	0	0	0	0
0.5	0.5	0.05	0.05	1	6	0	0	0.5
0	0	0	0	0	0	0	0	0
0.5	1	0.05	0.05	3	10	0	0	0.5
0	0	0	0	0	0	0	0	0
0.5	2	0.05	0.05	3	10	0	0	0.5
0	0	0	0	0	0	0	0	0
0.5	1	0.05	0.05	3	6	0	0	0.5
0	0	0	0	0	0	0	0	0
0.5	1	0.05	0.05	3	6	0	0	0.5
0	0	0	0	0	0	0	0	0
0.5	4	0.05	0.7	4	121	0	0	0.5
0	0	0	0	0	0	0	0	0
0.5	1	0.05	0.05	3	13	0	0	0.5
0	0	0	0	0	0	0	0	0
0.5	2	0.05	0.05	2	10	0	0	0.5
0	0	0	0	0	0	0	0	0
0.5	1	0.05	0.05	1	7	0	0	0.5
0	0	0	0	0	0	0	0	0
0.5	0.5	0.05	0.05	1	5	0	0	0.5
0	0	0	0	0	0	0	0	0
0.5	0.5	0.05	0.05	1	4	0	0	0.5
0	0	0	0	0	0	0	0	0
0.5	0.5	0.05	0.05	1	5	0	0	0.5
0	0	0	0	0	0	0	0	0
0.5	0.5	0.1	0.05	1	4	0	0	0.5
0	0	0	0	0	0	0	0	0
0.5	0.5	0.05	0.05	1	20	0	0	0.5
0	0	0	0	0	0	0	0	0
0.5	0.5	0.05	0.05	1	7	0	0	0.5
0	0	0	0	0	0	0	0	0
0.5	1	0.05	0.05	1	6	0	0	0.5
0	0	0	0	0	0	0	0	0
0.5	0.5	0.05	0.05	1	5	0	0	0.5
0	0	0	0	0	0	0	0	0
0.5	0.5	0.05	0.05	1	4	0	0	0.5
0	0	0	0	0	0	0	0	0
0.5	0.5	0.05	0.05	1	4	0	0	0.5
0	0	0	0	0	0	0	0	0
0.5	0.5	0.05	0.05	2	3	0	0	0.5
0	0	0	0	0	0	0	0	0

1	0.5	0.05	0.05	1	4	0	0	0.5
0	0	0	0	0	0	0	0	0
0.5	0.5	0.05	0.05	1	4	0	0	0.5
0.61	0.9	0.05	0.05	2	4.9	0	0	0.05
0	0	0	0	0	0	0	0	0
0.5	3	0.05	0.05	2	24	0	0	0.5
0.5	1	0.05	0.05	4	8	0	0	0.5
0.5	3	0.05	0.1	2	71	0	0	0.5
0	0	0	0	0	0	0	0	0
0.5	2	0.05	0.05	2	14	0	0	0.5
0	0	0	0	0	0	0	0	0
0.5	2	0.05	0.05	2	10	0	0	0.5
0	0	0	0	0	0	0	0	0
0.5	2	0.05	0.05	2	24	0	0	0.5
0	0	0	0	0	0	0	0	0
0.5	2	0.05	0.05	2	10	0	0	0.5
0	0	0	0	0	0	0	0	0
0.5	2	0.05	0.05	1	30	0	0	0.5
0	0	0	0	0	0	0	0	0
0.5	2	0.05	0.05	0.5	24	0	0	0.5
0	0	0	0	0	0	0	0	0
0.5	3	0.05	0.05	1	38	0	0	0.5
0	0	0	0	0	0	0	0	0
0.5	0.5	0.05	0.05	1	6	0	0	0.5
0	0	0	0	0	0	0	0	0
0.5	0.5	0.05	0.05	1	4	0	0	0.5
0	0	0	0	0	0	0	0	0
0.5	0.5	0.05	0.05	1	2	0	0	0.5
0	0	0	0	0	0	0	0	0
0.5	0.5	0.05	0.05	1	2	0	0	0.5
0	0	0	0	0	0	0	0	0
0.5	0.5	0.05	0.05	1	2	0	0	0.5
0	0	0	0	0	0	0	0	0
0.5	0.5	0.05	0.05	1	1	0	0	0.5
0.5	0.5	0.05	0.05	2	4	0	0	0.5
0.5	0.5	0.05	0.05	3	4	0	0	0.5
0.5	0.5	0.05	0.05	4	18	0	0	0.5
0.5	2	0.05	0.05	2	32	0	0	0.5
0	0	0	0	0	0	0	0	0
0.5	1	0.05	0.05	2	17	0	0	0.5
0.5	2	0.05	0.05	2	34	0	0	0.5
0.5	1	0.05	0.05	2	25	0	0	0.5
0.5	1	0.05	0.05	2	18	0	0	0.5
0.5	0.5	0.05	0.05	2	8	0	0	0.5
0.5	1	0.05	0.05	2	21	0	0	0.5
0.5	0.5	0.05	0.05	0.5	11	0	0	0.5
0.5	0.5	0.05	0.05	0.5	5	0	0	0.5
0.5	0.5	0.05	0.05	0.5	5	0	0	0.5
0.5	0.5	0.05	0.05	0.5	6	0	0	0.5
0.5	0.5	0.05	0.05	1	5	0	0	0.5

0.5	0.5	0.05	0.05	1	2	0	0	0.5
0.5	0.5	0.05	0.05	2	0.5	0	0	0.5
0.5	0.5	0.05	0.05	1	3	0	0	0.5
0.5	0.5	0.05	0.05	1	0.5	0	0	0.5
0.5	0.5	0.05	0.05	1	1	0	0	0.5
0.5	0.5	0.05	0.05	1	1	0	0	0.5
0.5	0.5	0.05	0.05	1	2	0	0	0.5
0.5	0.5	0.1	0.05	2	1	0	0	0.5
0.5	0.5	0.05	0.05	1	1	0	0	0.5
0.5	0.5	0.05	0.05	1	0.5	0	0	0.5

Lead (µg/L)	Manganese (dissolved) (µg/L)	Manganese (µg/L)	Nickel (dissolved) (µg/L)	Nickel (µg/L)	Zinc (dissolved) (µg/L)	Zinc (µg/L)
12	13	990	1	18	2.5	38
0.5	17	43	0.5	0.5	2.5	2.5
0.5	28	42	0.5	0.5	2.5	2.5
0.5	35	59	0.5	0.5	2.5	6
0.5	2	3	0.5	0.5	2.5	2.5
0.5	30	31	0.5	0.5	2.5	2.5
0.5	9	54	0.5	1	2.5	2.5
0.5	9	63	0.5	0.5	2.5	2.5
0.5	7	79	0.5	1	2.5	6
1	12	78	0.5	2	2.5	19
2	23	147	0.5	3	2.5	11
0.5	5	21	0.5	0.5	2.5	20
0.5	10	30	0.5	1	2.5	11
0.5	9	46	0.5	0.5	2.5	12
0.5	108	120	0.5	0.5	2.5	2.5
0.5	110	116	0.5	0.5	2.5	2.5
0.5	31	48	0.5	0.5	2.5	2.5
0	0	0	0	0	0	0
1	10	80	0.5	3	8	2.5
0	0	0	0	0	0	0
2	12	82	0.5	3	2.5	2.5
0	0	0	0	0	0	0
0.5	28	58	0.5	0.5	2.5	2.5
0	0	0	0	0	0	0
0.5	7	52	0.5	1	2.5	30
0	0	0	0	0	0	0
0.5	25	68	0.5	2	2.5	2.5
0.5	17	42	0.5	0.5	2.5	2.5
0.5	28	48	0.5	13	2.5	2.5
0	0	0	0	0	0	0
2	30	226	0.5	4	2.5	7
2	0.5	105	0.5	2	2.5	2.5
0.5	8	43	0.5	0.5	2.5	2.5
0.5	0.5	39	0.5	0.5	2.5	2.5
0.5	0.5	40	0.5	0.5	2.5	10
0.5	0.5	21	0.5	0.5	2.5	2.5
0.5	0.5	29	0.5	0.5	2.5	2.5
2	6	130	0.5	5	2.5	7
2	6	124	0.5	2	2.5	2.5
0.5	13	75	0.5	1	2.5	2.5

2	5	170	0.5	4	2.5	2.5
0.5	11	69	0.5	0.5	2.5	2.5
0.5	34	68	0.5	0.5	2.5	2.5
0.5	53	64	0.5	0.5	2.5	2.5
0.5	43	46	0.5	0.5	2.5	2.5
0.5	22	21	0.5	0.5	2.5	2.5
0.5	46	44	0.5	0.5	2.5	2.5
0.5	31	31	0.5	0.5	2.5	2.5
0.5	53	31	0.5	0.5	2.5	2.5
0.5	43	12	0.5	0.5	2.5	2.5
2	0.5	161	0.5	4	2.5	7
0	0	0	0	0	0	0
0.5	16	140	0.5	0.5	2.5	2.5
0.5	11	65	0.5	0.5	2.5	2.5
7	2	777	0.5	20	2.5	24
1	3	134	0.5	4	2.5	5
0.5	3	146	1	3	2.5	2.5
0.5	0.5	76	0.5	0.5	102	6
1	5	156	0.5	3	2.5	19
0.5	19	63	0.5	0.5	2.5	11
0.5	1	53	0.5	0.5	2.5	2.5
3	4	350	0.5	2	2.5	8
2	1	160	0.5	2	2.5	8
0.5	2	101	0.5	2	2.5	6
0.5	15	65	0.5	1	2.5	2.5
1	17	89	0.5	1	2.5	2.5
0.5	0.5	110	0.5	0.5	2.5	2.5
0.5	0.5	116	0.5	1	2.5	2.5
0.5	0.5	110	0.5	1	2.5	2.5
0.5	0.5	109	0.5	0.5	2.5	2.5
0.5	0.5	144	0.5	0.5	2.5	2.5
7	5	388	0.5	9	2.5	39
3	4	171	0.5	3	2.5	10
4	16	76	0.5	4	2.5	7
2	1	107	0.5	3	2.5	2.5
1	1	76	0.5	1	2.5	6
0.5	3	75	0.5	2	2.5	2.5
0.5	5	76	0.5	0.5	10	2.5
0.5	20	101	0.5	0.5	2.5	2.5
0.5	1	133	0.5	1	2.5	2.5
0.5	18	119	0.5	1	2.5	2.5
2	8	89	0.5	1	2.5	35
0.5	7	87	0.5	1	2.5	2.5
0.5	10	81	0.5	0.5	2.5	2.5
0.5	3	77	0.5	1	2.5	6
0.5	31	117	0.5	1	2.5	2.5
0.5	3	77	0.5	1	2.5	6
1	23	45	0.5	0.5	2.5	7
0.5	36	78	0.5	0.5	2.5	13
0.5	26	104	0.5	0.5	2.5	9

0.5	26	252	0.5	0.5	2.5	15
0.5	16	168	0.5	0.5	2.5	20
0.5	6	133	0.5	2	2.5	2.5
0.5	6	133	0.5	1	2.5	2.5
0.5	122	103	0.5	0.5	2.5	2.5
0.5	5	66	0.5	0.5	2.5	2.5
0.5	56	97	0.5	0.5	2.5	2.5
0.5	61	0.05	0.5	0.5	2.5	2.5
0.5	78	110	0.5	0.5	2.5	2.5
0.5	79	119	0.5	0.5	2.5	2.5
0.5	78	117	0.5	0.5	2.5	2.5
0.5	73	143	0.5	0.5	2.5	8
0.5	104	170	0.5	0.5	2.5	2.5
0.5	52	93	0.5	0.5	2.5	2.5
0.5	56	107	0.5	0.5	2.5	2.5
0.5	53	92	0.5	0.5	2.5	2.5
0.5	76	207	0.5	1	2.5	37
0	0	0	0	0	0	0
11	6	632	0.5	16	2.5	25
0	0	0	0	0	0	0
1	8	127	0.5	3	5	2.5
0	0	0	0	0	0	0
0.5	30	47	0.5	0.5	2.5	2.5
0	0	0	0	0	0	0
0.5	34	46	0.5	2	2.5	207
0	0	0	0	0	0	0
6	18	183	1	4	31	14
0	0	0	0	0	0	0
3	6	208	0.5	6	5	7
0	0	0	0	0	0	0
7	4	345	0.5	11	2.5	18
0	0	0	0	0	0	0
4	7	135	0.5	4	2.5	15
0	0	0	0	0	0	0
1	12	71	0.5	2	2.5	2.5
0	0	0	0	0	0	0
3	4	232	0.5	11	2.5	16
0	0	0	0	0	0	0
0.5	14	48	0.5	1	2.5	2.5
0	0	0	0	0	0	0
0.5	21	53	0.5	0.5	2.5	2.5
0	0	0	0	0	0	0
0.5	11	54	0.5	0.5	2.5	2.5
0	0	0	0	0	0	0
0.5	3	53	0.5	0.5	2.5	2.5
0	0	0	0	0	0	0
0.5	2	54	0.5	0.5	2.5	2.5
0	0	0	0	0	0	0
0.5	2	53	0.5	0.5	2.5	2.5
0	0	0	0	0	0	0

0.5	46	128	0.5	0.5	2.5	2.5
0.5	5	61	0.5	2	2.5	2.5
0.5	9	83	0.5	2	2.5	2.5
0.5	10	30	0.5	0.5	2.5	2.5
0.5	11	49	0.5	0.5	2.5	2.5
0	0	0	0	0	0	0
0.5	9	51	19	0.5	2.5	2.5
0	0	0	0	0	0	0
0.5	10	61	0.5	1	2.5	2.5
0	0	0	0	0	0	0
0.5	5	51	0.5	0.5	2.5	2.5
0	0	0	0	0	0	0
0.5	4	48	0.5	0.5	2.5	2.5
0.5	0.5	91	0.5	0.5	2.5	2.5
0	0	0	0	0	0	0
1	14	114	0.5	3	2.5	2.5
0	0	0	0	0	0	0
0.5	8	80	0.5	2	2.5	2.5
0	0	0	0	0	0	0
0.5	20	64	0.5	1	2.5	2.5
0	0	0	0	0	0	0
5	7	496	0.5	13	2.5	23
0	0	0	0	0	0	0
1	7	157	0.5	9	2.5	2.5
0	0	0	0	0	0	0
0.5	7	70	0.5	2	2.5	2.5
0	0	0	0	0	0	0
2	17	160	0.5	3	2.5	5
0	0	0	0	0	0	0
1	0.5	95	0.5	2	2.5	2.5
0	0	0	0	0	0	0
2	6	89	0.5	2	2.5	15
0	0	0	0	0	0	0
3	5	88	0.5	2	2.5	13
0	0	0	0	0	0	0
2	10	96	0.5	2	2.5	11
0	0	0	0	0	0	0
4	4	63	8	2	2.5	16
0	0	0	0	0	0	0
22	11	1820	0.5	39	2.5	93
0	0	0	0	0	0	0
2	5	133	0.5	5	2.5	7
0	0	0	0	0	0	0
2	0.5	108	0.5	3	2.5	6
0	0	0	0	0	0	0
1	0.5	119	0.5	3	2.5	2.5
0	0	0	0	0	0	0
0.5	0.5	98	0.5	2	2.5	2.5
0	0	0	0	0	0	0
0.5	0.5	74	0.5	2	2.5	2.5

0	0	0	0	0	0	0
0.5	0.5	88	0.5	2	2.5	2.5
0	0	0	0	0	0	0
0.5	0.5	84	0.5	2	2.5	7
0	0	0	0	0	0	0
6	1	305	0.5	11	2.5	16
0	0	0	0	0	0	0
2	0.5	84	0.5	3	2.5	8
0	0	0	0	0	0	0
1	0.5	65	0.5	2	2.5	2.5
0	0	0	0	0	0	0
1	0.5	100	0.5	2	2.5	6
0	0	0	0	0	0	0
0.5	0.5	56	0.5	2	2.5	2.5
0	0	0	0	0	0	0
0.5	0.5	58	0.5	2	2.5	2.5
0	0	0	0	0	0	0
0.5	0.5	66	0.5	2	2.5	2.5
0	0	0	0	0	0	0
0.5	0.5	59	0.5	2	2.5	7
0	0	0	0	0	0	0
0.5	0.5	50	0.5	2	2.5	2.5
1.4	6.3	120	0.73	2.1	1.4	#VALUE!
0	0	0	0	0	0	0
15	1	670	0.5	14	2.5	29
1	0.5	155	0.5	1	2.5	8
0.5	0.5	0.5	0.5	0.5	2.5	2.5
0	0	0	0	0	0	0
41	0.5	1400	0.5	39	2.5	84
0	0	0	0	0	0	0
6	0.5	137	0.5	6	2.5	8
0	0	0	0	0	0	0
4	0.5	91	0.5	4	2.5	2.5
0	0	0	0	0	0	0
4	0.5	222	0.5	9	2.5	13
0	0	0	0	0	0	0
8	0.5	499	0.5	12	2.5	19
0	0	0	0	0	0	0
2	0.5	112	0.5	2	2.5	2.5
0	0	0	0	0	0	0
6	0.5	436	0.5	12	2.5	21
0	0	0	0	0	0	0
5	0.5	332	0.5	11	2.5	14
0	0	0	0	0	0	0
6	0.5	432	0.5	14	2.5	18
0	0	0	0	0	0	0
1	0.5	87	0.5	2	2.5	2.5
0	0	0	0	0	0	0
0.5	0.5	61	0.5	0.5	2.5	2.5
0	0	0	0	0	0	0

0.5	0.5	62	0.5	2	2.5	2.5
0	0	0	0	0	0	0
0.5	0.5	67	0.5	0.5	2.5	2.5
0	0	0	0	0	0	0
0.5	0.5	64	0.5	0.5	2.5	2.5
0	0	0	0	0	0	0
0.5	0.5	63	0.5	0.5	2.5	2.5
0.5	0.5	144	0.5	1	2.5	2.5
0.5	0.5	48	0.5	0.5	2.5	2.5
0.5	0.5	0.5	0.5	0.5	2.5	2.5
5	0.5	366	0.5	10	2.5	20
0	0	0	0	0	0	0
4	1	179	0.5	8	2.5	17
5	1	379	0.5	15	2.5	18
3	0.5	265	0.5	8	2.5	11
4	1	241	0.5	5	2.5	8
0.5	0.5	54	0.5	2	2.5	2.5
3	0.5	225	0.5	7	2.5	12
0.5	0.5	75	0.5	2	2.5	5
1	0.5	128	0.5	2	2.5	6
0.5	0.5	102	0.5	1	2.5	2.5
0.5	0.5	94	0.5	0.5	2.5	2.5
0.5	0.5	100	0.5	0.5	2.5	2.5
0.5	0.5	127	0.5	0.5	2.5	2.5
0.5	60	123	0.5	0.5	9	28
0.5	0.5	148	0.5	0.5	2.5	7
0.5	0.5	135	0.5	0.5	2.5	6
0.5	0.5	157	0.5	0.5	2.5	2.5
0.5	0.5	184	0.5	0.5	2.5	2.5
0.5	0.5	157	0.5	0.5	2.5	2.5
0.5	0.5	157	0.5	0.5	2.5	2.5
0.5	0.5	2	0.5	0.5	2.5	2.5
3	7	224	0.5	6	2.5	8
0.5	57	91	0.5	0.5	2.5	2.5
0.5	79	127	1	1	2.5	2.5
0.5	329	389	0.5	1	2.5	9
2	1	145	0.5	3	2.5	6
3	4	346	0.5	4	8	12
1	2	138	0.5	2	2.5	2.5
3	16	85	0.5	0.5	2.5	2.5
6	6	297	0.5	7	2.5	11
0.5	17	81	0.5	1	2.5	2.5
0.5	50	77	0.5	0.5	2.5	2.5
0.5	71	87	0.5	2	2.5	2.5
0.5	91	91	0.5	0.5	2.5	2.5
0.5	52	52	0.5	0.5	2.5	2.5
0.5	36	37	0.5	0.5	2.5	2.5
0.5	45	33	0.5	0.5	2.5	2.5
0.5	49	18	0.5	0.5	2.5	2.5
1	1	119	0.5	3	2.5	2.5

0	0	0	0	0	0	0
0.5	6	99	0.5	0.5	2.5	2.5
0.5	5	50	0.5	0.5	2.5	2.5
5	4	692	0.5	16	2.5	17
1	2	155	0.5	4	2.5	6
0.5	2	159	0.5	3	2.5	2.5
0.5	0.5	106	1	0.5	100	2.5
1	6	122	0.5	2	2.5	2.5
0.5	8	110	0.5	0.5	2.5	2.5
0.5	2	97	0.5	0.5	2.5	2.5
4	4	439	0.5	2	2.5	9
2	2	186	0.5	0.5	2.5	8
1	2	116	0.5	2	2.5	2.5
0.5	45	116	0.5	1	2.5	2.5
0.5	72	173	0.5	1	2.5	2.5
0.5	4	191	0.5	1	2.5	5
0.5	2	194	0.5	1	2.5	2.5
0.5	2	193	0.5	0.5	2.5	2.5
0.5	1	178	0.5	0.5	2.5	2.5
0.5	0.5	160	0.5	0.5	2.5	2.5
5	6	388	0.5	8	2.5	21
3	3	156	0.5	2	2.5	9
2	9	71	1	2	2.5	6
6	6	425	0.5	12	7	22
2	1	98	0.5	3	2.5	2.5
0.5	6	88	0.5	0.5	2.5	2.5
0.5	10	104	0.5	1	2.5	2.5
0.5	16	124	0.5	1	13	2.5
0.5	61	164	0.5	0.5	2.5	2.5
0.5	1	126	0.5	1	2.5	2.5
0.5	19	107	0.5	1	2.5	2.5
0.5	10	87	0.5	1	2.5	2.5
0.5	3	62	0.5	0.5	2.5	2.5
0.5	1	45	0.5	0.5	2.5	2.5
0.5	2	38	0.5	0.5	2.5	2.5
0.5	0.5	31	0.5	0.5	2.5	2.5
0.5	0.5	31	0.5	0.5	2.5	2.5
4	5	378	0.5	13	2.5	17
0.5	50	123	0.5	1	2.5	2.5
0.5	270	371	0.5	0.5	2.5	6
3	12	304	0.5	9	2.5	11
4	2	268	0.5	8	2.5	0
0.5	12	84	0.5	2	2.5	2.5
0.5	24	68	0.5	1	2.5	2.5
0.5	53	72	0.5	0.5	5	2.5
0.5	50	76	0.5	0.5	2.5	2.5
0.5	47	47	0.5	0.5	2.5	7
0.5	105	166	0.5	0.5	2.5	8
0.5	59	148	0.5	0.5	2.5	8
0.5	66	183	0.5	0.5	2.5	2.5

0.5	61	240	0.5	1	2.5	12
0.5	13	212	0.5	2	2.5	2.5
0.5	11	134	0.5	2	2.5	2.5
0.5	24	154	0.5	0.5	2.5	2.5
0.5	43	146	0.5	0.5	2.5	2.5
4	6	330	0.5	8	2.5	12
6	13	536	0.5	13	2.5	33
18	4	871	0.5	24	2.5	86
2	4	238	0.5	5	2.5	9
1	49	132	0.5	2	2.5	6
1	690	690	3	3	5	5
0.5	33	105	0.5	2	2.5	5
0.5	28	70	0.5	1	2.5	2.5
0.5	57	76	0.5	0.5	2.5	2.5
0.5	68	79	0.5	0.5	2.5	2.5
0.5	86	108	0.5	0.5	2.5	2.5
0.5	73	84	0.5	0.5	2.5	2.5
0.5	74	106	0.5	0.5	2.5	2.5
0.5	80	117	0.5	0.5	2.5	2.5
0.5	76	104	0.5	0.5	2.5	2.5
0.5	44	132	0.5	0.5	2.5	2.5
0.5	62	125	0.5	0.5	7	2.5
0.5	58	125	0.5	0.5	2.5	2.5
0.5	74	116	0.5	0.5	2.5	2.5
0.5	52	107	0.5	0.5	2.5	2.5
0.5	46	104	0.5	0.5	2.5	2.5
0.5	65	0.05	0.5	0.5	2.5	2.5
2	72	122	0.5	0.5	2.5	2.5
0.5	85	135	0.5	0.5	2.5	2.5
0.5	76	150	0.5	0.5	2.5	2.5
6	61	156	0.5	0.5	2.5	2.5
0.5	51	167	0.5	0.5	5	2.5
0.5	94	150	0.5	0.5	2.5	2.5
0.5	84	153	0.5	0.5	2.5	2.5
0.5	36	106	0.5	0.5	7	2.5
0.5	18	162	0.5	0.5	24	2.5
0	0	0	0	0	0	0
6	12	464	0.5	13	5	19
0	0	0	0	0	0	0
11	6	566	0.5	16	5	31
0	0	0	0	0	0	0
0.5	8	118	0.5	3	2.5	6
0	0	0	0	0	0	0
3	23	156	0.5	8	2.5	10
0	0	0	0	0	0	0
5	137	343	0.5	6	2.5	14
0	0	0	0	0	0	0
3	13	129	0.5	4	2.5	2.5
0	0	0	0	0	0	0
0.5	24	66	0.5	0.5	2.5	2.5

0	0	0	0	0	0	0
0.5	43	62	0.5	1	2.5	9
0	0	0	0	0	0	0
0.5	37	51	0.5	1	9	2.5
6	5	108	0.5	3	2.5	13
0	0	0	0	0	0	0
2	8	113	0.5	6	2.5	7
0	0	0	0	0	0	0
7	5	369	0.5	12	2.5	22
0	0	0	0	0	0	0
3	28	140	0.5	4	2.5	17
0	0	0	0	0	0	0
4	14	91	0.5	3	2.5	25
0	0	0	0	0	0	0
2	6	163	0.5	4	2.5	9
0	0	0	0	0	0	0
0.5	21	85	0.5	1	2.5	2.5
0	0	0	0	0	0	0
0.5	25	67	0.5	0.5	2.5	2.5
0	0	0	0	0	0	0
0.5	25	86	0.5	0.5	2.5	2.5
0	0	0	0	0	0	0
0.5	9	102	0.5	0.5	2.5	2.5
0	0	0	0	0	0	0
0.5	46	125	0.5	0.5	2.5	2.5
0	0	0	0	0	0	0
0.5	52	122	0.5	1	2.5	2.5
0	0	0	0	0	0	0
0.5	3	47	0.5	0.5	2.5	2.5
0.5	5	53	0.5	2	2.5	2.5
0.5	9	56	0.5	1	2.5	2.5
0.5	12	52	0.5	0.5	2.5	6
0.5	13	52	0.5	0.5	2.5	2.5
0	0	0	0	0	0	0
0.5	22	80	19	1	2.5	2.5
0	0	0	0	0	0	0
0.5	25	89	0.5	0.5	2.5	2.5
0	0	0	0	0	0	0
0.5	34	102	0.5	0.5	2.5	2.5
0	0	0	0	0	0	0
0.5	35	110	0.5	0.5	2.5	2.5
0	0	0	0	0	0	0
0.5	0.5	284	0.5	0.5	13	2.5
0	0	0	0	0	0	0
3	8	262	0.5	8	2.5	12
0	0	0	0	0	0	0
1	14	107	0.5	3	2.5	6
0	0	0	0	0	0	0
0.5	19	83	0.5	2	2.5	2.5
0	0	0	0	0	0	0

0.5	28	83	0.5	1	2.5	2.5
0	0	0	0	0	0	0
3	40	338	0.5	7	2.5	11
0	0	0	0	0	0	0
1	12	118	0.5	4	2.5	2.5
0	0	0	0	0	0	0
0.5	19	96	0.5	2	2.5	2.5
0	0	0	0	0	0	0
2	13	238	0.5	5	2.5	6
0	0	0	0	0	0	0
1	0.5	156	0.5	2	2.5	2.5
0	0	0	0	0	0	0
3	10	129	0.5	3	2.5	15
0	0	0	0	0	0	0
3	10	138	0.5	3	2.5	15
0	0	0	0	0	0	0
2	15	109	0.5	2	2.5	8
0	0	0	0	0	0	0
1	14	100	0.5	1	2.5	6
0	0	0	0	0	0	0
16	10	1990	0.5	43	2.5	90
0	0	0	0	0	0	0
3	5	140	1	5	2.5	8
0	0	0	0	0	0	0
2	0.5	174	0.5	4	2.5	6
0	0	0	0	0	0	0
1	0.5	185	0.5	3	2.5	2.5
0	0	0	0	0	0	0
0.5	0.5	186	0.5	2	2.5	2.5
0	0	0	0	0	0	0
0.5	0.5	234	0.5	2	2.5	2.5
0	0	0	0	0	0	0
0.5	0.5	154	0.5	2	2.5	2.5
0	0	0	0	0	0	0
0.5	0.5	133	0.5	1	2.5	2.5
0	0	0	0	0	0	0
5	1	268	0.5	8	2.5	14
0	0	0	0	0	0	0
1	0.5	91	0.5	3	2.5	5
0	0	0	0	0	0	0
1	0.5	72	0.5	2	2.5	2.5
0	0	0	0	0	0	0
0.5	0.5	72	0.5	2	2.5	2.5
0	0	0	0	0	0	0
0.5	0.5	79	0.5	2	2.5	2.5
0	0	0	0	0	0	0
0.5	0.5	102	0.5	1	2.5	2.5
0	0	0	0	0	0	0
0.5	0.5	83	0.5	1	2.5	2.5
0	0	0	0	0	0	0

0.5	0.5	66	0.5	1	2.5	2.5
0	0	0	0	0	0	0
0.5	0.5	77	0.5	1	2.5	2.5
0.9	71	430	1.1	2	2.8	#VALUE!
0	0	0	0	0	0	0
18	4	800	0.5	10	2.5	26
0.5	0.5	137	0.5	0.5	2.5	2.5
21	0.5	774	0.5	23	2.5	42
0	0	0	0	0	0	0
6	0.5	165	0.5	7	2.5	16
0	0	0	0	0	0	0
3	0.5	133	0.5	4	2.5	2.5
0	0	0	0	0	0	0
5	0.5	310	0.5	8	2.5	10
0	0	0	0	0	0	0
2	1	115	0.5	4	2.5	2.5
0	0	0	0	0	0	0
6	0.5	367	0.5	12	2.5	17
0	0	0	0	0	0	0
5	0.5	344	0.5	11	2.5	15
0	0	0	0	0	0	0
6	0.5	453	0.5	16	2.5	26
0	0	0	0	0	0	0
0.5	0.5	86	0.5	2	2.5	2.5
0	0	0	0	0	0	0
0.5	0.5	73	0.5	1	2.5	8
0	0	0	0	0	0	0
0.5	0.5	94	0.5	0.5	2.5	2.5
0	0	0	0	0	0	0
0.5	0.5	114	0.5	0.5	2.5	2.5
0	0	0	0	0	0	0
0.5	0.5	144	0.5	0.5	2.5	2.5
0	0	0	0	0	0	0
0.5	0.5	136	0.5	0.5	2.5	2.5
0.5	0.5	180	0.5	1	2.5	2.5
0.5	1	1	0.5	0.5	15	15
2	2	116	0.5	5	2.5	6
5	0.5	358	0.5	12	2.5	18
0	0	0	0	0	0	0
4	2	168	0.5	7	2.5	14
5	1	334	0.5	13	2.5	17
2	0.5	243	0.5	6	2.5	9
3	2	223	0.5	6	2.5	10
0.5	1	59	0.5	2	2.5	2.5
3	0.5	202	0.5	8	2.5	11
2	0.5	200	0.5	4	2.5	12
0.5	0.5	56	0.5	1	2.5	10
0.5	0.5	82	0.5	2	2.5	17
1	0.5	128	0.5	2	2.5	2.5
0.5	0.5	129	0.5	1	2.5	28

0.5	0.5	123	0.5	0.5	2.5	2.5
0.5	0.5	115	0.5	0.5	2.5	2.5
0.5	0.5	171	0.5	0.5	2.5	2.5
0.5	51	185	0.5	0.5	2.5	10
0.5	0.5	144	0.5	0.5	2.5	2.5
0.5	0.5	143	0.5	0.5	2.5	2.5
0.5	0.5	158	0.5	0.5	2.5	2.5
0.5	0.5	164	8	0.5	54	2.5
0.5	0.5	203	0.5	0.5	2.5	2.5
0.5	0.5	231	0.5	0.5	2.5	2.5

DO NOT change column headings. Values in the Data column must be a number. This data is used for Piper plo

Monitoring Point	Date	Calcium (mg/L)	Magnesium (mg/L)	Sodium (mg/L)	Potassium (mg/L)	Chloride (mg/L)	Sulfate as SO4 (mg/L)	Bicarbonate Alkalinity as CaCO3 (mg/L)
CC-05	11 Jan 2015	12	3	6	4	3	0.5	50
CC-05	03 Jan 2016	22	5	13	3	6	5	99
CC-05	04 Jan 2016	30	6	17	4	7	7	121
CC-05	05 Jan 2016	34	7	18	4	8	7	140
CC-05	07 Jan 2016	1	1	2	4	4	1	7
CC-05	08 Jan 2016	39	8	19	5	8	8	153
CC-05	01 Feb 2016	17	3	11	3	4	2	82
CC-05	14 Feb 2016	26	6	13	4	4	3	121
CC-05	10 Mar 2016	15	3	2	5	1	0.5	61
CC-05	05 Mar 2018	11	2	5	3	3	0.5	43
CC-05	06 Mar 2018	12	3	4	3	3	1	52
CC-05	18 Mar 2018	33	8	12	4	8	5	127
CC-05	19 Mar 2018	33	8	11	5	7	5	126
CC-05	20 Mar 2018	36	8	12	5	8	5	128
CC-05	11 Feb 2019	43	15	27	6	20	27	171
CC-05	12 Feb 2019	37	14	27	5	12	14	166
CC-05	13 Feb 2019	32	12	26	5	12	11	162
CC-05	27 Jan 2020	8	2	6	3	3	0.5	36
CC-05	28 Jan 2020	10	2	7	3	4	0.5	44
CC-05	02 Feb 2020	25	5	16	4	7	4	100
CC-05	03 Feb 2020	14	4	17	3	6	0.5	74
CC-05	08 Feb 2020	20	5	12	3	4	2	91
CC-05	06 Mar 2020	16	3	10	3	4	2	68
CC-05	08 Mar 2020	28	6	16	4	4	4	115
CC-05	24 Dec 2020	12	2	4	4	2	0.5	52
CC-05	07 Feb 2023	13	2	3	3	1	0.5	47
CC-05	15 Mar 2023	33	14	35	4	13	9	176
CC-05	16 Mar 2023	35	15	39	4	14	11	194
CC-05	17 Mar 2023	39	17	46	5	16	12	204
CC-05	18 Mar 2023	43	18	51	5	18	13	230
CC-05	19 Mar 2023	42	17	49	5	18	13	216
DR-10	19 Dec 2015	10	2	6	3	2	0.5	46
DR-10	31 Dec 2015	10	2	7	3	4	2	47
DR-10	01 Jan 2016	17	3	10	3	7	3	76
DR-10	02 Jan 2016	11	2	5	2	3	0.5	53
DR-10	03 Jan 2016	19	3	10	3	6	4	80
DR-10	04 Jan 2016	22	5	14	3	8	6	92
DR-10	05 Jan 2016	26	6	17	4	10	8	111
DR-10	06 Jan 2016	31	7	19	4	12	10	131
DR-10	07 Jan 2016	36	8	19	4	8	8	138
DR-10	09 Jan 2016	38	8	23	4	14	13	156
DR-10	10 Jan 2016	38	10	26	5	15	16	172
DR-10	11 Jan 2016	38	10	27	5	15	16	174
DR-10	12 Jan 2016	14	3	8	3	5	4	66
DR-10	31 Jan 2016	50	12	35	5	21	18	223
DR-10	14 Feb 2016	39	10	34	4	17	14	180

DR-10	05 Mar 2016	11	2	8	3	4	0.5	54
DR-10	06 Mar 2016	12	2	7	4	4	0.5	53
DR-10	07 Mar 2016	13	3	8	4	5	0.5	64
DR-10	08 Mar 2016	14	3	9	4	4	0.5	64
DR-10	09 Mar 2016	14	3	9	4	5	3	67
DR-10	10 Mar 2016	13	3	8	4	5	0.5	58
DR-10	11 Mar 2016	14	3	8	4	4	0.5	63
DR-10	12 Mar 2016	10	2	4	4	2	0.5	45
DR-10	13 Mar 2016	12	2	6	3	3	0.5	55
DR-10	14 Mar 2016	10	2	4	3	2	0.5	47
DR-10	15 Mar 2016	12	2	5	3	2	0.5	56
DR-10	16 Mar 2016	14	3	6	4	3	0.5	68
DR-10	17 Mar 2016	20	4	8	4	4	1	83
DR-10	18 Mar 2016	20	4	8	4	4	2	84
DR-10	19 Mar 2016	20	4	8	4	4	2	81
DR-10	20 Mar 2016	20	4	8	4	4	1	83
DR-10	21 Mar 2016	19	4	9	4	4	3	87
DR-10	23 May 2016	8	1	2	4	2	0.5	39
DR-10	24 May 2016	8	1	2	4	2	2	38
DR-10	25 May 2016	9	2	2	4	2	2	45
DR-10	09 Mar 2017	10	2	6	2	3	2	0.5
DR-10	10 Mar 2017	14	3	12	3	4	2	0.5
DR-10	11 Mar 2017	18	3	10	8	4	2	0.5
DR-10	12 Mar 2017	20	4	12	4	4	2	0.5
DR-10	13 Mar 2017	22	5	13	4	5	3	0.5
DR-10	14 Mar 2017	23	5	4	12	5	3	0.5
DR-10	16 Mar 2017	25	5	12	4	5	3	0.5
DR-10	17 Mar 2017	25	5	4	12	5	3	0.5
DR-10	18 Mar 2017	25	5	12	4	5	3	0.5
DR-10	19 Mar 2017	25	5	12	4	5	3	0.5
DR-10	20 Mar 2017	26	5	13	4	5	3	0.5
DR-10	20 Mar 2017	26	5	12	4	5	3	0.5
DR-10	21 Mar 2017	26	5	13	4	5	3	0.5
DR-10	12 Mar 2018	16	4	13	3	7	4	79
DR-10	15 Mar 2018	25	6	15	4	10	6	104
DR-10	17 Mar 2018	29	7	16	4	10	7	117
DR-10	18 Mar 2018	31	7	17	4	11	7	134
DR-10	19 Mar 2018	33	8	18	4	12	7	136
DR-10	20 Mar 2018	34	8	18	5	13	7	139
DR-10	21 Mar 2018	36	8	20	5	13	9	141
DR-10	22 Mar 2018	36	9	21	5	14	9	152
DR-10	23 Mar 2018	36	9	21	5	14	9	155
DR-10	20 Feb 2019	51	17	48	6	29	20	248
DR-10	21 Feb 2019	54	17	50	7	39	22	249
DR-10	22 Feb 2019	55	18	53	7	33	21	256
DR-10	23 Feb 2019	57	19	55	7	35	26	268
DR-10	24 Feb 2019	59	19	56	7	36	28	281
DR-10	25 Feb 2019	57	19	55	7	35	25	278
DR-10	26 Feb 2019	58	20	58	7	36	30	276
DR-10	27 Feb 2019	61	20	63	7	42	26	293

DR-10	28 Feb 2019	62	21	64	7	42	30	292
DR-10	01 Mar 2019	63	21	66	7	42	34	319
DR-10	02 Mar 2019	64	21	68	7	46	34	300
DR-10	27 Jan 2020	6	0.5	4	2	1	0.5	33
DR-10	28 Jan 2020	12	2	7	3	4	3	51
DR-10	02 Feb 2020	18	5	16	4	8	5	82
DR-10	03 Feb 2020	20	6	18	4	9	6	92
DR-10	04 Feb 2020	12	3	8	3	5	2	54
DR-10	05 Feb 2020	10	2	7	2	4	2	48
DR-10	06 Feb 2020	7	2	8	2	3	1	40
DR-10	07 Feb 2020	8	2	8	2	3	2	44
DR-10	08 Feb 2020	15	3	12	3	4	3	77
DR-10	09 Feb 2020	11	3	8	3	4	3	52
DR-10	10 Feb 2020	18	4	15	3	7	4	92
DR-10	11 Feb 2020	24	6	21	4	10	5	110
DR-10	12 Feb 2020	24	6	20	4	11	6	121
DR-10	13 Feb 2020	24	6	20	4	10	5	114
DR-10	14 Feb 2020	24	6	20	3	11	6	119
DR-10	15 Feb 2020	25	6	21	4	11	4	120
DR-10	16 Feb 2020	26	6	20	4	10	5	124
DR-10	06 Mar 2020	10	2	8	2	4	2	51
DR-10	07 Mar 2020	13	3	10	3	5	3	63
DR-10	08 Mar 2020	17	4	13	3	6	4	75
DR-10	09 Mar 2020	20	5	14	4	7	4	88
DR-10	10 Mar 2020	19	5	14	3	7	5	91
DR-10	11 Mar 2020	18	4	14	3	7	5	91
DR-10	12 Mar 2020	20	5	16	3	7	5	97
DR-10	13 Mar 2020	20	5	15	3	7	2	96
DR-10	25 Apr 2020	30	8	24	5	9	4	142
DR-10	24 Dec 2020	14	2	8	3	5	3	59
DR-10	25 Dec 2020	18	3	10	4	6	4	70
DR-10	26 Dec 2020	22	4	11	4	7	5	78
DR-10	27 Dec 2020	11	2	3	3	2	0.5	47
DR-10	28 Dec 2020	10	2	4	2	2	0.5	45
DR-10	29 Dec 2020	13	3	5	3	2	0.5	53
DR-10	30 Dec 2020	15	3	5	4	3	0.5	52
DR-10	31 Dec 2020	16	3	6	4	3	1	61
DR-10	03 Feb 2021	11	2	3	4	2	0.5	44
DR-10	04 Feb 2021	11	2	3	4	2	0.5	44
DR-10	05 Feb 2021	13	2	3	4	2	2	50
DR-10	06 Feb 2021	14	2	4	4	2	0.5	55
DR-10	07 Feb 2021	8	1	2	3	1	0.5	39
DR-10	08 Feb 2021	8	1	6	2	2	0.5	37
DR-10	09 Feb 2021	11	2	7	3	4	0.5	48
DR-10	10 Feb 2021	14	2	7	3	2	0.5	56
DR-10	11 Feb 2021	16	3	8	3	2	1	63
DR-10	12 Feb 2021	17	3	8	3	2	3	71
DR-10	13 Feb 2021	18	2	7	3	3	1	67
DR-10	14 Feb 2021	18	2	7	3	3	0.5	70
DR-10	15 Feb 2021	7	1	6	2	2	0.5	31

DR-10	16 Feb 2021	13	2	7	3	2	0.5	50
DR-10	17 Feb 2021	16	3	8	3	3	2	59
DR-10	18 Feb 2021	19	3	9	3	3	2	68
DR-10	19 Feb 2021	18	3	8	3	3	2	69
DR-10	20 Feb 2021	19	3	8	3	3	2	75
DR-10	21 Feb 2021	19	3	8	3	3	2	72
DR-10	22 Feb 2021	20	3	9	3	3	2	72
DR-10	23 Feb 2021	20	3	9	3	4	2	75
DR-10	18 May 2021	22	3.7	9.6	5	3.7	0.5	101
DR-10	03 Sep 2021	8	1	2	4	1	1	26
DR-10 R1	30 Sep 2021	21	3	2	6	2	0.5	67
DR-10 R2 (	30 Sep 2021	0.5	0.5	0.5	0.5	0.5	0.5	4
DR-10	21 Jan 2022	26	3	2	5	2	0.5	67
DR-10	22 Jan 2022	13	2	2	4	2	0.5	43
DR-10	23 Jan 2022	15	2	2	4	2	0.5	51
DR-10	26 Jan 2022	11	2	3	2	2	0.5	39
DR-10	27 Jan 2022	16	2	3	4	2	0.5	55
DR-10	28 Jan 2022	17	2	3	4	2	0.5	61
DR-10	29 Jan 2022	12	2	4	3	2	0.5	46
DR-10	30 Jan 2022	10	2	5	2	2	0.5	40
DR-10	31 Jan 2022	8	1	5	2	2	0.5	37
DR-10	01 Feb 2022	14	2	6	3	2	0.5	56
DR-10	02 Feb 2022	18	3	7	3	3	0.5	69
DR-10	03 Feb 2022	21	4	8	4	4	0.5	83
DR-10	04 Feb 2022	23	4	8	4	4	1	90
DR-10	05 Feb 2022	24	4	8	4	4	1	90
DR-10	06 Feb 2022	21	4	9	4	4	1	93
DR-10	30 Mar 2022	19	3	3	5	3	1	70
DR-10 R1	29 Sep 2022	17	3	0.5	4	2	0.5	70
DR-10 R2	29 Sep 2022	0.5	0.5	0.5	0.5	0.5	0.5	5
DR-10	28 Nov 2022	8	1	1	3	1	0.5	28
DR-10	25 Dec 2022	9	1	3	3	2	0.5	32
DR-10	27 Dec 2022	10	1	3	3	2	0.5	35
DR-10	14 Jan 2023	10	2	3	3	1	0.5	39
DR-10	07 Feb 2023	7	1	3	3	1	0.5	36
DR-10	08 Feb 2023	12	2	4	3	2	0.5	48
DR-10	07 Mar 2023	6	2	9	2	3	0.5	40
DR-10	11 Mar 2023	16	5	9	3	5	4	76
DR-10	12 Mar 2023	18	4	7	3	4	3	67
DR-10	13 Mar 2023	27	7	15	4	8	6	105
DR-10	14 Mar 2023	34	10	22	4	11	9	138
DR-10	15 Mar 2023	37	12	26	5	12	11	152
DR-10	16 Mar 2023	41	13	30	5	14	12	171
DR-10	17 Mar 2023	44	14	34	5	17	15	185
DR-10	18 Mar 2023	50	17	40	6	22	17	217
DR-10	19 Mar 2023	50	17	41	6	21	17	211
DR-10	20 Mar 2023	55	19	46	6	24	20	238
DR-10	21 Mar 2023	56	19	47	6	24	20	235
DR-10	22 Mar 2023	55	19	52	5	25	20	257
DR-10	23 Mar 2023	59	20	56	6	27	21	275

DR-14	17 Jan 2015	9	2	3	6	2	0.5	40
DR-14	24 Jan 2015	37	9	26	5	17	10	148
DR-14	26 Jan 2015	18	4	9	4	7	4	55
DR-14	31 Jan 2015	42	12	33	5	20	16	176
DR-14	19 Dec 2015	10	2	5	5	2	0.5	45
DR-14	30 Dec 2015	8	1	4	2	2	5	33
DR-14	31 Dec 2015	9	2	6	3	3	1	43
DR-14	01 Jan 2016	17	3	10	3	6	3	77
DR-14	02 Jan 2016	6	1	3	2	2	0.5	32
DR-14	03 Jan 2016	17	3	10	3	6	4	74
DR-14	04 Jan 2016	21	5	13	3	8	6	93
DR-14	05 Jan 2016	25	6	16	4	10	8	110
DR-14	07 Jan 2016	33	7	20	4	13	11	138
DR-14	08 Jan 2016	35	8	21	4	14	12	145
DR-14	09 Jan 2016	38	9	23	4	15	13	154
DR-14	10 Jan 2016	37	10	26	4	16	15	168
DR-14	11 Jan 2016	38	11	27	4	16	16	176
DR-14	12 Jan 2016	16	3	10	3	5	4	76
DR-14	31 Jan 2016	49	12	33	5	18	16	213
DR-14	14 Feb 2016	43	12	37	4	19	16	197
DR-14	05 Mar 2016	7	1	4	3	2	0.5	33
DR-14	06 Mar 2016	14	3	9	4	5	0.5	63
DR-14	07 Mar 2016	16	3	8	4	5	0.5	72
DR-14	08 Mar 2016	16	3	9	4	4	0.5	70
DR-14	09 Mar 2016	15	3	8	4	4	1	64
DR-14	10 Mar 2016	15	3	8	4	5	1	67
DR-14	11 Mar 2016	17	4	9	4	5	2	74
DR-14	12 Mar 2016	10	2	4	4	2	0.5	45
DR-14	13 Mar 2016	12	2	5	4	2	0.5	54
DR-14	14 Mar 2016	10	2	4	3	2	0.5	47
DR-14	15 Mar 2016	12	2	5	3	2	0.5	55
DR-14	16 Mar 2016	14	3	5	4	3	0.5	58
DR-14	17 Mar 2016	18	4	7	4	4	0.5	79
DR-14	18 Mar 2016	18	4	7	4	4	0.5	78
DR-14	19 Mar 2016	18	4	7	4	4	0.5	78
DR-14	20 Mar 2016	18	4	7	4	4	0.5	78
DR-14	21 Mar 2016	19	4	8	4	4	2	86
DR-14	23 May 2016	8	1	2	4	2	0.5	4
DR-14	24 May 2016	9	1	2	4	2	1	42
DR-14	25 May 2016	10	2	2	4	2	2	40
DR-14	08 Mar 2017	5	0.5	3	2	2	0.5	0.5
DR-14	09 Mar 2017	10	2	6	2	3	1	0.5
DR-14	10 Mar 2017	14	3	13	3	4	2	0.5
DR-14	11 Mar 2017	16	3	9	3	4	2	0.5
DR-14	12 Mar 2017	19	4	12	4	4	2	0.5
DR-14	13 Mar 2017	22	6	13	4	5	2	0.5
DR-14	14 Mar 2017	24	5	4	12	5	3	0.5
DR-14	16 Mar 2017	26	5	13	4	5	3	0.5
DR-14	17 Mar 2017	27	6	4	13	5	3	0.5
DR-14	18 Mar 2017	27	6	13	4	5	3	0.5

DR-14	19 Mar 2017	28	6	13	4	5	3	0.5
DR-14	20 Mar 2017	28	6	13	4	6	3	0.5
DR-14	20 Mar 2017	28	6	13	4	6	3	0.5
DR-14	21 Mar 2017	28	6	13	4	6	3	0.5
DR-14	04 Mar 2018	8	1	2	3	3	0.5	34
DR-14	05 Mar 2018	17	3	7	3	6	3	61
DR-14	06 Mar 2018	21	5	7	4	6	3	83
DR-14	07 Mar 2018	11	2	12	3	8	5	58
DR-14	08 Mar 2018	8	2	2	2	3	3	37
DR-14	09 Mar 2018	10	2	11	3	6	3	54
DR-14	10 Mar 2018	12	3	11	3	6	3	58
DR-14	11 Mar 2018	14	4	12	3	7	4	70
DR-14	12 Mar 2018	16	4	13	3	8	4	79
DR-14	13 Mar 2018	18	5	14	3	8		86
DR-14	15 Mar 2018	26	6	16	4	11	6	104
DR-14	17 Mar 2018	30	8	17	4	12	8	119
DR-14	18 Mar 2018	34	8	19	4	14	8	134
DR-14	19 Mar 2018	36	9	20	4	15	9	151
DR-14	20 Mar 2018	41	10	21	5	18	10	161
DR-14	21 Mar 2018	43	10	22	5	22	11	163
DR-14	22 Mar 2018	46	12	25	5	24	11	183
DR-14	23 Mar 2018	47	12	25	5	24	11	194
DR-14	31 Jan 2019	5	1	3	3	2	2.5	30
DR-14	01 Feb 2019	4	0.5	3	2	1	0.5	25
DR-14	02 Feb 2019	6	0.5	1	1	0.5	3	25
DR-14	03 Feb 2019	5	1	2	2	0.5	2	22
DR-14	04 Feb 2019	12	2	3	2	1	4	36
DR-14	05 Feb 2019	48	8	4	4	3	36	114
DR-14	06 Feb 2019	14	5	9	4	4	4	68
DR-14	07 Feb 2019	19	7	12	4	5	5	87
DR-14	08 Feb 2019	28	8	16	4	8	8	113
DR-14	09 Feb 2019	33	10	20	5	9	10	134
DR-14	10 Feb 2019	34	11	22	5	10	10	164
DR-14	11 Feb 2019	34	13	24	5	8	8	155
DR-14	12 Feb 2019	39	14	29	5	21	11	165
DR-14	13 Feb 2019	36	14	31	6	21	11	176
DR-14	14 Feb 2019	43	15	36	6	21	15	190
DR-14	15 Feb 2019	42	15	37	6	22	15	199
DR-14	16 Feb 2019	44	16	40	6	26	15	219
DR-14	17 Feb 2019	48	18	45	6	27	19	216
DR-14	18 Feb 2019	47	17	48	6	27	19	222
DR-14	19 Feb 2019	51	17	47	6	34	18	242
DR-14	20 Feb 2019	52	17	49	6	30	22	255
DR-14	21 Feb 2019	54	17	51	7	36	22	260
DR-14	22 Feb 2019	56	18	55	7	36	27	260
DR-14	23 Feb 2019	58	19	56	7	35	25	278
DR-14	24 Feb 2019	59	19	58	7	37	30	276
DR-14	25 Feb 2019	59	20	58	7	42	23	276
DR-14	26 Feb 2019	59	20	59	7	41	30	300
DR-14	27 Feb 2019	62	21	65	7	44	26	302

DR-14	28 Feb 2019	63	21	65	7	44	31	302
DR-14	01 Mar 2019	64	21	67	7	46	34	309
DR-14	02 Mar 2019	66	22	69	8	48	36	316
DR-14	26 Jan 2020	8	1	4	3	2	0.5	35
DR-14	27 Jan 2020	6	1	4	2	1	0.5	33
DR-14	28 Jan 2020	12	2	8	3	5	3	50
DR-14	29 Jan 2020	13	2	2	2	2	21	27
DR-14	30 Jan 2020	8	2	8	2	6	4	36
DR-14	31 Jan 2020	9	2	11	3	6	2	46
DR-14	01 Feb 2020	14	4	14	4	8	5	64
DR-14	02 Feb 2020	17	5	16	4	9	6	77
DR-14	03 Feb 2020	21	5	17	4	10	6	88
DR-14	04 Feb 2020	12	3	9	3	5	3	57
DR-14	05 Feb 2020	11	3	7	3	4	2	51
DR-14	06 Feb 2020	8	2	8	3	3	1	41
DR-14	07 Feb 2020	9	2	8	2	3	2	46
DR-14	08 Feb 2020	14	3	12	3	4	3	65
DR-14	09 Feb 2020	15	3	10	3	4	3	67
DR-14	10 Feb 2020	18	4	13	3	6	3	83
DR-14	11 Feb 2020	20	5	17	3	9	5	100
DR-14	12 Feb 2020	22	5	18	4	9	4	102
DR-14	13 Feb 2020	22	5	19	4	9	5	109
DR-14	14 Feb 2020	23	6	19	4	12	5	114
DR-14	15 Feb 2020	25	6	20	4	10	4	116
DR-14	16 Feb 2020	26	6	21	4	11	6	124
DR-14	06 Mar 2020	10	2	8	2	4	2	47
DR-14	07 Mar 2020	12	3	10	3	5	4	63
DR-14	08 Mar 2020	15	4	12	3	6	3	71
DR-14	09 Mar 2020	18	4	13	4	8	4	84
DR-14	10 Mar 2020	18	4	13	3	7	4	87
DR-14	11 Mar 2020	18	5	14	3	6	4	90
DR-14	12 Mar 2020	20	5	14	4	6	4	92
DR-14	13 Mar 2020	21	5	14	4	7	4	96
DR-14	23 Apr 2020	30	8	24	5	10	3	139
DR-14	23 Dec 2020	4	0.5	0.5	1	1	0.5	27
DR-14	24 Dec 2020	13	2	8	3	5	3	57
DR-14	25 Dec 2020	17	3	10	3	6	4	65
DR-14	26 Dec 2020	20	4	11	4	8	4	72
DR-14	27 Dec 2020	13	2	5	3	4	2	51
DR-14	28 Dec 2020	11	2	4	3	2	0.5	48
DR-14	29 Dec 2020	14	3	5	3	3	0.5	54
DR-14	30 Dec 2020	15	3	5	3	2	0.5	49
DR-14	31 Dec 2020	15	3	5	3	3	1	58
DR-14	03 Feb 2021	11	2	3	4	1	0.5	46
DR-14	04 Feb 2021	11	2	3	4	1	0.5	48
DR-14	05 Feb 2021	13	2	3	4	2	0.5	54
DR-14	06 Feb 2021	14	2	4	4	2	1	56
DR-14	07 Feb 2021	8	1	2	2	1	0.5	37
DR-14	08 Feb 2021	8	1	7	2	3	0.5	47
DR-14	09 Feb 2021	11	2	7	3	2	0.5	45

DR-14	10 Feb 2021	13	2	7	3	2	0.5	54
DR-14	11 Feb 2021	16	3	7	3	2	0.5	65
DR-14	12 Feb 2021	17	3	7	3	2	0.5	70
DR-14	13 Feb 2021	18	3	7	3	3	1	70
DR-14	14 Feb 2021	19	3	7	3	3	0.5	70
DR-14	15 Feb 2021	7	1	6	2	1	0.5	32
DR-14	16 Feb 2021	13	2	7	3	3	0.5	50
DR-14	17 Feb 2021	15	3	8	3	3	0.5	59
DR-14	18 Feb 2021	18	3	9	3	3	1	68
DR-14	19 Feb 2021	19	3	9	3	4	2	70
DR-14	20 Feb 2021	16	3	7	3	3	1	75
DR-14	21 Feb 2021	20	4	9	4	4	2	78
DR-14	22 Feb 2021	21	4	9	4	4	2	82
DR-14	23 Feb 2021	22	4	9	4	4	2	79
DR-14	19 May 2021	36	5.5	9.7	4.6	3.5	<0.3	139
DR-14	03 Sep 2021	8	1	2	4	1	1	26
DR-14	30 Sep 2021	40	7	8	9	4	0.5	136
DR-14	21 Jan 2022	25	3	2	5	2	0.5	66
DR-14	22 Jan 2022	13	2	2	4	2	0.5	45
DR-14	23 Jan 2022	15	2	2	4	2	0.5	53
DR-14	27 Jan 2022	16	2	3	4	2	0.5	52
DR-14	28 Jan 2022	18	3	3	4	2	0.5	58
DR-14	29 Jan 2022	12	2	4	3	2	0.5	43
DR-14	30 Jan 2022	10	2	5	2	2	0.5	43
DR-14	31 Jan 2022	8	1	5	2	2	0.5	40
DR-14	01 Feb 2022	13	2	5	3	2	0.5	52
DR-14	02 Feb 2022	18	3	7	3	3	0.5	67
DR-14	03 Feb 2022	20	4	7	4	4	0.5	81
DR-14	04 Feb 2022	23	4	8	4	4	0.5	86
DR-14	05 Feb 2022	24	4	8	4	4	0.5	88
DR-14	06 Feb 2022	22	4	8	4	4	1	93
DR-14 R1	31 Mar 2022	24	4	5	5	5	1	93
DR-14 R2 (	31 Mar 2022	7	2	10	2	14	0.5	32
DR-14	28 Sep 2022	16	3	3	3	2	0.5	70
DR-14	28 Nov 2022	8	1	2	3	1	0.5	31
DR-14	25 Dec 2022	9	1	4	3	2	0.5	32
DR-14	27 Dec 2022	10	1	3	3	2	0.5	35
DR-14	14 Jan 2023	14	3	3	3	2	0.5	47
DR-14	07 Feb 2023	7	1	3	2	1	0.5	34
DR-14	08 Feb 2023	12	2	4	3	2	0.5	40
DR-14	07 Mar 2023	6	1	9	2	4	0.5	48
DR-14	09 Mar 2023	10	2	4	3	2	1	42
DR-14	10 Mar 2023	12	3	6	3	3	3	47
DR-14	11 Mar 2023	16	5	9	3	5	4	76
DR-14	12 Mar 2023	18	4	7	3	4	3	68
DR-14	13 Mar 2023	27	7	15	4	8	6	105
DR-14	14 Mar 2023	38	10	22	4	12	12	157
DR-14	15 Mar 2023	37	12	25	5	12	12	154
DR-14	16 Mar 2023	42	13	30	5	15	15	175
DR-14	17 Mar 2023	51	15	34	5	20	17	199

DR-14	18 Mar 2023	52	17	40	6	20	18	214
DR-14	19 Mar 2023	50	17	40	6	21	18	209
DR-14	20 Mar 2023	55	19	48	6	24	21	241
DR-14	21 Mar 2023	54	19	47	6	25	21	237
DR-14	22 Mar 2023	56	19	53	5	27	20	260
DR-14	23 Mar 2023	60	20	56	6	30	22	265

ɔts in Power BI. Cells can be blank (<LOR RESULTS HAVE BEEN ENTERED AS 0.5*LOR AND SHADED GRE

Total Alkalinity as CaCO3 (mg/L)	Hydroxide Alkalinity as CaCO3 (mg/L)	Carbonate Alkalinity as CaCO3 (mg/L)
50	0.5	0.5
99	0.5	0.5
121	0.5	0.5
140	0.5	0.5
7	0.5	0.5
163	0.5	10
82	0.5	0.5
121	0.5	0.5
61	0.5	0.5
43	0.5	0.5
52	0.5	0.5
127	0.5	0.5
131	0.5	5
134	0.5	6
171	0.5	0.5
166	0.5	0.5
162	0.5	0.5
36	0.5	0.5
44	0.5	0.5
100	0.5	0.5
74	0.5	0.5
91	0.5	0.5
68	0.5	0.5
115	0.5	0.5
52	0.5	0.5
47	0.5	0.5
176	0.5	0.5
194	0.5	0.5
213	0.5	10
230	0.5	0.5
227	0.5	11
46	0.5	0.5
47	0.5	0.5
76	0.5	0.5
53	0.5	0.5
80	0.5	0.5
92	0.5	0.5
111	0.5	0.5
131	0.5	0.5
150	0.5	12
161	0.5	5
172	0.5	0.5
174	0.5	0.5
66	0.5	0.5
223	0.5	0.5
180	0.5	0.5

54	0.5	0.5
53	0.5	0.5
64	0.5	0.5
64	0.5	0.5
67	0.5	0.5
58	0.5	0.5
63	0.5	0.5
45	0.5	0.5
55	0.5	0.5
47	0.5	0.5
56	0.5	0.5
68	0.5	0.5
83	0.5	0.5
84	0.5	0.5
81	0.5	0.5
83	0.5	0.5
87	0.5	0.5
39	0.5	0.5
38	0.5	0.5
45	0.5	0.5
48	0.5	48
68	0.5	68
80	0.5	80
89	0.5	89
101	0.5	101
106	0.5	106
107	0.5	107
107	0.5	107
109	0.5	109
109	0.5	109
114	0.5	114
111	0.5	111
114	0.5	114
79	0.5	0.5
104	0.5	0.5
117	0.5	0.5
134	0.5	0.5
136	0.5	0.5
139	0.5	0.5
141	0.5	0.5
152	0.5	0.5
155	0.5	0.5
248	0.5	0.5
249	0.5	0.5
256	0.5	0.5
268	0.5	0.5
281	0.5	0.5
278	0.5	0.5
276	0.5	0.5
293	0.5	0.5

292	0.5	0.5
319	0.5	0.5
300	0.5	0.5
33	0.5	0.5
51	0.5	0.5
82	0.5	0.5
92	0.5	0.5
54	0.5	0.5
48	0.5	0.5
40	0.5	0.5
44	0.5	0.5
77	0.5	0.5
52	0.5	0.5
92	0.5	0.5
110	0.5	0.5
121	0.5	0.5
114	0.5	0.5
119	0.5	0.5
120	0.5	0.5
124	0.5	0.5
51	0.5	0.5
63	0.5	0.5
75	0.5	0.5
88	0.5	0.5
91	0.5	0.5
91	0.5	0.5
97	0.5	0.5
96	0.5	0.5
142	0.5	0.5
59	0.5	0.5
70	0.5	0.5
78	0.5	0.5
47	0.5	0.5
45	0.5	0.5
53	0.5	0.5
52	0.5	0.5
61	0.5	0.5
44	0.5	0.5
44	0.5	0.5
50	0.5	0.5
55	0.5	0.5
39	0.5	0.5
37	0.5	0.5
48	0.5	0.5
56	0.5	0.5
63	0.5	0.5
71	0.5	0.5
67	0.5	0.5
70	0.5	0.5
31	0.5	0.5

50	0.5	0.5
59	0.5	0.5
68	0.5	0.5
69	0.5	0.5
75	0.5	0.5
72	0.5	0.5
72	0.5	0.5
75	0.5	0.5
101	0.5	0.5
26	0.5	0.5
67	0.5	0.5
4	0.5	0.5
67	0.5	0.5
43	0.5	0.5
51	0.5	0.5
39	0.5	0.5
55	0.5	0.5
61	0.5	0.5
46	0.5	0.5
40	0.5	0.5
37	0.5	0.5
56	0.5	0.5
69	0.5	0.5
83	0.5	0.5
90	0.5	0.5
90	0.5	0.5
93	0.5	0.5
70	0.5	0.5
70	0.5	0.5
5	0.5	0.5
28	0.5	0.5
32	0.5	0.5
35	0.5	0.5
39	0.5	0.5
36	0.5	0.5
48	0.5	0.5
40	0.5	0.5
76	0.5	0.5
67	0.5	0.5
105	0.5	0.5
138	0.5	0.5
152	0.5	0.5
171	0.5	0.5
185	0.5	0.5
217	0.5	0.5
214	0.5	3
238	0.5	0.5
235	0.5	0.5
257	0.5	0.5
275	0.5	0.5

40	0.5	0.5
148	0.5	0.5
55	0.5	0.5
176	0.5	0.5
45	0.5	0.5
33	0.5	0.5
43	0.5	0.5
77	0.5	0.5
32	0.5	0.5
74	0.5	0.5
93	0.5	0.5
110	0.5	0.5
138	0.5	0.5
150	0.5	5
160	0.5	6
168	0.5	0.5
176	0.5	0.5
76	0.5	0.5
219	0.5	6
197	0.5	0.5
33	0.5	0.5
63	0.5	0.5
72	0.5	0.5
70	0.5	0.5
64	0.5	0.5
67	0.5	0.5
74	0.5	0.5
45	0.5	0.5
54	0.5	0.5
47	0.5	0.5
55	0.5	0.5
58	0.5	0.5
79	0.5	0.5
78	0.5	0.5
78	0.5	0.5
78	0.5	0.5
86	0.5	0.5
4	0.5	0.5
42	0.5	0.5
40	0.5	0.5
26	0.5	26
47	0.5	47
64	0.5	64
76	0.5	76
88	0.5	88
100	0.5	100
106	0.5	106
110	0.5	110
113	0.5	113
117	0.5	117

118	0.5	118
122	0.5	122
123	0.5	123
123	0.5	123
34	0.5	0.5
61	0.5	0.5
83	0.5	0.5
58	0.5	0.5
37	0.5	0.5
54	0.5	0.5
58	0.5	0.5
70	0.5	0.5
79	0.5	0.5
86	0.5	0.5
104	0.5	0.5
119	0.5	0.5
134	0.5	0.5
151	0.5	0.5
161	0.5	0.5
163	0.5	0.5
183	0.5	0.5
194	0.5	0.5
30	0.5	0.5
25	0.5	0.5
25	0.5	0.5
22	0.5	0.5
36	0.5	0.5
114	0.5	0.5
68	0.5	0.5
87	0.5	0.5
113	0.5	0.5
134	0.5	0.5
164	0.5	0.5
155	0.5	0.5
165	0.5	0.5
176	0.5	0.5
190	0.5	0.5
199	0.5	0.5
219	0.5	0.5
216	0.5	0.5
222	0.5	0.5
242	0.5	0.5
255	0.5	0.5
260	0.5	0.5
260	0.5	0.5
278	0.5	0.5
276	0.5	0.5
276	0.5	0.5
300	0.5	0.5
302	0.5	0.5

302	0.5	0.5
309	0.5	0.5
316	0.5	0.5
35	0.5	0.5
33	0.5	0.5
50	0.5	0.5
27	0.5	0.5
36	0.5	0.5
46	0.5	0.5
64	0.5	0.5
77	0.5	0.5
88	0.5	0.5
57	0.5	0.5
51	0.5	0.5
41	0.5	0.5
46	0.5	0.5
65	0.5	0.5
67	0.5	0.5
83	0.5	0.5
100	0.5	0.5
102	0.5	0.5
109	0.5	0.5
114	0.5	0.5
116	0.5	0.5
124	0.5	0.5
47	0.5	0.5
63	0.5	0.5
71	0.5	0.5
84	0.5	0.5
87	0.5	0.5
90	0.5	0.5
92	0.5	0.5
96	0.5	0.5
139	0.5	0.5
27	0.5	0.5
57	0.5	0.5
65	0.5	0.5
72	0.5	0.5
51	0.5	0.5
48	0.5	0.5
54	0.5	0.5
49	0.5	0.5
58	0.5	0.5
46	0.5	0.5
48	0.5	0.5
54	0.5	0.5
56	0.5	0.5
37	0.5	0.5
47	0.5	0.5
45	0.5	0.5

54	0.5	0.5
65	0.5	0.5
70	0.5	0.5
70	0.5	0.5
70	0.5	0.5
32	0.5	0.5
50	0.5	0.5
59	0.5	0.5
68	0.5	0.5
70	0.5	0.5
75	0.5	0.5
78	0.5	0.5
82	0.5	0.5
79	0.5	0.5
139	0.5	0.5
26	0.5	0.5
136	0.5	0.5
66	0.5	0.5
45	0.5	0.5
53	0.5	0.5
52	0.5	0.5
58	0.5	0.5
43	0.5	0.5
43	0.5	0.5
40	0.5	0.5
52	0.5	0.5
67	0.5	0.5
81	0.5	0.5
86	0.5	0.5
88	0.5	0.5
93	0.5	0.5
93	0.5	0.5
32	0.5	0.5
70	0.5	0.5
31	0.5	0.5
32	0.5	0.5
35	0.5	0.5
47	0.5	0.5
34	0.5	0.5
40	0.5	0.5
48	0.5	0.5
42	0.5	0.5
47	0.5	0.5
76	0.5	0.5
68	0.5	0.5
105	0.5	0.5
157	0.5	0.5
154	0.5	0.5
175	0.5	0.5
199	0.5	0.5

214	0.5	0.5
213	0.5	4
241	0.5	0.5
237	0.5	0.5
260	0.5	0.5
265	0.5	0.5

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DO NOT change column headings. Values in the Data column must be a number. This data is used for Piper p

Monitoring Point	Date	Calcium (filtered) (mg/L)	Magnesium (filtered) (mg/L)	Sodium (filtered) (mg/L)	Potassium (filtered) (mg/L)	Chloride (mg/L)	Fluoride (mg/L)	Sulfate as SO4 - Turbidimetric (filtered) (mg/L)
CC-05	11 Jan 2015	12	3	6	4	3	0.1	<1
CC-05	03 Jan 2016	22	5	13	3	6	0.1	5
CC-05	04 Jan 2016	30	6	17	4	7	0.2	7
CC-05	05 Jan 2016	34	7	18	4	8	0.2	7
CC-05	07 Jan 2016	1	1	2	4	4	<0.1	1
CC-05	08 Jan 2016	39	8	19	5	8	0.2	8
CC-05	01 Feb 2016	17	3	11	3	4	0.2	2
CC-05	14 Feb 2016	26	6	13	4	4	0.2	3
CC-05	10 Mar 2016	15	3	2	5	1	0.1	<1
CC-05	05 Mar 2018	11	2	5	3	3	<0.1	<1
CC-05	06 Mar 2018	12	3	4	3	3	<0.1	1
CC-05	18 Mar 2018	33	8	12	4	8	<0.1	5
CC-05	19 Mar 2018	33	8	11	5	7	<0.1	5
CC-05	20 Mar 2018	36	8	12	5	8	<0.1	5
CC-05	11 Feb 2019	43	15	27	6	20	0.4	27
CC-05	12 Feb 2019	37	14	27	5	12	0.4	14
CC-05	13 Feb 2019	32	12	26	5	12	0.3	11
CC-05	27 Jan 2020							
CC-05	27 Jan 2020	8	2	6	3	3	0.1	<1
CC-05	28 Jan 2020							
CC-05	28 Jan 2020	10	2	7	3	4	<0.1	<1
CC-05	02 Feb 2020							
CC-05	02 Feb 2020	25	5	16	4	7	0.2	4
CC-05	03 Feb 2020							
CC-05	03 Feb 2020	14	4	17	3	6	0.2	<1
CC-05	08 Feb 2020							
CC-05	08 Feb 2020	20	5	12	3	4	0.2	2
CC-05	06 Mar 2020	16	3	10	3	4	0.2	2
CC-05	08 Mar 2020	28	6	16	4	4	0.2	4
CC-05	24 Dec 2020							
CC-05	24 Dec 2020	12	2	4	4	2	<0.1	<1
CC-05	07 Feb 2023	13	2	3	3	1	<0.1	<1
CC-05	15 Mar 2023	33	14	35	4	13	0.4	9
CC-05	16 Mar 2023	35	15	39	4	14	0.4	11
CC-05	17 Mar 2023	39	17	46	5	16	0.4	12
CC-05	18 Mar 2023	43	18	51	5	18	0.5	13
CC-05	19 Mar 2023	42	17	49	5	18	0.5	13
DR-10	19 Dec 2015	10	2	6	3	2	0.2	<1
DR-10	31 Dec 2015	10	2	7	3	4	0.2	2
DR-10	01 Jan 2016	17	3	10	3	7	0.2	3

DR-10	02 Jan 2016	11	2	5	2	3	<0.1	<1
DR-10	03 Jan 2016	19	3	10	3	6	0.1	4
DR-10	04 Jan 2016	22	5	14	3	8	0.2	6
DR-10	05 Jan 2016	26	6	17	4	10	0.2	8
DR-10	06 Jan 2016	31	7	19	4	12	0.2	10
DR-10	07 Jan 2016	36	8	19	4	8	0.2	8
DR-10	08 Jan 2016							
DR-10	09 Jan 2016	38	8	23	4	14	0.2	13
DR-10	10 Jan 2016	38	10	26	5	15	0.3	16
DR-10	11 Jan 2016	38	10	27	5	15	0.2	16
DR-10	12 Jan 2016	14	3	8	3	5	0.1	4
DR-10	16 Jan 2016							
DR-10	31 Jan 2016	50	12	35	5	21	0.2	18
DR-10	14 Feb 2016	39	10	34	4	17	0.4	14
DR-10	05 Mar 2016	11	2	8	3	4	0.1	<1
DR-10	06 Mar 2016	12	2	7	4	4	0.1	<1
DR-10	07 Mar 2016	13	3	8	4	5	0.1	<1
DR-10	08 Mar 2016	14	3	9	4	4	0.1	<1
DR-10	09 Mar 2016	14	3	9	4	5	0.1	3
DR-10	10 Mar 2016	13	3	8	4	5	0.1	<1
DR-10	11 Mar 2016	14	3	8	4	4	0.1	<1
DR-10	12 Mar 2016	10	2	4	4	2	<0.1	<1
DR-10	13 Mar 2016	12	2	6	3	3	0.1	<1
DR-10	14 Mar 2016	10	2	4	3	2	<0.1	<1
DR-10	15 Mar 2016	12	2	5	3	2	<0.1	<1
DR-10	16 Mar 2016	14	3	6	4	3	0.1	<1
DR-10	17 Mar 2016	20	4	8	4	4	0.1	1
DR-10	18 Mar 2016	20	4	8	4	4	0.1	2
DR-10	19 Mar 2016	20	4	8	4	4	0.1	2
DR-10	20 Mar 2016	20	4	8	4	4	0.1	1
DR-10	21 Mar 2016	19	4	9	4	4	0.1	3
DR-10	23 May 2016	8	1	2	4	2	<0.1	<1
DR-10	24 May 2016	8	1	2	4	2	<0.1	2
DR-10	25 May 2016	9	2	2	4	2	<0.1	2
DR-10	09 Mar 2017	10	2	6	2	3	0.1	2
DR-10	10 Mar 2017	14	3	12	3	4	0.2	2
DR-10	11 Mar 2017	18	3	10	8	4	0.2	2
DR-10	12 Mar 2017	20	4	12	4	4	0.2	2
DR-10	13 Mar 2017	22	5	13	4	5	0.2	3
DR-10	14 Mar 2017	23	5	4	12	5	0.2	3
DR-10	16 Mar 2017	25	5	12	4	5	0.2	3
DR-10	17 Mar 2017	25	5	4	12	5	0.2	3
DR-10	18 Mar 2017	25	5	12	4	5	0.2	3
DR-10	19 Mar 2017	25	5	12	4	5	0.2	3
DR-10	20 Mar 2017	26	5	13	4	5	0.2	3
DR-10	20 Mar 2017	26	5	12	4	5	0.2	3
DR-10	21 Mar 2017	26	5	13	4	5	0.2	3
DR-10	12 Mar 2018	16	4	13	3	7	0.1	4
DR-10	15 Mar 2018	25	6	15	4	10	<0.1	6
DR-10	17 Mar 2018	29	7	16	4	10	0.1	7

DR-10	18 Mar 2018	31	7	17	4	11	0.1	7
DR-10	19 Mar 2018	33	8	18	4	12	0.1	7
DR-10	20 Mar 2018	34	8	18	5	13	<0.1	7
DR-10	21 Mar 2018	36	8	20	5	13	<0.1	9
DR-10	22 Mar 2018	36	9	21	5	14	<0.1	9
DR-10	23 Mar 2018	36	9	21	5	14	<0.1	9
DR-10	20 Feb 2019	51	17	48	6	29	0.4	20
DR-10	21 Feb 2019	54	17	50	7	39	0.4	22
DR-10	22 Feb 2019	55	18	53	7	33	0.4	21
DR-10	23 Feb 2019	57	19	55	7	35	0.4	26
DR-10	24 Feb 2019	59	19	56	7	36	0.4	28
DR-10	25 Feb 2019	57	19	55	7	35	0.4	25
DR-10	26 Feb 2019	58	20	58	7	36	0.4	30
DR-10	27 Feb 2019	61	20	63	7	42	0.4	26
DR-10	28 Feb 2019	62	21	64	7	42	0.4	30
DR-10	01 Mar 2019	63	21	66	7	42	0.4	34
DR-10	02 Mar 2019	64	21	68	7	46	0.4	34
DR-10	27 Jan 2020							
DR-10	27 Jan 2020	6	<1	4	2	1	0.1	<1
DR-10	28 Jan 2020							
DR-10	28 Jan 2020	12	2	7	3	4	0.1	3
DR-10	02 Feb 2020							
DR-10	02 Feb 2020	18	5	16	4	8	0.2	5
DR-10	03 Feb 2020							
DR-10	03 Feb 2020	20	6	18	4	9	0.2	6
DR-10	04 Feb 2020							
DR-10	04 Feb 2020	12	3	8	3	5	0.1	2
DR-10	05 Feb 2020							
DR-10	05 Feb 2020	10	2	7	2	4	0.1	2
DR-10	06 Feb 2020							
DR-10	06 Feb 2020	7	2	8	2	3	0.2	1
DR-10	07 Feb 2020							
DR-10	07 Feb 2020	8	2	8	2	3	0.2	2
DR-10	08 Feb 2020							
DR-10	08 Feb 2020	15	3	12	3	4	0.2	3
DR-10	09 Feb 2020							
DR-10	09 Feb 2020	11	3	8	3	4	0.1	3
DR-10	10 Feb 2020							
DR-10	10 Feb 2020	18	4	15	3	7	0.2	4
DR-10	11 Feb 2020							
DR-10	11 Feb 2020	24	6	21	4	10	0.2	5
DR-10	12 Feb 2020							
DR-10	12 Feb 2020	24	6	20	4	11	0.2	6
DR-10	13 Feb 2020							
DR-10	13 Feb 2020	24	6	20	4	10	0.2	5
DR-10	14 Feb 2020							
DR-10	14 Feb 2020	24	6	20	3	11	0.2	6
DR-10	15 Feb 2020							
DR-10	15 Feb 2020	25	6	21	4	11	0.2	4
DR-10	16 Feb 2020							

DR-10	16 Feb 2020	26	6	20	4	10	0.2	5
DR-10	06 Mar 2020	10	2	8	2	4	0.1	2
DR-10	07 Mar 2020	13	3	10	3	5	0.2	3
DR-10	08 Mar 2020	17	4	13	3	6	0.2	4
DR-10	09 Mar 2020	20	5	14	4	7	0.2	4
DR-10	10 Mar 2020							
DR-10	10 Mar 2020	19	5	14	3	7	0.1	5
DR-10	11 Mar 2020							
DR-10	11 Mar 2020	18	4	14	3	7	0.1	5
DR-10	12 Mar 2020							
DR-10	12 Mar 2020	20	5	16	3	7	0.1	5
DR-10	13 Mar 2020							
DR-10	13 Mar 2020	20	5	15	3	7	0.1	2
DR-10	25 Apr 2020	30	8	24	5	9	0.2	4
DR-10	24 Dec 2020							
DR-10	24 Dec 2020	14	2	8	3	5	0.1	3
DR-10	25 Dec 2020							
DR-10	25 Dec 2020	18	3	10	4	6	0.1	4
DR-10	26 Dec 2020							
DR-10	26 Dec 2020	22	4	11	4	7	0.1	5
DR-10	27 Dec 2020							
DR-10	27 Dec 2020	11	2	3	3	2	<0.1	<1
DR-10	28 Dec 2020							
DR-10	28 Dec 2020	10	2	4	2	2	<0.1	<1
DR-10	29 Dec 2020							
DR-10	29 Dec 2020	13	3	5	3	2	<0.1	<1
DR-10	30 Dec 2020							
DR-10	30 Dec 2020	15	3	5	4	3	<0.1	<1
DR-10	31 Dec 2020							
DR-10	31 Dec 2020	16	3	6	4	3	<0.1	1
DR-10	03 Feb 2021							
DR-10	03 Feb 2021	11	2	3	4	2	<0.1	<1
DR-10	04 Feb 2021							
DR-10	04 Feb 2021	11	2	3	4	2	<0.1	<1
DR-10	05 Feb 2021							
DR-10	05 Feb 2021	13	2	3	4	2	<0.1	2
DR-10	06 Feb 2021							
DR-10	06 Feb 2021	14	2	4	4	2	<0.1	<1
DR-10	07 Feb 2021							
DR-10	07 Feb 2021	8	1	2	3	1	<0.1	<1
DR-10	08 Feb 2021							
DR-10	08 Feb 2021	8	1	6	2	2	0.1	<1
DR-10	09 Feb 2021							
DR-10	09 Feb 2021	11	2	7	3	4	0.1	<1
DR-10	10 Feb 2021							
DR-10	10 Feb 2021	14	2	7	3	2	0.1	<1
DR-10	11 Feb 2021							
DR-10	11 Feb 2021	16	3	8	3	2	0.1	1
DR-10	12 Feb 2021							
DR-10	12 Feb 2021	17	3	8	3	2	0.1	3

DR-10	13 Feb 2021							
DR-10	13 Feb 2021	18	2	7	3	3	0.1	1
DR-10	14 Feb 2021							
DR-10	14 Feb 2021	18	2	7	3	3	0.1	<1
DR-10	15 Feb 2021							
DR-10	15 Feb 2021	7	1	6	2	2	0.1	<1
DR-10	16 Feb 2021							
DR-10	16 Feb 2021	13	2	7	3	2	0.1	<1
DR-10	17 Feb 2021							
DR-10	17 Feb 2021	16	3	8	3	3	0.1	2
DR-10	18 Feb 2021							
DR-10	18 Feb 2021	19	3	9	3	3	0.1	2
DR-10	19 Feb 2021							
DR-10	19 Feb 2021	18	3	8	3	3	0.1	2
DR-10	20 Feb 2021							
DR-10	20 Feb 2021	19	3	8	3	3	0.1	2
DR-10	21 Feb 2021							
DR-10	21 Feb 2021	19	3	8	3	3	0.1	2
DR-10	22 Feb 2021							
DR-10	22 Feb 2021	20	3	9	3	3	0.1	2
DR-10	23 Feb 2021							
DR-10	23 Feb 2021	20	3	9	3	4	0.1	2
DR-10	18 May 2021	22	3.7	9.6	5	3.7	0.24	0.5
DR-10	18 May 2021							
DR-10	03 Sep 2021	8	1	2	4	1	<0.1	<2
DR-10 R1	30 Sep 2021	21	3	2	6	2	0.1	<1
DR-10 R2 (	30 Sep 2021	<1	<1	<1	<1	<1	<0.1	<1
DR-10	21 Jan 2022							
DR-10	21 Jan 2022	26	3	2	5	2	0.1	<1
DR-10	22 Jan 2022							
DR-10	22 Jan 2022	13	2	2	4	2	<0.1	<1
DR-10	23 Jan 2022							
DR-10	23 Jan 2022	15	2	2	4	2	<0.1	<1
DR-10	26 Jan 2022							
DR-10	26 Jan 2022	11	2	3	2	2	<0.1	<1
DR-10	27 Jan 2022							
DR-10	27 Jan 2022	16	2	3	4	2	<0.1	<1
DR-10	28 Jan 2022							
DR-10	28 Jan 2022	17	2	3	4	2	<0.1	<1
DR-10	29 Jan 2022							
DR-10	29 Jan 2022	12	2	4	3	2	<0.1	<1
DR-10	30 Jan 2022							
DR-10	30 Jan 2022	10	2	5	2	2	<0.1	<1
DR-10	31 Jan 2022							
DR-10	31 Jan 2022	8	1	5	2	2	<0.1	<1
DR-10	01 Feb 2022							
DR-10	01 Feb 2022	14	2	6	3	2	<0.1	<1
DR-10	02 Feb 2022							
DR-10	02 Feb 2022	18	3	7	3	3	0.2	<1
DR-10	03 Feb 2022							

DR-10	03 Feb 2022	21	4	8	4	4	0.2	<1
DR-10	04 Feb 2022							
DR-10	04 Feb 2022	23	4	8	4	4	0.2	1
DR-10	05 Feb 2022							
DR-10	05 Feb 2022	24	4	8	4	4	0.2	1
DR-10	06 Feb 2022							
DR-10	06 Feb 2022	21	4	9	4	4	0.2	1
DR-10	30 Mar 2022	19	3	3	5	3	0.1	1
DR-10 R1	29 Sep 2022	17	3	<1	4	2	<0.1	<1
DR-10 R2	29 Sep 2022	<1	<1	<1	<1	<1	<0.1	<1
DR-10	28 Nov 2022	8	1	1	3	1	<0.1	<1
DR-10	25 Dec 2022							
DR-10	25 Dec 2022	9	1	3	3	2	<0.1	<1
DR-10	27 Dec 2022	10	1	3	3	2	<0.1	<1
DR-10	14 Jan 2023	10	2	3	3	1	<0.1	<1
DR-10	07 Feb 2023	7	1	3	3	1	<0.1	<1
DR-10	08 Feb 2023	12	2	4	3	2	<0.1	<1
DR-10	07 Mar 2023	6	2	9	2	3	0.2	<1
DR-10	11 Mar 2023	16	5	9	3	5	0.1	4
DR-10	12 Mar 2023	18	4	7	3	4	0.1	3
DR-10	13 Mar 2023	27	7	15	4	8	0.2	6
DR-10	14 Mar 2023	34	10	22	4	11	0.2	9
DR-10	15 Mar 2023	37	12	26	5	12	0.2	11
DR-10	16 Mar 2023	41	13	30	5	14	0.2	12
DR-10	17 Mar 2023	44	14	34	5	17	0.3	15
DR-10	18 Mar 2023	50	17	40	6	22	0.3	17
DR-10	19 Mar 2023	50	17	41	6	21	0.3	17
DR-10	20 Mar 2023	55	19	46	6	24	0.3	20
DR-10	21 Mar 2023	56	19	47	6	24	0.3	20
DR-10	22 Mar 2023	55	19	52	5	25	0.4	20
DR-10	23 Mar 2023	59	20	56	6	27	0.4	21
DR-10 (Du	17 Jan 2015							
DR-14	17 Jan 2015	9	2	3	6	2	0.1	<1
DR-14	24 Jan 2015	37	9	26	5	17	0.2	10
DR-14	26 Jan 2015	18	4	9	4	7	<0.1	4
DR-14	31 Jan 2015	42	12	33	5	20	0.2	16
DR-14	19 Dec 2015	10	2	5	5	2	0.1	<1
DR-14	30 Dec 2015	8	1	4	2	2	<0.1	5
DR-14	31 Dec 2015	9	2	6	3	3	0.1	1
DR-14	01 Jan 2016	17	3	10	3	6	0.2	3
DR-14	02 Jan 2016	6	1	3	2	2	<0.1	<1
DR-14	03 Jan 2016	17	3	10	3	6	0.1	4
DR-14	04 Jan 2016	21	5	13	3	8	0.2	6
DR-14	05 Jan 2016	25	6	16	4	10	0.2	8
DR-14	07 Jan 2016	33	7	20	4	13	0.2	11
DR-14	08 Jan 2016	35	8	21	4	14	0.2	12
DR-14	09 Jan 2016	38	9	23	4	15	0.2	13
DR-14	10 Jan 2016	37	10	26	4	16	0.2	15
DR-14	11 Jan 2016	38	11	27	4	16	0.2	16
DR-14	12 Jan 2016	16	3	10	3	5	0.1	4

DR-14	16 Jan 2016							
DR-14	31 Jan 2016	49	12	33	5	18	0.2	16
DR-14	14 Feb 2016	43	12	37	4	19	0.3	16
DR-14	05 Mar 2016	7	1	4	3	2	<0.1	<1
DR-14	06 Mar 2016	14	3	9	4	5	0.1	<1
DR-14	07 Mar 2016	16	3	8	4	5	0.1	<1
DR-14	08 Mar 2016	16	3	9	4	4	0.1	<1
DR-14	09 Mar 2016	15	3	8	4	4	0.1	1
DR-14	10 Mar 2016	15	3	8	4	5	0.1	1
DR-14	11 Mar 2016	17	4	9	4	5	0.1	2
DR-14	12 Mar 2016	10	2	4	4	2	0.1	<1
DR-14	13 Mar 2016	12	2	5	4	2	0.1	<1
DR-14	14 Mar 2016	10	2	4	3	2	<0.1	<1
DR-14	15 Mar 2016	12	2	5	3	2	<0.1	<1
DR-14	16 Mar 2016	14	3	5	4	3	<0.1	<1
DR-14	17 Mar 2016	18	4	7	4	4	0.1	<1
DR-14	18 Mar 2016	18	4	7	4	4	0.1	<1
DR-14	19 Mar 2016	18	4	7	4	4	0.1	<1
DR-14	20 Mar 2016	18	4	7	4	4	0.1	<1
DR-14	21 Mar 2016	19	4	8	4	4	0.1	2
DR-14	23 May 2016	8	1	2	4	2	<0.1	<1
DR-14	24 May 2016	9	1	2	4	2	<0.1	1
DR-14	25 May 2016	10	2	2	4	2	<0.1	2
DR-14	08 Mar 2017	5	<1	3	2	2	0.2	<1
DR-14	09 Mar 2017	10	2	6	2	3	0.2	1
DR-14	10 Mar 2017	14	3	13	3	4	0.2	2
DR-14	11 Mar 2017	16	3	9	3	4	0.2	2
DR-14	12 Mar 2017	19	4	12	4	4	0.2	2
DR-14	13 Mar 2017	22	6	13	4	5	0.2	2
DR-14	14 Mar 2017	24	5	4	12	5	0.2	3
DR-14	16 Mar 2017	26	5	13	4	5	0.2	3
DR-14	17 Mar 2017	27	6	4	13	5	0.2	3
DR-14	18 Mar 2017	27	6	13	4	5	0.2	3
DR-14	19 Mar 2017	28	6	13	4	5	0.2	3
DR-14	20 Mar 2017	28	6	13	4	6	0.2	3
DR-14	20 Mar 2017	28	6	13	4	6	0.2	3
DR-14	21 Mar 2017	28	6	13	4	6	0.2	3
DR-14	04 Mar 2018	8	1	2	3	3	<0.1	<1
DR-14	05 Mar 2018	17	3	7	3	6	<0.1	3
DR-14	06 Mar 2018	21	5	7	4	6	<0.1	3
DR-14	07 Mar 2018	11	2	12	3	8	<0.1	5
DR-14	08 Mar 2018	8	2	2	2	3	<0.1	3
DR-14	09 Mar 2018	10	2	11	3	6	0.1	3
DR-14	10 Mar 2018	12	3	11	3	6	<0.1	3
DR-14	11 Mar 2018	14	4	12	3	7	0.1	4
DR-14	12 Mar 2018	16	4	13	3	8	0.1	4
DR-14	13 Mar 2018	18	5	14	3	8	0.1	
DR-14	15 Mar 2018	26	6	16	4	11	<0.1	6
DR-14	17 Mar 2018	30	8	17	4	12	0.1	8
DR-14	18 Mar 2018	34	8	19	4	14	<0.1	8

DR-14	19 Mar 2018	36	9	20	4	15	0.1	9
DR-14	20 Mar 2018	41	10	21	5	18	<0.1	10
DR-14	21 Mar 2018	43	10	22	5	22	<0.1	11
DR-14	22 Mar 2018	46	12	25	5	24	<0.1	11
DR-14	23 Mar 2018	47	12	25	5	24	<0.1	11
DR-14	31 Jan 2019	5	1	3	3	2	<0.1	<5
DR-14	01 Feb 2019	4	<1	3	2	1	0.5	0.5
DR-14	02 Feb 2019	6	0.5	1	1	0.5	0.5	3
DR-14	03 Feb 2019	5	1	2	2	0.5	0.5	2
DR-14	04 Feb 2019	12	2	3	2	1	0.5	4
DR-14	05 Feb 2019	48	8	4	4	3	0.1	36
DR-14	06 Feb 2019	14	5	9	4	4	0.2	4
DR-14	07 Feb 2019	19	7	12	4	5	0.1	5
DR-14	08 Feb 2019	28	8	16	4	8	0.2	8
DR-14	09 Feb 2019	33	10	20	5	9	0.2	10
DR-14	10 Feb 2019	34	11	22	5	10	0.3	10
DR-14	11 Feb 2019	34	13	24	5	8	0.2	8
DR-14	12 Feb 2019	39	14	29	5	21	0.3	11
DR-14	13 Feb 2019	36	14	31	6	21	0.3	11
DR-14	14 Feb 2019	43	15	36	6	21	0.3	15
DR-14	15 Feb 2019	42	15	37	6	22	0.3	15
DR-14	16 Feb 2019	44	16	40	6	26	0.3	15
DR-14	17 Feb 2019	48	18	45	6	27	0.3	19
DR-14	18 Feb 2019	47	17	48	6	27	0.3	19
DR-14	19 Feb 2019	51	17	47	6	34	0.4	18
DR-14	20 Feb 2019	52	17	49	6	30	0.4	22
DR-14	21 Feb 2019	54	17	51	7	36	0.4	22
DR-14	22 Feb 2019	56	18	55	7	36	0.4	27
DR-14	23 Feb 2019	58	19	56	7	35	0.4	25
DR-14	24 Feb 2019	59	19	58	7	37	0.4	30
DR-14	25 Feb 2019	59	20	58	7	42	0.4	23
DR-14	26 Feb 2019	59	20	59	7	41	0.4	30
DR-14	27 Feb 2019	62	21	65	7	44	0.4	26
DR-14	28 Feb 2019	63	21	65	7	44	0.4	31
DR-14	01 Mar 2019	64	21	67	7	46	0.4	34
DR-14	02 Mar 2019	66	22	69	8	48	0.4	36
DR-14	26 Jan 2020							
DR-14	26 Jan 2020	8	1	4	3	2	<0.1	<1
DR-14	27 Jan 2020							
DR-14	27 Jan 2020	6	1	4	2	1	0.1	<1
DR-14	28 Jan 2020							
DR-14	28 Jan 2020	12	2	8	3	5	0.1	3
DR-14	29 Jan 2020							
DR-14	29 Jan 2020	13	2	2	2	2	<0.1	21
DR-14	30 Jan 2020							
DR-14	30 Jan 2020	8	2	8	2	6	<0.1	4
DR-14	31 Jan 2020							
DR-14	31 Jan 2020	9	2	11	3	6	0.2	2
DR-14	01 Feb 2020							
DR-14	01 Feb 2020	14	4	14	4	8	0.2	5

DR-14	02 Feb 2020							
DR-14	02 Feb 2020	17	5	16	4	9	0.2	6
DR-14	03 Feb 2020							
DR-14	03 Feb 2020	21	5	17	4	10	0.2	6
DR-14	04 Feb 2020	12	3	9	3	5	0.2	3
DR-14	05 Feb 2020							
DR-14	05 Feb 2020	11	3	7	3	4	0.1	2
DR-14	06 Feb 2020							
DR-14	06 Feb 2020	8	2	8	3	3	0.2	1
DR-14	07 Feb 2020							
DR-14	07 Feb 2020	9	2	8	2	3	0.2	2
DR-14	08 Feb 2020							
DR-14	08 Feb 2020	14	3	12	3	4	0.2	3
DR-14	09 Feb 2020							
DR-14	09 Feb 2020	15	3	10	3	4	0.2	3
DR-14	10 Feb 2020							
DR-14	10 Feb 2020	18	4	13	3	6	0.2	3
DR-14	11 Feb 2020							
DR-14	11 Feb 2020	20	5	17	3	9	0.2	5
DR-14	12 Feb 2020							
DR-14	12 Feb 2020	22	5	18	4	9	0.2	4
DR-14	13 Feb 2020							
DR-14	13 Feb 2020	22	5	19	4	9	0.2	5
DR-14	14 Feb 2020							
DR-14	14 Feb 2020	23	6	19	4	12	0.2	5
DR-14	15 Feb 2020							
DR-14	15 Feb 2020	25	6	20	4	10	0.2	4
DR-14	16 Feb 2020							
DR-14	16 Feb 2020	26	6	21	4	11	0.2	6
DR-14	06 Mar 2020	10	2	8	2	4	0.1	2
DR-14	07 Mar 2020	12	3	10	3	5	0.1	4
DR-14	08 Mar 2020	15	4	12	3	6	0.1	3
DR-14	09 Mar 2020	18	4	13	4	8	0.2	4
DR-14	10 Mar 2020							
DR-14	10 Mar 2020	18	4	13	3	7	0.1	4
DR-14	11 Mar 2020							
DR-14	11 Mar 2020	18	5	14	3	6	0.1	4
DR-14	12 Mar 2020							
DR-14	12 Mar 2020	20	5	14	4	6	0.1	4
DR-14	13 Mar 2020							
DR-14	13 Mar 2020	21	5	14	4	7	0.1	4
DR-14	04 Apr 2020							
DR-14	23 Apr 2020	30	8	24	5	10	0.2	3
DR-14	23 Dec 2020							
DR-14	23 Dec 2020	4	<1	<1	1	1	<0.1	<1
DR-14	24 Dec 2020							
DR-14	24 Dec 2020	13	2	8	3	5	0.1	3
DR-14	25 Dec 2020							
DR-14	25 Dec 2020	17	3	10	3	6	0.2	4
DR-14	26 Dec 2020							

DR-14	26 Dec 2020	20	4	11	4	8	0.2	4
DR-14	27 Dec 2020							
DR-14	27 Dec 2020	13	2	5	3	4	<0.1	2
DR-14	28 Dec 2020							
DR-14	28 Dec 2020	11	2	4	3	2	<0.1	<1
DR-14	29 Dec 2020							
DR-14	29 Dec 2020	14	3	5	3	3	<0.1	<1
DR-14	30 Dec 2020							
DR-14	30 Dec 2020	15	3	5	3	2	<0.1	<1
DR-14	31 Dec 2020							
DR-14	31 Dec 2020	15	3	5	3	3	<0.1	1
DR-14	03 Feb 2021							
DR-14	03 Feb 2021	11	2	3	4	1	<0.1	<1
DR-14	04 Feb 2021							
DR-14	04 Feb 2021	11	2	3	4	1	<0.1	<1
DR-14	05 Feb 2021							
DR-14	05 Feb 2021	13	2	3	4	2	<0.1	<1
DR-14	06 Feb 2021							
DR-14	06 Feb 2021	14	2	4	4	2	<0.1	1
DR-14	07 Feb 2021							
DR-14	07 Feb 2021	8	1	2	2	1	<0.1	<1
DR-14	08 Feb 2021							
DR-14	08 Feb 2021	8	1	7	2	3	0.1	<1
DR-14	09 Feb 2021							
DR-14	09 Feb 2021	11	2	7	3	2	0.1	<1
DR-14	10 Feb 2021							
DR-14	10 Feb 2021	13	2	7	3	2	0.1	<1
DR-14	11 Feb 2021							
DR-14	11 Feb 2021	16	3	7	3	2	0.1	<1
DR-14	12 Feb 2021							
DR-14	12 Feb 2021	17	3	7	3	2	0.1	<1
DR-14	13 Feb 2021							
DR-14	13 Feb 2021	18	3	7	3	3	0.1	1
DR-14	14 Feb 2021							
DR-14	14 Feb 2021	19	3	7	3	3	0.1	<1
DR-14	15 Feb 2021							
DR-14	15 Feb 2021	7	1	6	2	1	0.1	<1
DR-14	16 Feb 2021							
DR-14	16 Feb 2021	13	2	7	3	3	0.1	<1
DR-14	17 Feb 2021							
DR-14	17 Feb 2021	15	3	8	3	3	0.1	<1
DR-14	18 Feb 2021							
DR-14	18 Feb 2021	18	3	9	3	3	0.1	1
DR-14	19 Feb 2021							
DR-14	19 Feb 2021	19	3	9	3	4	0.1	2
DR-14	20 Feb 2021							
DR-14	20 Feb 2021	16	3	7	3	3	0.1	1
DR-14	21 Feb 2021							
DR-14	21 Feb 2021	20	4	9	4	4	0.1	2
DR-14	22 Feb 2021							

DR-14	22 Feb 2021	21	4	9	4	4	0.1	2
DR-14	23 Feb 2021							
DR-14	23 Feb 2021	22	4	9	4	4	0.1	2
DR-14	19 May 2021	36	5.5	9.7	4.6	3.5	0.21	<0.3
DR-14	19 May 2021							
DR-14	03 Sep 2021	8	1	2	4	1	<0.1	<2
DR-14	30 Sep 2021	40	7	8	9	4	0.2	<1
DR-14	21 Jan 2022	25	3	2	5	2	<0.1	<1
DR-14	22 Jan 2022							
DR-14	22 Jan 2022	13	2	2	4	2	<0.1	<1
DR-14	23 Jan 2022							
DR-14	23 Jan 2022	15	2	2	4	2	<0.1	<1
DR-14	27 Jan 2022							
DR-14	27 Jan 2022	16	2	3	4	2	<0.1	<1
DR-14	28 Jan 2022							
DR-14	28 Jan 2022	18	3	3	4	2	<0.1	<1
DR-14	29 Jan 2022							
DR-14	29 Jan 2022	12	2	4	3	2	<0.1	<1
DR-14	30 Jan 2022							
DR-14	30 Jan 2022	10	2	5	2	2	<0.1	<1
DR-14	31 Jan 2022							
DR-14	31 Jan 2022	8	1	5	2	2	<0.1	<1
DR-14	01 Feb 2022							
DR-14	01 Feb 2022	13	2	5	3	2	<0.1	<1
DR-14	02 Feb 2022							
DR-14	02 Feb 2022	18	3	7	3	3	0.2	<1
DR-14	03 Feb 2022							
DR-14	03 Feb 2022	20	4	7	4	4	0.2	<1
DR-14	04 Feb 2022							
DR-14	04 Feb 2022	23	4	8	4	4	0.2	<1
DR-14	05 Feb 2022							
DR-14	05 Feb 2022	24	4	8	4	4	0.2	<1
DR-14	06 Feb 2022							
DR-14	06 Feb 2022	22	4	8	4	4	0.2	1
DR-14 R1	31 Mar 2022	24	4	5	5	5	0.1	1
DR-14 R2 (	31 Mar 2022	7	2	10	2	14	<0.1	<1
DR-14	28 Sep 2022	16	3	3	3	2	<0.1	<1
DR-14	28 Nov 2022	8	1	2	3	1	<0.1	<1
DR-14	25 Dec 2022							
DR-14	25 Dec 2022	9	1	4	3	2	<0.1	<1
DR-14	27 Dec 2022	10	1	3	3	2	<0.1	<1
DR-14	14 Jan 2023	14	3	3	3	2	<0.1	<1
DR-14	07 Feb 2023	7	1	3	2	1	<0.1	<1
DR-14	08 Feb 2023	12	2	4	3	2	<0.1	<1
DR-14	07 Mar 2023	6	1	9	2	4	0.2	<1
DR-14	09 Mar 2023	10	2	4	3	2	<0.1	1
DR-14	10 Mar 2023	12	3	6	3	3	<0.1	3
DR-14	11 Mar 2023	16	5	9	3	5	0.1	4
DR-14	12 Mar 2023	18	4	7	3	4	0.1	3
DR-14	13 Mar 2023	27	7	15	4	8	0.2	6

DR-14	14 Mar 2023	38	10	22	4	12	0.2	12
DR-14	15 Mar 2023	37	12	25	5	12	0.2	12
DR-14	16 Mar 2023	42	13	30	5	15	0.2	15
DR-14	17 Mar 2023	51	15	34	5	20	0.2	17
DR-14	18 Mar 2023	52	17	40	6	20	0.3	18
DR-14	19 Mar 2023	50	17	40	6	21	0.3	18
DR-14	20 Mar 2023	55	19	48	6	24	0.3	21
DR-14	21 Mar 2023	54	19	47	6	25	0.3	21
DR-14	22 Mar 2023	56	19	53	5	27	0.4	20
DR-14	23 Mar 2023	60	20	56	6	30	0.4	22

lots in Power BI. Cells can be blank. DATA IN THIS SHEET ARE EXACTLY AS RECORDED BY MMG

Sulphur as S (filtered) (mg/L)	Bicarbonate as CaCO3 (mg/L)	Total Alkalinity as CaCO3 (mg/L)	Hydroxide Alkalinity as CaCO3 (mg/L)	Carbonate Alkalinity as CaCO3 (mg/L)	Total Hardness as CaCO3 (mg/L)	Total Hardness as CaCO3 (filtered) (mg/L)	Total Anions (meq/L)	Total Anions (mg/L)
	50	50	<1	<1		42	1.12	
	99	99	<1	<1		76	2.25	
	121	121	<1	<1		100	2.76	
	140	140	<1	<1		114	3.17	
	7	7	<1	<1		7	0.27	
	153	163	<1	10		130	3.65	
	82	82	<1	<1		55	1.79	
	121	121	<1	<1		90	2.59	
	61	61	<1	<1		50	1.25	
	43	43	<1	<1		36	0.94	
	52	52	<1	<1		42	1.14	
	127	127	<1	<1		115	2.87	
	126	131	<1	5		115	2.92	
	128	134	<1	6		123	3.01	
	171	171	<1	<1		169	4.54	
	166	166	<1	<1		150	3.95	
	162	162	<1	<1		129	3.8	
	36	36	<1	<1		28	0.8	
	44	44	<1	<1		33	0.99	
	100	100	<1	<1		83	2.28	
	74	74	<1	<1		51	1.65	
	91	91	<1	<1		70	1.97	
	68	68	<1	<1		52	1.51	
	115	115	<1	<1		95	2.49	
	52	52	<1	<1		38	1.1	
	47	47	<1	<1		41	0.97	
	176	176	<1	<1		140	4.07	
	194	194	<1	<1		149	4.5	
	204	213	<1	10		167	4.96	
	230	230	<1	<1		181	5.37	
	216	227	<1	11		175	5.31	
	46	46	<1	<1		33	0.98	
	47	47	<1	<1		33	1.09	
	76	76	<1	<1		55	1.78	

53	53	<1	<1	36	1.14
80	80	<1	<1	60	1.85
92	92	<1	<1	76	2.19
111	111	<1	<1	90	2.67
131	131	<1	<1	106	3.16
138	150	<1	12	123	3.39
156	161	<1	5	128	3.88
172	172	<1	<1	136	4.19
174	174	<1	<1	136	4.23
66	66	<1	<1	47	1.54
223	223	<1	<1	174	5.42
180	180	<1	<1	138	4.37
54	54	<1	<1	36	1.19
53	53	<1	<1	38	1.17
64	64	<1	<1	45	1.42
64	64	<1	<1	47	1.39
67	67	<1	<1	47	1.54
58	58	<1	<1	45	1.3
63	63	<1	<1	47	1.37
45	45	<1	<1	33	0.96
55	55	<1	<1	38	1.18
47	47	<1	<1	33	0.94
56	56	<1	<1	38	1.18
68	68	<1	<1	47	1.44
83	83	<1	<1	66	1.79
84	84	<1	<1	66	1.83
81	81	<1	<1	66	1.77
83	83	<1	<1	66	1.79
87	87	<1	<1	64	1.91
39	39	<1	<1	24	0.84
38	38	<1	<1	24	0.86
45	45	<1	<1	31	1
<1	48	<1	48	33	1.08
<1	68	<1	68	47	1.51
<1	80	<1	80	57	1.75
<1	89	<1	89	66	1.93
<1	101	<1	101	76	2.22
<1	106	<1	106	78	2.32
<1	107	<1	107	83	2.34
<1	107	<1	107	83	2.34
<1	109	<1	109	83	2.38
<1	109	<1	109	83	2.38
<1	114	<1	114	86	2.48
<1	111	<1	111	86	2.42
<1	114	<1	114	86	2.48
79	79	<1	<1	56	1.86
104	104	<1	<1	87	2.48
117	117	<1	<1	101	2.76

134	134	<1	<1	106	3.13
136	136	<1	<1	115	3.2
139	139	<1	<1	118	3.29
141	141	<1	<1	123	3.37
152	152	<1	<1	127	3.62
155	155	<1	<1	127	3.68
248	248	<1	<1	197	6.19
249	249	<1	<1	205	6.53
256	256	<1	<1	211	6.48
268	268	<1	<1	220	6.88
281	281	<1	<1	226	7.21
278	278	<1	<1	220	7.06
276	276	<1	<1	227	7.15
293	293	<1	<1	235	7.58
292	292	<1	<1	241	7.64
319	319	<1	<1	244	8.27
300	300	<1	<1	246	8
33	33	<1	<1	15	0.69
51	51	<1	<1	38	1.19
82	82	<1	<1	66	1.97
92	92	<1	<1	75	2.22
54	54	<1	<1	42	1.26
48	48	<1	<1	33	1.11
40	40	<1	<1	26	0.9
44	44	<1	<1	28	1
77	77	<1	<1	50	1.71
52	52	<1	<1	40	1.21
92	92	<1	<1	61	2.12
110	110	<1	<1	85	2.58
121	121	<1	<1	85	2.85
114	114	<1	<1	85	2.66
119	119	<1	<1	85	2.81
120	120	<1	<1	87	2.79

124	124	<1	<1	90	2.86
51	51	<1	<1	33	1.17
63	63	<1	<1	45	1.46
75	75	<1	<1	59	1.75
88	88	<1	<1	70	2.04
91	91	<1	<1	68	2.12
91	91	<1	<1	61	2.12
97	97	<1	<1	70	2.24
96	96	<1	<1	70	2.16
142	142	<1	<1	108	3.17
59	59	<1	<1	43	1.38
70	70	<1	<1	57	1.65
78	78	<1	<1	71	1.86
47	47	<1	<1	36	1
45	45	<1	<1	33	0.96
53	53	<1	<1	45	1.12
52	52	<1	<1	50	1.12
61	61	<1	<1	52	1.32
44	44	<1	<1	36	0.94
44	44	<1	<1	36	0.94
50	50	<1	<1	41	1.1
55	55	<1	<1	43	1.16
39	39	<1	<1	24	0.81
37	37	<1	<1	24	0.8
48	48	<1	<1	36	1.07
56	56	<1	<1	43	1.18
63	63	<1	<1	52	1.34
71	71	<1	<1	55	1.54

	67	67	<1	<1		53	1.44	
	70	70	<1	<1		53	1.48	
	31	31	<1	<1		22	0.68	
	50	50	<1	<1		41	1.06	
	59	59	<1	<1		52	1.3	
	68	68	<1	<1		60	1.48	
	69	69	<1	<1		57	1.5	
	75	75	<1	<1		60	1.62	
	72	72	<1	<1		60	1.56	
	72	72	<1	<1		62	1.56	
	75	75	<1	<1		62	1.65	
0.16	101	101	<1	<1	70			64.3
	26	26	<1	<1		24	0.55	
	67	67	<1	<1		65	1.4	
	4	4	<1	<1		<1	0.08	
	67	67	<1	<1		77	1.4	
	43	43	<1	<1		41	0.92	
	51	51	<1	<1		46	1.08	
	39	39	<1	<1		36	0.84	
	55	55	<1	<1		48	1.16	
	61	61	<1	<1		51	1.28	
	46	46	<1	<1		38	0.98	
	40	40	<1	<1		33	0.86	
	37	37	<1	<1		24	0.8	
	56	56	<1	<1		43	1.18	
	69	69	<1	<1		57	1.46	

83	83	<1	<1	69	1.77
90	90	<1	<1	74	1.93
90	90	<1	<1	76	1.93
93	93	<1	<1	69	1.99
70	70	<1	<1	60	1.5
70	70	<1	<1	55	1.46
5	5	<1	<1	<1	0.1
28	28	<1	<1	24	0.59
32	32	<1	<1	26	0.7
35	35	<1	<1	29	0.76
39	39	<1	<1	33	0.81
36	36	<1	<1	22	0.75
48	48	<1	<1	38	1.02
40	40	<1	<1	23	0.88
76	76	<1	<1	60	1.74
67	67	<1	<1	61	1.51
105	105	<1	<1	96	2.45
138	138	<1	<1	126	3.25
152	152	<1	<1	142	3.6
171	171	<1	<1	156	4.06
185	185	<1	<1	168	4.49
217	217	<1	<1	195	5.31
211	214	<1	3	195	5.22
238	238	<1	<1	216	5.85
235	235	<1	<1	218	5.79
257	257	<1	<1	216	6.26
275	275	<1	<1	230	6.69
40	40	<1	<1	31	0.86
148	148	<1	<1	129	
55	55	<1	<1	61	
176	176	<1	<1	154	4.41
45	45	<1	<1	33	0.96
33	33	<1	<1	24	0.82
43	43	<1	<1	31	0.96
77	77	<1	<1	55	1.77
32	32	<1	<1	19	0.7
74	74	<1	<1	55	1.73
93	93	<1	<1	73	2.21
110	110	<1	<1	87	2.65
138	138	<1	<1	111	3.35
145	150	<1	5	120	3.64
154	160	<1	6	132	3.89
168	168	<1	<1	134	4.12
176	176	<1	<1	140	4.3
76	76	<1	<1	52	1.74

213	219	<1	6	172	5.22
197	197	<1	<1	157	4.8
33	33	<1	<1	22	0.72
63	63	<1	<1	47	1.4
72	72	<1	<1	52	1.58
70	70	<1	<1	52	1.51
64	64	<1	<1	50	1.41
67	67	<1	<1	50	1.5
74	74	<1	<1	59	1.66
45	45	<1	<1	33	0.96
54	54	<1	<1	38	1.14
47	47	<1	<1	33	1
55	55	<1	<1	38	1.16
58	58	<1	<1	47	1.24
79	79	<1	<1	61	1.69
78	78	<1	<1	61	1.67
78	78	<1	<1	61	1.67
78	78	<1	<1	61	1.67
86	86	<1	<1	64	1.87
4	4	<1	<1	24	0.86
42	42	<1	<1	26	0.92
40	40	<1	<1	33	0.9
<1	26	<1	26	12	0.58
<1	47	<1	47	33	1.04
<1	64	<1	64	47	1.43
<1	76	<1	76	52	1.67
<1	88	<1	88	64	1.91
<1	100	<1	100	80	2.18
<1	106	<1	106	80	2.32
<1	110	<1	110	86	2.4
<1	113	<1	113	92	2.46
<1	117	<1	117	92	2.54
<1	118	<1	118	95	2.56
<1	122	<1	122	95	2.67
<1	123	<1	123	95	2.69
<1	123	<1	123	95	2.69
34	34	<1	<1	24	0.76
61	61	<1	<1	55	1.45
83	83	<1	<1	73	1.89
58	58	<1	<1	36	1.49
37	37	<1	<1	28	0.89
54	54	<1	<1	33	1.31
58	58	<1	<1	42	1.39
70	70	<1	<1	51	1.68
79	79	<1	<1	56	1.89
86	86	<1	<1	66	2.05
104	104	<1	<1	90	2.51
119	119	<1	<1	108	2.88
134	134	<1	<1	118	3.24

151	151	<1	<1	127	3.63
161	161	<1	<1	144	3.93
163	163	<1	<1	148	4.11
183	183	<1	<1	164	4.56
194	194	<1	<1	167	4.78
30	30	<1	<1	17	0.66
25	25	0.5	0.5	10	0.53
25	25	0.5	0.5	15	0.56
22	22	0.5	0.5	17	0.48
36	36	0.5	0.5	38	0.83
114	114	0.5	0.5	153	3.11
68	68	<1	<1	56	1.55
87	87	<1	<1	76	1.98
113	113	<1	<1		2.65
134	134	<1	<1	124	3.14
164	164	<1	<1	130	3.77
155	155	<1	<1	138	3.6
165	165	<1	<1	155	4.12
176	176	<1	<1	148	4.34
190	190	<1	<1	169	4.7
199	199	<1	<1	167	4.91
219	219	<1	<1	176	5.42
216	216	<1	<1	194	5.47
222	222	<1	<1	187	5.59
242	242	<1	<1	197	6.17
255	255	<1	<1	200	6.4
260	260	<1	<1	205	6.67
260	260	<1	<1	214	6.77
278	278	<1	<1	223	7.06
276	276	<1	<1	226	7.18
276	276	<1	<1	230	7.18
300	300	<1	<1	230	7.78
302	302	<1	<1	241	7.82
302	302	<1	<1	244	7.92
309	309	<1	<1	246	8.18
316	316	<1	<1	255	8.42
35	35	<1	<1	24	0.76
33	33	<1	<1	19	0.69
50	50	<1	<1	38	1.2
27	27	<1	<1	41	1.03
36	36	<1	<1	28	0.97
46	46	<1	<1	31	1.13
64	64	<1	<1	51	1.61

77	77	<1	<1	63	1.92
88	88	<1	<1	73	2.16
57	57	<1	<1	42	1.34
51	51	<1	<1	40	1.17
41	41	<1	<1	28	0.92
46	46	<1	<1	31	1.04
65	65	<1	<1	47	1.47
67	67	<1	<1	50	1.51
83	83	<1	<1	61	1.89
100	100	<1	<1	70	2.36
102	102	<1	<1	76	2.38
109	109	<1	<1	76	2.54
114	114	<1	<1	82	2.72
116	116	<1	<1	87	2.68
124	124	<1	<1	90	2.91
47	47	<1	<1	33	1.09
63	63	<1	<1	42	1.48
71	71	<1	<1	54	1.65
84	84	<1	<1	61	1.99
87	87	<1	<1	61	2.02
90	90	<1	<1	66	2.05
92	92	<1	<1	70	2.09
96	96	<1	<1	73	2.2
139	139	<1	<1	108	3.12
27	27	<1	<1	10	0.57
57	57	<1	<1	41	1.34
65	65	<1	<1	55	1.55

72	72	<1	<1	66	1.75
51	51	<1	<1	41	1.17
48	48	<1	<1	36	1.02
54	54	<1	<1	47	1.16
49	49	<1	<1	50	1.04
58	58	<1	<1	50	1.26
46	46	<1	<1	36	0.95
48	48	<1	<1	36	0.99
54	54	<1	<1	41	1.14
56	56	<1	<1	43	1.2
37	37	<1	<1	24	0.77
47	47	<1	<1	24	1.02
45	45	<1	<1	36	0.96
54	54	<1	<1	41	1.14
65	65	<1	<1	52	1.36
70	70	<1	<1	55	1.46
70	70	<1	<1	57	1.5
70	70	<1	<1	60	1.48
32	32	<1	<1	22	0.67
50	50	<1	<1	41	1.08
59	59	<1	<1	50	1.26
68	68	<1	<1	57	1.46
70	70	<1	<1	60	1.55
75	75	<1	<1	52	1.6
78	78	<1	<1	66	1.71

	82	82	<1	<1		69	1.79	
	79	79	<1	<1		71	1.73	
<0.1	139	139	<1	<1	110			86.9
	26	26	<1	<1		24	0.55	
	136	136	<1	<1		129	2.83	
	66	66	<1	<1		75	1.38	
	45	45	<1	<1		41	0.96	
	53	53	<1	<1		46	1.12	
	52	52	<1	<1		48	1.1	
	58	58	<1	<1		57	1.22	
	43	43	<1	<1		38	0.92	
	43	43	<1	<1		33	0.92	
	40	40	<1	<1		24	0.86	
	52	52	<1	<1		41	1.1	
	67	67	<1	<1		57	1.42	
	81	81	<1	<1		66	1.73	
	86	86	<1	<1		74	1.83	
	88	88	<1	<1		76	1.87	
	93	93	<1	<1		71	1.99	
	93	93	<1	<1		76	2.02	
	32	32	<1	<1		26	1.03	
	70	70	<1	<1		52	1.46	
	31	31	<1	<1		24	0.65	
	32	32	<1	<1		26	0.7	
	35	35	<1	<1		29	0.76	
	47	47	<1	<1		47	1	
	34	34	<1	<1		22	0.71	
	40	40	<1	<1		38	0.86	
	48	48	<1	<1		19	1.07	
	42	42	<1	<1		33	0.92	
	47	47	<1	<1		42	1.09	
	76	76	<1	<1		60	1.74	
	68	68	<1	<1		61	1.53	
	105	105	<1	<1		96	2.45	

157	157	<1	<1	136	3.72
154	154	<1	<1	142	3.66
175	175	<1	<1	158	4.23
199	199	<1	<1	189	4.89
214	214	<1	<1	200	5.21
209	213	<1	4	195	5.22
241	241	<1	<1	216	5.93
237	237	<1	<1	213	5.88
260	260	<1	<1	218	6.37
265	265	<1	<1	232	6.6

Total Cations (meq/L)	Total Cations (mg/L)	Ionic Balance (%)
1.21		
2.15		
2.83		
3.16		0.16
0.32		
3.56		1.24
1.65		
2.46		
1.21		
1.01		
1.1		
2.93		
2.91		
3.1		1.6
4.71		1.79
4.3		4.29
3.84		0.51
0.9		
1.04		
2.46		
1.84		
2.01		
1.56		
2.69		
1.04		
1.02		
4.42		4.16
4.78		3.01
5.47		4.96
5.97		5.28
5.75		3.98
1		
1.04		
1.61		

0.98	
1.71	
2.2	
2.63	
3.05	1.8
3.38	0.08
3.66	2.98
3.98	
4.02	
1.37	
5.13	
4.35	
1.14	
1.17	
1.34	
1.44	
1.44	
1.34	
1.4	
0.94	
1.1	
0.91	
1.06	
1.31	
1.78	
1.78	
1.78	
1.78	
1.77	
0.67	
0.67	
0.8	
0.98	
1.54	
1.78	
1.95	
2.18	
2.18	
2.28	
2.28	
2.28	
2.28	
2.38	
2.33	
2.38	
1.77	
2.5	
2.82	

2.96	2.76
3.19	0.17
3.26	0.36
3.45	1.19
3.58	0.57
3.58	1.39
6.18	0.03
6.45	0.66
6.71	1.72
6.98	0.69
7.12	0.63
6.98	0.59
7.24	0.61
7.61	0.19
7.78	0.92
7.92	2.13
8.06	0.37

0.52

1.14

2.11

2.38

1.27

1.02

0.91

0.96

1.59

1.22

1.96

2.71

2.66

2.66

2.64

2.76

2.76
1.06
1.41
1.82
2.12

2.04

1.93

2.18

2.14
3.33 2.35

1.29

1.68

2.01

0.92

0.89

1.19

1.32

1.41

0.95

0.95

1.05

1.14

0.64

0.79

1.09

1.24

1.47

1.52

1.44

1.44

0.74

1.19

1.47

1.66

1.57

1.62

1.62

1.71

1.71

40.3 -4.57

0.67

1.54

<0.01

1.76

1

1.1

0.9

1.2

1.24

1.01

0.93

0.75

1.2

1.53

1.83	
1.93	
1.98	
1.87	
1.45	
1.2	
<0.01	
0.6	
0.74	
0.79	
0.87	
0.64	
1.01	
0.91	
1.68	
1.61	
2.68	
3.58	4.74
4.09	6.34
4.55	5.66
4.95	4.94
5.79	4.3
5.83	5.51
6.46	4.99
6.56	6.22
6.7	3.41
7.18	3.5
0.95	
4.65	2.57
1.01	
0.71	
0.95	
1.61	
0.56	
1.61	
2.1	
2.54	
3.2	2.4
3.42	3.12
3.74	1.97
3.9	
4.08	
1.56	

5
4.84
0.68
1.44
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1.31
0.7
1.22
1.4
1.63
1.77
2
2.59
3
3.28 0.69

3.51	1.65
3.91	0.29
4.05	0.65
4.5	0.71
4.55	2.51
0.54	
0.38	
0.37	
0.47	
0.84	
3.33	3.38
1.6	
2.15	
2.85	
3.47	4.97
3.69	1.08
3.94	4.46
4.49	4.29
4.45	1.28
5.1	4.07
5.09	1.84
5.4	0.14
5.99	4.49
5.98	3.39
6.14	0.22
6.28	0.95
6.49	1.35
6.85	0.55
7.07	0.08
7.21	0.19
7.29	0.79
7.34	2.91
7.83	0.08
7.88	0.27
8.02	1.01
8.31	0.64
0.73	
0.61	
1.19	
0.95	
0.96	
1.17	
1.74	

2.06

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1.87
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1.25
0.64

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0.79
1.15
0.61
1.01
0.82
0.91
1.18
1.68
1.61
2.68

3.78	0.71
4.05	4.98
4.6	4.15
5.39	4.79
5.89	6.06
5.79	5.13
6.55	4.97
6.46	4.69
6.79	3.18
7.23	4.56

DO NOT change column headings. Values in the Rainfall (mm) column must be a number. Sheet can be blan

Station Name	Station Number	Date	Rainfall (mm)
Cloncurry Airport	29141	1/05/2022	0
Cloncurry Airport	29141	2/05/2022	0
Cloncurry Airport	29141	3/05/2022	0
Cloncurry Airport	29141	4/05/2022	0
Cloncurry Airport	29141	5/05/2022	0
Cloncurry Airport	29141	6/05/2022	0
Cloncurry Airport	29141	7/05/2022	0
Cloncurry Airport	29141	8/05/2022	0
Cloncurry Airport	29141	9/05/2022	0
Cloncurry Airport	29141	10/05/2022	27.6
Cloncurry Airport	29141	11/05/2022	0.8
Cloncurry Airport	29141	12/05/2022	0
Cloncurry Airport	29141	13/05/2022	0
Cloncurry Airport	29141	14/05/2022	0
Cloncurry Airport	29141	15/05/2022	0
Cloncurry Airport	29141	16/05/2022	0
Cloncurry Airport	29141	17/05/2022	0
Cloncurry Airport	29141	18/05/2022	0
Cloncurry Airport	29141	19/05/2022	0
Cloncurry Airport	29141	20/05/2022	0
Cloncurry Airport	29141	21/05/2022	0
Cloncurry Airport	29141	22/05/2022	0
Cloncurry Airport	29141	23/05/2022	0
Cloncurry Airport	29141	24/05/2022	0
Cloncurry Airport	29141	25/05/2022	0
Cloncurry Airport	29141	26/05/2022	0
Cloncurry Airport	29141	27/05/2022	0
Cloncurry Airport	29141	28/05/2022	0
Cloncurry Airport	29141	29/05/2022	0
Cloncurry Airport	29141	30/05/2022	0
Cloncurry Airport	29141	31/05/2022	0
Cloncurry Airport	29141	1/06/2022	0
Cloncurry Airport	29141	2/06/2022	0
Cloncurry Airport	29141	3/06/2022	0
Cloncurry Airport	29141	4/06/2022	0
Cloncurry Airport	29141	5/06/2022	0
Cloncurry Airport	29141	6/06/2022	0
Cloncurry Airport	29141	7/06/2022	0
Cloncurry Airport	29141	8/06/2022	0
Cloncurry Airport	29141	9/06/2022	0
Cloncurry Airport	29141	10/06/2022	0
Cloncurry Airport	29141	11/06/2022	0
Cloncurry Airport	29141	12/06/2022	0
Cloncurry Airport	29141	13/06/2022	0
Cloncurry Airport	29141	14/06/2022	0
Cloncurry Airport	29141	15/06/2022	0
Cloncurry Airport	29141	16/06/2022	0
Cloncurry Airport	29141	17/06/2022	0

Cloncurry Airport	29141	18/06/2022	0
Cloncurry Airport	29141	19/06/2022	0
Cloncurry Airport	29141	20/06/2022	0
Cloncurry Airport	29141	21/06/2022	0
Cloncurry Airport	29141	22/06/2022	0
Cloncurry Airport	29141	23/06/2022	0
Cloncurry Airport	29141	24/06/2022	0
Cloncurry Airport	29141	25/06/2022	0
Cloncurry Airport	29141	26/06/2022	0
Cloncurry Airport	29141	27/06/2022	0
Cloncurry Airport	29141	28/06/2022	0
Cloncurry Airport	29141	29/06/2022	0
Cloncurry Airport	29141	30/06/2022	0
Cloncurry Airport	29141	1/07/2022	22
Cloncurry Airport	29141	2/07/2022	12
Cloncurry Airport	29141	3/07/2022	0.2
Cloncurry Airport	29141	4/07/2022	0
Cloncurry Airport	29141	5/07/2022	0
Cloncurry Airport	29141	6/07/2022	0
Cloncurry Airport	29141	7/07/2022	0
Cloncurry Airport	29141	8/07/2022	0
Cloncurry Airport	29141	9/07/2022	0
Cloncurry Airport	29141	10/07/2022	0
Cloncurry Airport	29141	11/07/2022	0
Cloncurry Airport	29141	12/07/2022	0
Cloncurry Airport	29141	13/07/2022	0
Cloncurry Airport	29141	14/07/2022	0
Cloncurry Airport	29141	15/07/2022	0
Cloncurry Airport	29141	16/07/2022	0
Cloncurry Airport	29141	17/07/2022	0
Cloncurry Airport	29141	18/07/2022	0
Cloncurry Airport	29141	19/07/2022	0
Cloncurry Airport	29141	20/07/2022	0
Cloncurry Airport	29141	21/07/2022	0
Cloncurry Airport	29141	22/07/2022	0
Cloncurry Airport	29141	23/07/2022	0
Cloncurry Airport	29141	24/07/2022	0
Cloncurry Airport	29141	25/07/2022	0
Cloncurry Airport	29141	26/07/2022	0
Cloncurry Airport	29141	27/07/2022	0
Cloncurry Airport	29141	28/07/2022	0
Cloncurry Airport	29141	29/07/2022	0
Cloncurry Airport	29141	30/07/2022	0
Cloncurry Airport	29141	31/07/2022	0
Cloncurry Airport	29141	1/08/2022	0
Cloncurry Airport	29141	2/08/2022	0
Cloncurry Airport	29141	3/08/2022	0
Cloncurry Airport	29141	4/08/2022	0
Cloncurry Airport	29141	5/08/2022	0
Cloncurry Airport	29141	6/08/2022	0

Cloncurry Airport	29141	7/08/2022	0
Cloncurry Airport	29141	8/08/2022	0
Cloncurry Airport	29141	9/08/2022	0
Cloncurry Airport	29141	10/08/2022	0
Cloncurry Airport	29141	11/08/2022	0
Cloncurry Airport	29141	12/08/2022	0
Cloncurry Airport	29141	13/08/2022	0
Cloncurry Airport	29141	14/08/2022	0
Cloncurry Airport	29141	15/08/2022	0
Cloncurry Airport	29141	16/08/2022	0
Cloncurry Airport	29141	17/08/2022	0
Cloncurry Airport	29141	18/08/2022	0
Cloncurry Airport	29141	19/08/2022	0
Cloncurry Airport	29141	20/08/2022	0
Cloncurry Airport	29141	21/08/2022	0
Cloncurry Airport	29141	22/08/2022	0
Cloncurry Airport	29141	23/08/2022	0
Cloncurry Airport	29141	24/08/2022	0
Cloncurry Airport	29141	25/08/2022	0
Cloncurry Airport	29141	26/08/2022	0
Cloncurry Airport	29141	27/08/2022	0
Cloncurry Airport	29141	28/08/2022	0
Cloncurry Airport	29141	29/08/2022	1.2
Cloncurry Airport	29141	30/08/2022	16
Cloncurry Airport	29141	31/08/2022	0
Cloncurry Airport	29141	1/09/2022	0
Cloncurry Airport	29141	2/09/2022	4.6
Cloncurry Airport	29141	3/09/2022	0.2
Cloncurry Airport	29141	4/09/2022	0
Cloncurry Airport	29141	5/09/2022	0
Cloncurry Airport	29141	6/09/2022	0
Cloncurry Airport	29141	7/09/2022	0
Cloncurry Airport	29141	8/09/2022	0
Cloncurry Airport	29141	9/09/2022	0
Cloncurry Airport	29141	10/09/2022	0
Cloncurry Airport	29141	11/09/2022	0
Cloncurry Airport	29141	12/09/2022	0
Cloncurry Airport	29141	13/09/2022	0
Cloncurry Airport	29141	14/09/2022	0
Cloncurry Airport	29141	15/09/2022	0
Cloncurry Airport	29141	16/09/2022	0
Cloncurry Airport	29141	17/09/2022	0
Cloncurry Airport	29141	18/09/2022	0
Cloncurry Airport	29141	19/09/2022	0
Cloncurry Airport	29141	20/09/2022	0
Cloncurry Airport	29141	21/09/2022	11.2
Cloncurry Airport	29141	22/09/2022	0.2
Cloncurry Airport	29141	23/09/2022	0
Cloncurry Airport	29141	24/09/2022	0
Cloncurry Airport	29141	25/09/2022	0

Cloncurry Airport	29141	26/09/2022	0
Cloncurry Airport	29141	27/09/2022	0
Cloncurry Airport	29141	28/09/2022	1.6
Cloncurry Airport	29141	29/09/2022	6.4
Cloncurry Airport	29141	30/09/2022	0
Cloncurry Airport	29141	1/10/2022	0
Cloncurry Airport	29141	2/10/2022	0
Cloncurry Airport	29141	3/10/2022	0
Cloncurry Airport	29141	4/10/2022	0
Cloncurry Airport	29141	5/10/2022	1.4
Cloncurry Airport	29141	6/10/2022	0.6
Cloncurry Airport	29141	7/10/2022	0
Cloncurry Airport	29141	8/10/2022	21.4
Cloncurry Airport	29141	9/10/2022	0
Cloncurry Airport	29141	10/10/2022	0
Cloncurry Airport	29141	11/10/2022	0
Cloncurry Airport	29141	12/10/2022	0
Cloncurry Airport	29141	13/10/2022	0
Cloncurry Airport	29141	14/10/2022	0
Cloncurry Airport	29141	15/10/2022	0
Cloncurry Airport	29141	16/10/2022	0
Cloncurry Airport	29141	17/10/2022	18.4
Cloncurry Airport	29141	18/10/2022	1
Cloncurry Airport	29141	19/10/2022	1.8
Cloncurry Airport	29141	20/10/2022	0
Cloncurry Airport	29141	21/10/2022	0
Cloncurry Airport	29141	22/10/2022	0
Cloncurry Airport	29141	23/10/2022	0
Cloncurry Airport	29141	24/10/2022	0
Cloncurry Airport	29141	25/10/2022	0
Cloncurry Airport	29141	26/10/2022	4.4
Cloncurry Airport	29141	27/10/2022	1
Cloncurry Airport	29141	28/10/2022	0
Cloncurry Airport	29141	29/10/2022	0
Cloncurry Airport	29141	30/10/2022	0
Cloncurry Airport	29141	31/10/2022	0
Cloncurry Airport	29141	1/11/2022	3.2
Cloncurry Airport	29141	2/11/2022	0
Cloncurry Airport	29141	3/11/2022	0
Cloncurry Airport	29141	4/11/2022	0
Cloncurry Airport	29141	5/11/2022	0
Cloncurry Airport	29141	6/11/2022	1.2
Cloncurry Airport	29141	7/11/2022	0
Cloncurry Airport	29141	8/11/2022	0
Cloncurry Airport	29141	9/11/2022	0
Cloncurry Airport	29141	10/11/2022	21.6
Cloncurry Airport	29141	11/11/2022	0.2
Cloncurry Airport	29141	12/11/2022	0
Cloncurry Airport	29141	13/11/2022	0
Cloncurry Airport	29141	14/11/2022	58.8

Cloncurry Airport	29141	15/11/2022	0.2
Cloncurry Airport	29141	16/11/2022	0
Cloncurry Airport	29141	17/11/2022	0
Cloncurry Airport	29141	18/11/2022	0
Cloncurry Airport	29141	19/11/2022	0
Cloncurry Airport	29141	20/11/2022	0
Cloncurry Airport	29141	21/11/2022	0
Cloncurry Airport	29141	22/11/2022	0
Cloncurry Airport	29141	23/11/2022	0
Cloncurry Airport	29141	24/11/2022	0
Cloncurry Airport	29141	25/11/2022	0
Cloncurry Airport	29141	26/11/2022	0
Cloncurry Airport	29141	27/11/2022	0
Cloncurry Airport	29141	28/11/2022	32.8
Cloncurry Airport	29141	29/11/2022	12.6
Cloncurry Airport	29141	30/11/2022	0
Cloncurry Airport	29141	1/12/2022	0
Cloncurry Airport	29141	2/12/2022	0
Cloncurry Airport	29141	3/12/2022	0
Cloncurry Airport	29141	4/12/2022	0
Cloncurry Airport	29141	5/12/2022	0
Cloncurry Airport	29141	6/12/2022	0
Cloncurry Airport	29141	7/12/2022	
Cloncurry Airport	29141	8/12/2022	0
Cloncurry Airport	29141	9/12/2022	0
Cloncurry Airport	29141	10/12/2022	0
Cloncurry Airport	29141	11/12/2022	0
Cloncurry Airport	29141	12/12/2022	0
Cloncurry Airport	29141	13/12/2022	0
Cloncurry Airport	29141	14/12/2022	0
Cloncurry Airport	29141	15/12/2022	0
Cloncurry Airport	29141	16/12/2022	0
Cloncurry Airport	29141	17/12/2022	0
Cloncurry Airport	29141	18/12/2022	0
Cloncurry Airport	29141	19/12/2022	4
Cloncurry Airport	29141	20/12/2022	0
Cloncurry Airport	29141	21/12/2022	0
Cloncurry Airport	29141	22/12/2022	0
Cloncurry Airport	29141	23/12/2022	0
Cloncurry Airport	29141	24/12/2022	11.4
Cloncurry Airport	29141	25/12/2022	3
Cloncurry Airport	29141	26/12/2022	5.4
Cloncurry Airport	29141	27/12/2022	59.8
Cloncurry Airport	29141	28/12/2022	6.4
Cloncurry Airport	29141	29/12/2022	4.2
Cloncurry Airport	29141	30/12/2022	0
Cloncurry Airport	29141	31/12/2022	0.4
Cloncurry Airport	29141	1/01/2023	8
Cloncurry Airport	29141	2/01/2023	2.2
Cloncurry Airport	29141	3/01/2023	20.6

Cloncurry Airport	29141	4/01/2023	21
Cloncurry Airport	29141	5/01/2023	3.8
Cloncurry Airport	29141	6/01/2023	0.2
Cloncurry Airport	29141	7/01/2023	0
Cloncurry Airport	29141	8/01/2023	0
Cloncurry Airport	29141	9/01/2023	0
Cloncurry Airport	29141	10/01/2023	0
Cloncurry Airport	29141	11/01/2023	7.2
Cloncurry Airport	29141	12/01/2023	8
Cloncurry Airport	29141	13/01/2023	10.6
Cloncurry Airport	29141	14/01/2023	0
Cloncurry Airport	29141	15/01/2023	0
Cloncurry Airport	29141	16/01/2023	0.2
Cloncurry Airport	29141	17/01/2023	0
Cloncurry Airport	29141	18/01/2023	0
Cloncurry Airport	29141	19/01/2023	0
Cloncurry Airport	29141	20/01/2023	0
Cloncurry Airport	29141	21/01/2023	0
Cloncurry Airport	29141	22/01/2023	0
Cloncurry Airport	29141	23/01/2023	0
Cloncurry Airport	29141	24/01/2023	0
Cloncurry Airport	29141	25/01/2023	0
Cloncurry Airport	29141	26/01/2023	0.6
Cloncurry Airport	29141	27/01/2023	0.2
Cloncurry Airport	29141	28/01/2023	0
Cloncurry Airport	29141	29/01/2023	2.8
Cloncurry Airport	29141	30/01/2023	0
Cloncurry Airport	29141	31/01/2023	18.4
Cloncurry Airport	29141	1/02/2023	0.4
Cloncurry Airport	29141	2/02/2023	0
Cloncurry Airport	29141	3/02/2023	0
Cloncurry Airport	29141	4/02/2023	0
Cloncurry Airport	29141	5/02/2023	0
Cloncurry Airport	29141	6/02/2023	13.8
Cloncurry Airport	29141	7/02/2023	21
Cloncurry Airport	29141	8/02/2023	0
Cloncurry Airport	29141	9/02/2023	2.8
Cloncurry Airport	29141	10/02/2023	0.6
Cloncurry Airport	29141	11/02/2023	0
Cloncurry Airport	29141	12/02/2023	0
Cloncurry Airport	29141	13/02/2023	0
Cloncurry Airport	29141	14/02/2023	0
Cloncurry Airport	29141	15/02/2023	0
Cloncurry Airport	29141	16/02/2023	0
Cloncurry Airport	29141	17/02/2023	9
Cloncurry Airport	29141	18/02/2023	33.6
Cloncurry Airport	29141	19/02/2023	15.6
Cloncurry Airport	29141	20/02/2023	0
Cloncurry Airport	29141	21/02/2023	0
Cloncurry Airport	29141	22/02/2023	0

Cloncurry Airport	29141	23/02/2023	0
Cloncurry Airport	29141	24/02/2023	0
Cloncurry Airport	29141	25/02/2023	0
Cloncurry Airport	29141	26/02/2023	0
Cloncurry Airport	29141	27/02/2023	0
Cloncurry Airport	29141	28/02/2023	0
Cloncurry Airport	29141	1/03/2023	0
Cloncurry Airport	29141	2/03/2023	0
Cloncurry Airport	29141	3/03/2023	0.2
Cloncurry Airport	29141	4/03/2023	8.8
Cloncurry Airport	29141	5/03/2023	0
Cloncurry Airport	29141	6/03/2023	0.8
Cloncurry Airport	29141	7/03/2023	3.6
Cloncurry Airport	29141	8/03/2023	21
Cloncurry Airport	29141	9/03/2023	60.8
Cloncurry Airport	29141	10/03/2023	16
Cloncurry Airport	29141	11/03/2023	10.6
Cloncurry Airport	29141	12/03/2023	40.2
Cloncurry Airport	29141	13/03/2023	14.2
Cloncurry Airport	29141	14/03/2023	0
Cloncurry Airport	29141	15/03/2023	0
Cloncurry Airport	29141	16/03/2023	0
Cloncurry Airport	29141	17/03/2023	0
Cloncurry Airport	29141	18/03/2023	0
Cloncurry Airport	29141	19/03/2023	0
Cloncurry Airport	29141	20/03/2023	0
Cloncurry Airport	29141	21/03/2023	0
Cloncurry Airport	29141	22/03/2023	0

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k if no data available.

DO NOT change column headings or data. Additional rows can be added. Existing EA or pr

Indicator	Unit	ANZECC aquatic ecosystem trigger value
pH - min	pH unit	6
pH - max	pH unit	8.5
Electrical Conductivity	µS/cm	500
Sulfate	mg/L	
Fluoride	mg/L	2.4
Nitrate	mg/L	0.7
Ammonia	mg/L	0.9
Total Phosphorus	mg/L	0.01
Aluminium - Dissolved	µg/L	55
Aluminium - Total	µg/L	
Antimony - Dissolved	µg/L	9
Antimony - Total	µg/L	
Arsenic - Dissolved	µg/L	13
Arsenic - Total	µg/L	
Boron - Dissolved	µg/L	370
Boron - Total	µg/L	
Cadmium - Dissolved	µg/L	0.2
Cadmium - Total	µg/L	
Copper - Dissolved	µg/L	1.4
Copper - Total	µg/L	
Chromium - Dissolved	µg/L	1
Chromium - Total	µg/L	
Cobalt - Dissolved	µg/L	1.4
Cobalt - Total	µg/L	
Iron - Dissolved	µg/L	300
Iron - Total	µg/L	
Lead - Dissolved	µg/L	3.4
Lead - Total	µg/L	
Manganese - Dissolved	µg/L	1900
Manganese - Total	µg/L	
Mercury - Dissolved	µg/L	0.6
Mercury - Total	µg/L	
Molybdenum - Dissolved	µg/L	34
Molybdenum - Total	µg/L	
Nickel - Dissolved	µg/L	11
Nickel - Total	µg/L	
Selenium - Dissolved	µg/L	5
Selenium - Total	µg/L	
Silver - Dissolved	µg/L	0.05
Silver - Total	µg/L	
Uranium - Dissolved	µg/L	0.5
Uranium - Total	µg/L	
Vanadium - Dissolved	µg/L	6
Vanadium - Total	µg/L	
Thallium - Dissolved	µg/L	0.03
Thallium - Total	µg/L	
Zinc - Dissolved	µg/L	8
Zinc - Total	µg/L	

Aluminium - Dissolved	mg/L	0.055
Aluminium - Total	mg/L	
Antimony - Dissolved	mg/L	0.009
Antimony - Total	mg/L	
Arsenic - Dissolved	mg/L	0.013
Arsenic - Total	mg/L	
Boron - Dissolved	mg/L	0.37
Boron - Total	mg/L	
Cadmium - Dissolved	mg/L	0.0002
Cadmium - Total	mg/L	
Copper - Dissolved	mg/L	0.0014
Copper - Total	mg/L	
Chromium - Dissolved	mg/L	0.001
Chromium - Total	mg/L	
Cobalt - Dissolved	mg/L	0.0014
Cobalt - Total	mg/L	
Iron - Dissolved	mg/L	0.3
Iron - Total	mg/L	
Lead - Dissolved	mg/L	0.0034
Lead - Total	mg/L	
Manganese - Dissolved	mg/L	1.9
Manganese - Total	mg/L	
Mercury - Dissolved	mg/L	0.0006
Mercury - Total	mg/L	
Molybdenum - Dissolved	mg/L	0.034
Molybdenum - Total	mg/L	
Nickel - Dissolved	mg/L	0.011
Nickel - Total	mg/L	
Selenium - Dissolved	mg/L	0.005
Selenium - Total	mg/L	
Silver - Dissolved	mg/L	0.00005
Silver - Total	mg/L	
Uranium - Dissolved	mg/L	0.0005
Uranium - Total	mg/L	
Vanadium - Dissolved	mg/L	0.006
Vanadium - Total	mg/L	
Thallium - Dissolved	mg/L	0.00003
Thallium - Total	mg/L	
Zinc - Dissolved	mg/L	0.008
Zinc - Total	mg/L	

roposed limits and triggers can be added.

Australian drinking water guideline	ANZECC Stock watering guideline	Limit
6.5	6	
8.5	8.5	
	5970	
250	1000	
1.5	2	
50	400	
0.5		
100	5000	
0	0	
10	500	
4000	5000	
2	10	
2000	1000	
50	1000	
0	1000	
10	100	
500	0	
1	2	
50	150	
20	1000	
10	20	
17	200	
0	0	
0	0	
3000	20000	

0.1	5
0.01	0.5
4	5
0.002	0.01
2	1
0.05	1
	1
0.01	0.1
0.5	
0.001	0.002
0.05	0.15
0.02	1
0.01	0.02
0.017	0.2
3	20

Trigger

DO NOT change column headings or data. Data should be exported from Power BI. Manually er

Group	Indicator/unit	Count	Min	Median	Max

ıter data for triggers and limits. See user guide for details. Trigger and limit: add this data into the s

80th percentile	95th percentile	Proposed Limit A	Proposed Limit B	Trigger	Limit

heet if available. This data does not come from Power BI. User defines.

DO NOT change column headings or data. Data should be exported from Power BI. See user guide for

Monitoring Point	Group	Indicator/unit	Count	Min	Median	Max

details.

80th percentile 95th percentile

Monitoring Point	Indicator	Count	Min	Median	Max	Mean + SD*4

Outliers

APPENDIX G: Memorandum, PAF 2 Run Off Dam Consequence Category Assessment – Response to DES Comments (ATC Williams, 2024)

MEMORANDUM

TO	Gemma Green	**COMPANY**	MMG Dugald River
FROM	James Parker	**OFFICE**	Brisbane
EMAIL	jamesp@atcwilliams.com.au	**PHONE**	(07) 3352 7222
PROJECT TITLE	PAF Stage 2 Dam Consequence Category Assessment		
SUBJECT	Response to DES comments		
DATE	3 May 2024	**OUR REF**	108003.65-M02

1 INTRODUCTION

ATCW prepared a Consequence Category Assessment (CCA) for the Dugald River Mines PAF Stage 2 Dam in May 2023. This memorandum provides a response to the Department of Environment and Science (DES) comments on the CCA report, received 17 April 2024.

2 DES COMMENTS

There were four main issues raised in the DES comments:

- Context for the change in the CCA from 2015 to 2023.
- Clarification of the impact of an overtopping event, with respect to the resulting direction of flows.
- Clarification of the impact of an overtopping or partial/full collapse of Sediment Dam G in the 'failure to contain – dam break' scenario for the PAF Stage 2 Dam.
- Provide information on the intended hydraulic performance objectives for 'failure to contain - dam break' scenarios.

These issues are presented in detail in the following sections.

2.1 Change in Consequence Category

2.1.1 Comments received from DES

The hydraulic performance criteria specified in Schedule D – Table 2 (Hydraulic performance criteria for Regulated Dams) for the Stage 2 PAF Pad Run Off Dam was assessed as significant under the scenario 'failure to contain – overtopping' in 2015 (see footnote 1 of this table). It is proposed the hydraulic performance criteria is removed for the Stage 2 PAF Run Off Dam in accordance with the revised consequence category assessment (CCA) provided (Appendix F) which has assessed the Stage 2 PAF Pad Run Off Dam as low under the 'failure to contain – overtopping' scenario. It is unclear how this assessment has changed since 2015 with further information is required to support this proposal.

2.1.2 Request from DES

Provide further information concerning the change in the CCA for the Stage 2 PAF Pad Run Off Dam for the 'failure to contain – overtopping' scenario from 2015 to 2023.

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2.1.3 ATCW response

Although the initial CCA (undertaken in 2012) assessed the both the Failure to Contain and the Dam Break Scenarios, as a “SIGNIFICANT” Hazard Category, subsequent assessments have assigned the Failure to Contain scenarios as “LOW” Hazard Category.

The following is a summary of the CCA history for the PAF Stage 2 Dam:

- **2012** – WRM conducted the initial hazard category assessment. On the basis of the Failure to Contain scenario, a “SIGNIFICANT” Hazard Category was assessed based on ‘General Environmental Harm’ and ‘Loss of Stock’. On the basis of the Dam Break scenario a “SIGNIFICANT” Hazard Category was assessed based on ‘General Environmental Harm’ and ‘Loss of Stock’. As such, an overall “SIGNIFICANT” Hazard Category was adopted. This assessment was undertaken against Version 1 of ‘the Manual’ (DERM, 2012).
- **2014** – ATCW undertook a review of the hazard category assessment in line with the updated guideline but using the original information from WRM's assessment. The outcome of the Failure to Contain scenario was a “LOW” Hazard Category, while the Dam Break Scenarios resulted in a “SIGNIFICANT” Hazard Category. This assessment was undertaken against Version 3.01 of ‘the Manual’ (DERM, 2013).
- **2015** – ATCW undertook a review of the hazard category assessment. As per the 2014 assessment, the outcome of the Failure to Contain scenario was a “LOW” Hazard Category, while the Dam Break Scenarios resulted in a “SIGNIFICANT” Hazard Category. This assessment was undertaken in accordance with version 4.00 of the Manual. (DES, 2014).
- **2019** - ATCW undertook a review of the hazard category assessment, as part of preparing the Stage 2 PAF Pad Runoff Dam Operation Plan October 2019. There was no change from the 2014 and 2015 results; the outcome of the Failure to Contain scenario was a “LOW” Hazard Category, while the Dam Break Scenarios resulted in a “SIGNIFICANT” Hazard Category. This assessment was undertaken in accordance with version 5.01 of the Manual (DES, 2016).
- **2023** – ATCW undertook a review off the hazard category assessment to determine if there is change to the consequence category and any applicable hydraulic performance criteria. This review found no changes for the outcome of the Failure to Contain scenario of “LOW” or the Dam Break scenario of a “SIGNIFICANT” Hazard Categories. This assessment was undertaken in accordance with version 5.01 of the Manual (DES, 2016).

These outcomes are summarised in **Table 1**.

Table 1 – CCA History for PAF Stage 2 Dam

Author	Year	Failure to Contain	Dam Break	Overall
WRM	2012	Significant	Significant	Significant
ATCW	2014	Low	Significant	Significant
ATCW	2015	Low	Significant	Significant
ATCW	2019	Low	Significant	Significant
ATCW	2023	Low	Significant	Significant

The original Failure to Contain assessment (WRM, 2012) gave a Hazard Category of “SIGNIFICANT” based on a presumed “SIGNIFICANT” impact of “General Environmental Harm” and “Loss of Stock”.

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In both cases this was due to an assumed release of contaminated water, with high levels of Cadmium, Lead, Zinc, and Sulphates predicted.

The WRM assessment was made prior to construction of the dam and prior to any water quality testing. WRM therefore, conservatively, assumed that contaminant levels would be high. As detailed in the 2023 CCA **[2]**, Table 1 shows that with the exception of Cadmium, Sulphate and EC, all other sampled analytes were below EA release limits, including Lead and Zinc. Zinc sampling showed historical exceedances of EA release limits; however, since 2018 were below release limits.

The 2023 CCA **[2]** assessment assumed that in the event of an overtopping failure, water quality parameters would be diluted due to significant, prolonged rainfall in the upstream catchment sufficient to produce runoff to result in 'failure to contain scenario. Impacts to the downstream areas would be likely; however, would not be expected to reach the thresholds for a 'Significant' or 'High' consequence impact.

2.2 Overtopping event – direction of flows

2.2.1 Comments received from DES

It is stated in section 4.2.3.1.3. of the report "in the event of an overtopping failure from the PAF Stage 2 Run Off Dam, flows would pass south entering Dugald River via the unnamed Dugald River tributaries." Further on it is stated "in the event of a dam break failure of the PAF Stage 2 Runoff, flows would pass north east entering Dugald River via the unnamed Dugald River tributaries." However, in Appendix F table 6, it is noted that in the event of an overtopping failure, flows would pass to the north or east. From the information provided, it is unclear the direction of flow under each scenario.

2.2.2 Request from DES

Provide clarification regarding the CCA in terms of an overtopping event and the direction of flow suspected under this scenario.

2.2.3 ATCW response

In Section 4.2.3.1.3 (Table 6) of the CCA **[2],** the phrase 'Flows would pass south entering the Dugald River' refers to the alignment of the unnamed tributary of the Dugald River (referred to informally as North Creek) being on an approximately southerly bearing. It in noted that the initial direction of overtopping is at the northeast, as shown in Diagram 6 of the CCA **[2]**.

As such, phrasing could be modified in the following terms.

'In the event of an overtopping of PAF Stage 2 Dam, flows would initially pass northeast where they would enter the unnamed tributary of the Dugald River (North Creek). When the unnamed tributary of the Dugald River (North Creek) enters the Dugald River, flows are heading in a southerly direction. The Dugald River then flows north towards the Gulf of Carpentaria.'

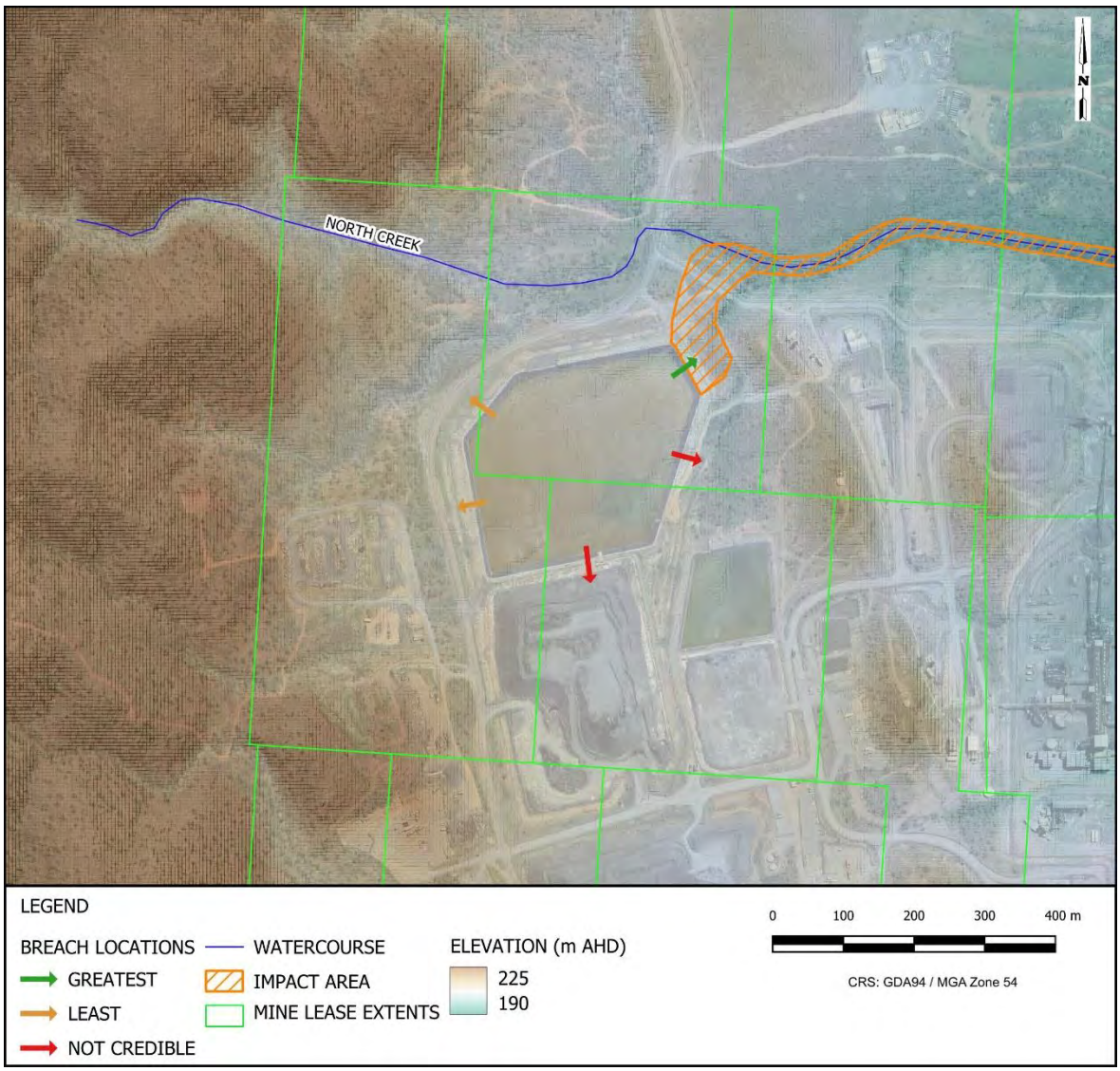
Further, the overtopping location was assumed to occur at the northeast corner of the structure for the following (conservative) reasons:

- Overtopping at the northeast corner will result in the largest potential impact area and was thus considered a conservative assessment methodology.
- Overtopping into the North Creek will result in a impact area currently not authorised for impact, as described in 'Schedule A – Table 1' and 'Schedule K – Figure 1a' of the Environmental Authority (EA) **[1].**
- Overtopping to the south and southeast will impact existing mine infrastructure. Additionally, ground rises to the south of the PAF Stage 2 Dam, and it is therefore not considered a credible failure location.
- Overtopping to the east will enter an unnamed tributary of North Creek prior to entering North Creek, and thus results in a reduced potential impact area.

The location of assumed overtopping location is shown on **Diagram 1**.

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Diagram 1 – Assumed Overtopping Location



2.3 Sediment Dam G

2.3.1 Comments received from DES

Appendix F details in the event of dam break from the Stage 2 PAF Pad Run Off Dam, sediment dam G would be impacted resulting in an overtopping or partial/full collapse of sediment dam G. Limited information is provided to understand the potential impacts this may have on the receiving environment, and if this further exacerbates a dam break scenario for the Stage 2 PAF Pad Run Off Dam.

2.3.2 Request from DES

Provide information regarding the impacts of an overtopping or partial/full collapse of sediment dam G in the 'failure to contain – dam break' scenario for the Stage 2 PAF Pad Run Off Dam. Clarify the expected capacity of sediment dam G under this scenario, the type of waters directed and reporting to this sediment dam, and the potential impacts of such an overtopping or partial/full collapse event of this sediment dam to the receiving environment.

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2.3.3 ATCW response

Sediment Dam G is located immediately downstream of the PAF Stage 2 Dam and is not a regulated structure. It is approximately 44 m wide, 130 m long, and 2 m deep, with a sandy base. Sediment Dam G receives runoff from upstream mine impacted areas, whereupon it infiltrates and/or evaporates. It contains waters after periods of rainfall sufficient to produce runoff in the mine infrastructure area and is generally empty. The typical conditions of Sediment Dam G are depicted in **Photo 1**.

Photo 1 – Sediment Dam G



As detailed in Section 3.2.2 of the CCA **[3] '**A dam break failure of the PAF Stage 2 Dam into the sediment dam would cause either an overtopping or partial/full collapse of the sediment dam embankment. However, as the assumed breach occurs as part of a SDF, the downstream sediment dam would not contain any impounded water. As such, no additional mine-impacted waters would be released into North Creek; however, sediment release would be expected to occur'. This assessment still stands.

2.4 Hydraulic performance objectives

2.4.1 Comments received from DES

Additionally, hydraulic performance objectives for 'failure to contain – dam break' scenario are specified in the Manual for assessing consequence categories and hydraulic performance of structures (ESR/2016/1933, Version 5.03) (the Manual). No information has been provided to demonstrate the application of the design criteria required for significant dam break scenarios.

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2.4.2 Request from DES

Provide information on the intended hydraulic performance objectives for 'failure to contain -dam break' for the Stage 2 PAF Run Off Dam.

2.4.3 ATCW response

Based upon the outcomes of 'Failure to Contain – Overtopping', being 'Significant', the applicable hydraulic design criteria as stipulated by the Manual **[1]** are detailed in **Table 2**.

Table 2 – Hydraulic Performance Criteria

Failure Scenario	Consequence Category	Spillway Capacity AEP	Flood Level for embankment crest levels
Failure to Contain – Dam Break	Significant	1:1,000 AEP	Spillway design peak flood level + wave runup allowance for 1:10 AEP wind

The PAF Stage 2 Dam spillway was designed to pass the 1:1,000 AEP event, as per the original 'SIGNIFICANT' criteria assigned in the WRM CCA. This is documented in the design calculations, undertaken by Jacobs in 2012 **[5]**.

A review of the conformance of the PAF Stage 2 Dam with the requirements of the Manual **[1]** should be undertake as part of the next annual inspection report as per Condition D18 of the EA **[1].**

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REFERENCES

[1] Department of Environment and Science (2016), 'Manual for Assessing Consequence Categories and Hydraulic Performance of Structures', ESR/2016/1933, March 2016, version 5.01, Queensland Government.

[2] ATC Williams (2019), 'Dugald River Mine – PAF Stage 2 Dam Pad Runoff Dam Operation Plan', Ref: 108003.40-R01, dated 1 October 2019.

[3] ATC Williams (2023), 'Dugald River Mine – PAF Stage 2 Dam Consequence Category Assessment', Ref: 108003.63.R01, dated 25 July 2023.

[4] Department of Environment and Science (2023), 'Environmental Authority EPML00731213' dated 21 April 2023, Queensland Government.

[5] Jacobs (2012), 'MMG Dugald River Project: Stage 2 PAF Pad Runoff Dam – IFC calculations', Ref:11442-0000-T9028-Rev P1, dated 17 September 2012.

[6] WRM (2012), 'Review of hazard categories, design criteria and project site water balance modelling, Dugald River Project", Ref: 0435-03-M Rev2, dated 6 November 2012.

APPENDIX H: Hybrid Generation Report (AECOM, 2023)

Prepared for
MMG Australia Limited
ABN: 33 115 312 860

AECOM

Hybrid Generation Report

Dugald River Mine

14-Feb-2023
Dugald River Hybrid Renewable Integration Study
Doc No. 0016-REP-3120-EPS-0017
Commercial-in-Confidence



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Delivering a better world

Hybrid Generation Report

Dugald River Mine

Client: MMG Australia Limited

ABN: 33 115 312 860

Prepared by

AECOM Australia Pty Ltd
Wurundjeri and Bunurong Country, Tower 2, Level 10, 727 Collins Street, Melbourne VIC 3008, Australia
T +61 3 8670 6800 www.aecom.com
ABN 20 093 846 925

14-Feb-2023

Job No.: 60663430

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Quality Information

Document Hybrid Generation Report

Ref 60663430

Date 14-Feb-2023

Prepared by Dane Noble

Reviewed by Dirk Agenbag

Revision History

Rev	Revision Date	Details	Authorised	
			Name/Position	Signature
A	14-Dec-2022	Issued For Review	Don Webb ANZ Practice Lead, Renewables & Storage	
0	10-Feb-2023	Issued For Use	Dirk Agenbag Generation Lead, Victoria	
1	14-Feb-2023	Issued For Use (Client Comments)	Dirk Agenbag Generation Lead, Victoria	

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Executive Summary

Dugald River is an underground zinc-lead-silver mine in Northern Queensland and is owned and operated by MMG Australia Limited (MMG).

The existing mine currently obtains its purchased power from the North-West Power System (NWPS) electricity grid owned and operated by Ergon Energy Corporation Limited (Ergon Network). It is noted due to the remote location of the Mt Isa region, the network is not connected to the National Electricity Market (NEM) and the mine is connected to the NWPS via a 62km MMG private 220kV overhead line (OHL) connecting into the Chumvale zone substation.

AECOM have been working with MMG on the Dugald River Hybrid Integration project since June 2021 taking the project through early feasibility to investigate behind the meter wind and solar prior to a Power Purchase Agreement (PPA) negotiation for the solar component that drove the project down a wind only behind the meter pathway.

The project objective is to reduce overall energy operating costs by optimising the displacement of the current gas firming and electricity supply provided by the Diamantina Power Station (APA) with renewables in the form of contracted solar via PPA and on-site wind generation. The primary intent and purpose of the project is to meet existing Dugald River mine infrastructure electrical demand rather than export energy.

With the variable nature of renewables and the complementary diurnal relationship that exists on site between solar production during the day and increased average wind conditions over night the modelling indicates 8 x 6.0MW wind turbines in conjunction with the Mica Creek Solar Farm PPA results in an optimised renewable energy penetration of 75% when compared over the base case of solar + grid connection only with a corresponding renewable penetration of only 32%. The turbine quantity is constrained to a maximum of 8 based on high level micro-siting study completed in an earlier phase. A possible future stage BESS will also likely support energy shifting to further increase renewable penetration.

As such, the recommended go-forward approach is to progress the 8 x 6.0MW wind generation option into the subsequent Feasibility Study.

1.0 Glossary

Below is a list of terms and acronyms used in the report

1.1 List of Acronyms

Table 1 List of Acronyms

Acronym	Meaning
Base Case	The combination of generators, loads and input values used as the default model.
BESS	Battery Energy Storage System
Deferrable Load	Electrical load that requires a certain amount of energy within a given period, but the exact timing is flexible.
HOMER	Hybrid Optimization of Multiple Energy Resources (modelling software)
IRR	Internal Rate of Return
GWh	Giga Watt-hour
kWh	kilo Watt-hour
kV	kilo Volt
LGC	Large Generator Certificates – part of the RET scheme
LCOE	Levelised Cost of Energy
m	millions. Also metres
MMG	MMG Australia Limited
MW	Mega Watt
MWh	Mega Watt-hour
NEM	National Electricity Market
NPC	Net Present Cost
NWPS	North-West Power System
OEM	Original Equipment Manufacturer
O&M	Operation and Maintenance
PPA	Power Purchase Agreement
PV	Photovoltaic (generator), Solar
RET	Renewable Energy Targets
RL	Relative Level
Sensitivity	An input value for which multiple values can be specified, with each value modelled separately.
VRE	Variable Renewable Energy – typically wind and solar
WTG	Wind Turbine Generator

2.0 Approach and Methodology

2.1 Purpose

The purpose of this report is to provide the basis on which the proposed concept hybrid generation mix configuration(s) was selected, and the methodology and approach used in its determination. The key elements of this report include:

1. How the wind and solar resource information was determined and applied,
2. How demand profiles have been determined,
3. How CAPEX and OPEX inputs were applied,
4. What scenarios were modelled,
5. Capturing the results and findings,
6. Future optionality

2.2 Overview

AECOM performed the hybrid energy generation analysis using:

- HOMER Pro 3.14.5.
- Microsoft Excel for wind resource analysis, demand profile modelling, LGC calculations, LCOE of wind only options and results correlation

HOMER is a well-known commercial techno-economic software package that considers all generation options, climatic conditions and power losses in a manner intended to best serve a demand profile.

Wind resource parameters were imported into HOMER software – which formed a major part of the analysis. The load demand and solar generation profiles were provided by MMG and imported into HOMER.

This document does not represent a warranted guaranteed output, nor is it intended to inform investment decisions or the development of any performance guarantee. The model inputs used to derive the energy yield results are based on synthetic data and a typical hybrid system design; future design stages and collected site data may change the model inputs and thus the predicted energy generation mix.

2.3 Model Inputs

2.3.1 System Components

The equipment modelled by AECOM has been selected based on the latest technologies available from tier 1 suppliers only. The nominated wind turbine generators have been selected based on the Sensitivity Analysis exercise described within Phase 2 techno-economic report document 0016-REP-3120-EPS-0017_A.

2.3.2 Model data

Table 2 lists the data inputs, Excel calculations and assumptions used in the development of the HOMER hybrid generation model.

Table 2 Files used in the development of the HOMER hybrid generation model

Item	File Name	Comment	Rev	Revision Date
Model Files				
HOMER Files	60663430_MMG_Phase 4 -Wind Only Update_01Feb23.homer	Model file for Base Case	0	01/02/2023
Input Files				
Mica Creek Solar Farm Generation Data	APA – MICA CREEK SF (UGL) – v7.0_VD3_HourlyRes_0 (50%_2%_6,45%_0.18)_issued.csv	MMG provided year 1 solar PPA generation data, interval data format from PVSyst	0	23/11/2021
	APA PPA Min Solar Generation profile.pdf	MMG provided annual solar PPA generation values	0	25/02/2022
	60663430_MMG_Solar PPA for HOMER_Generation profile.csv	AECOM extract of solar PPA generation data – prepared for input into HOMER as interval data	0	15/08/2022
	60663430_MMG_ Solar PPA for HOMER_Annual values ph3.xlsx	AECOM extract of solar PPA generation data – prepared for input into HOMER as annual values for 2027 – 2047	0	15/08/2022
DR Load Profile	60663430_MMG_DR_SiteLoad_Demand 10min.csv	MMG provided load profile in 10-minute interval data	0	27/07/2021
Economic Inputs	60663430_MMG_DR_EconomicAssumptions-v13.xlsx	MMG provided list of economic inputs - AECOM edit to include LGC calculation	13	31/01/2023
	0016-REP-312-PME-0002_Rev 0.pdf	Dugald River - Hybrid Renewable Integration CAPEX & OPEX Cost Plan	0	23/02/2022
	60663430_Incremental Cost Breakdown.xlsx	CAPEX and OPEX split into incremental for varying wind and fixed system costs	0	31/02/2023
Wind Resource	6066340_MMG_DR_WindSpeedData-130m.txt	Site wind resource data	0	13/09/2021

3.0 Results

3.1 Scenarios Modelled

AECOM has analysed three different generation combinations for Dugald River for life of mine to 2047. These are:

0. Grid only
1. Grid supply and solar PPA
2. Grid supply, solar PPA and behind-the-meter wind generation

3.2 Scenario 2 was used as a base case upon which various sensitivities have been run, namely varying the number of WTG's. The results of this sensitivity are outlined and discussed in Section 3.2. Results of the different scenarios modelled

The results show that the addition of wind generation to the existing solar (via PPA) and grid connection dramatically increases the percentage of mine load served by renewable sources from 32% up to 77% for 9 wind turbines (refer Figure 1). Above 9 turbines the incremental benefit plateaus and would require a BESS or similar energy storage form to further meaningfully increase renewable penetration. Of further consideration is the available suitable wind turbine locations on the mining lease which is constrained to a maximum of 8. On this basis eight wind turbines provides the maximum renewable penetration (75%) to most effectively serve the mine load within the site spatial constraints.

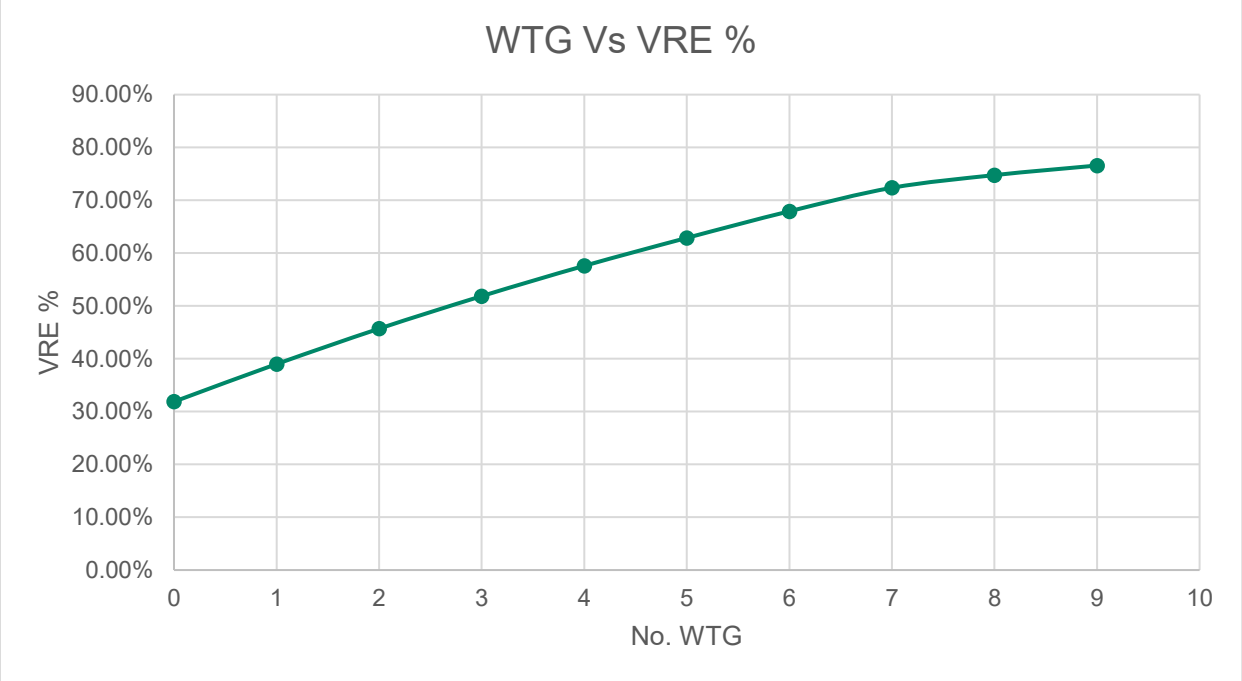


Figure 1 VRE Penetration versus number of WTG's

To further illustrate the benefits of scenario 2 the below Figure 2 demonstrates the mine load (**blue**), renewable energy serving production (**green**) and supplementary short fall for grid purchases (**orange**). For information the drop in the final year displays production beyond proposed life of mine.

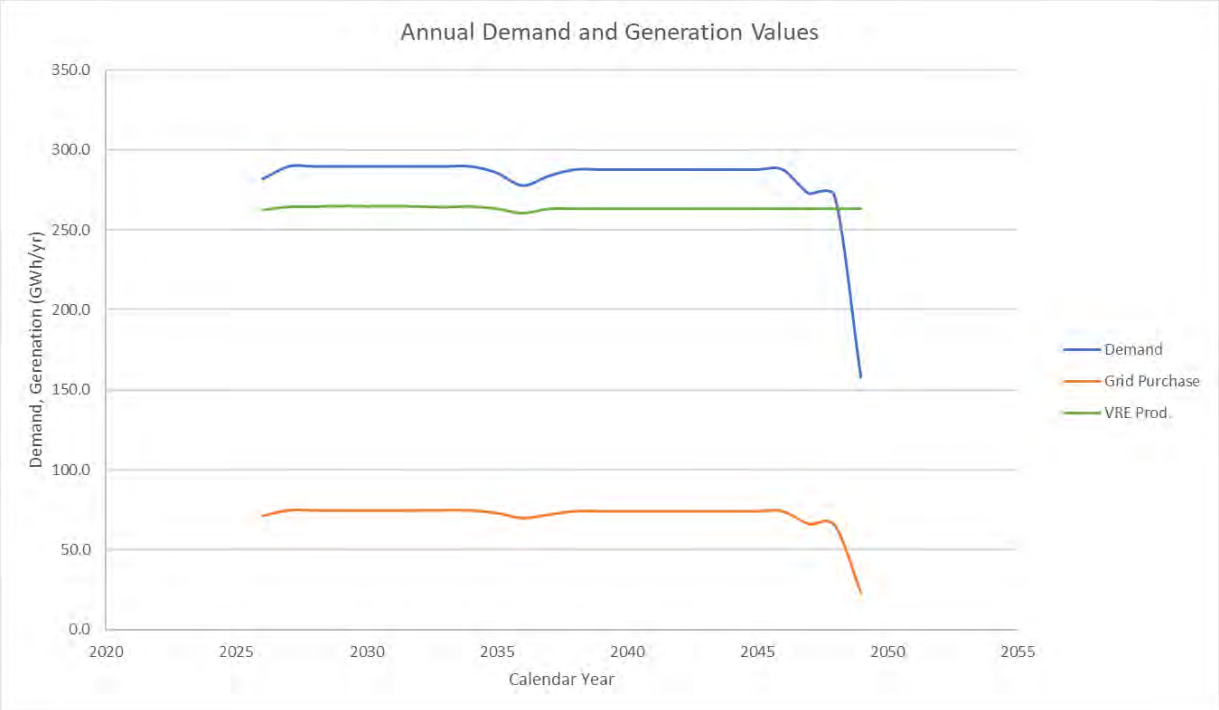


Figure 2 Mine load demand, renewable generation, and grid purchases for 8 WTG's scenario

The importance of wind generation as a renewable energy source for the Dugald River site is further demonstrated via Figure 3 which clearly shows the diurnal and complementary relationship between strong wind generation (**purple**) throughout the evening and night-time, and solar energy generation (**orange**) picking up where wind dramatically drops off (during the daylight hours). This graph is specific to Dugald River and taken as a sample over a week whilst also overlaying the mine load (**pink**) demonstrating rare occurrences of single source generation exceeding load i.e. that is to say renewables have not been oversized based on Scenario 2.

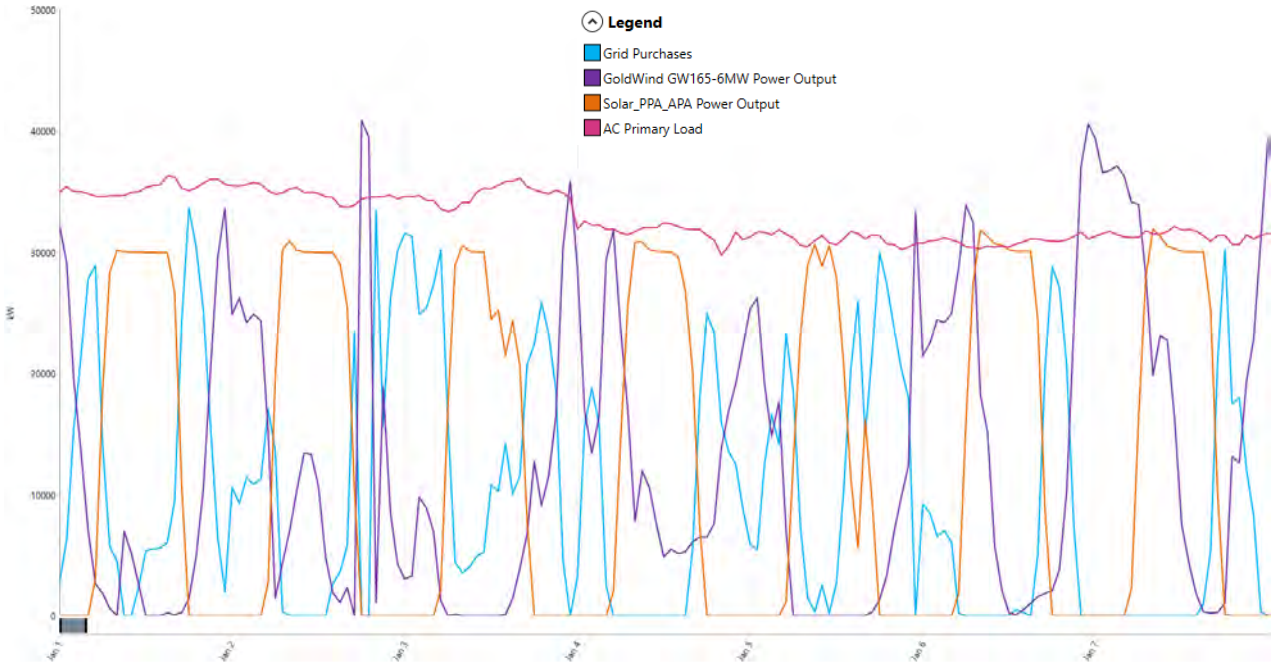


Figure 3 Time series plot for power generation and grid purchase to serve mine load

Raw figures for demand, VRE generation, spilt energy and renewable energy fraction as a percentage of mine load served are provided in Table 3 below for each year out to end of mine life.

Table 3 Annual Demand and Generation Values for Scenario 2

Calendar Year	Model Year	Demand	Grid purchase	Wind out	Solar PPA	Wind Spill	VRE fraction
		GWh/yr	GWh/yr	GWh/yr	GWh/yr	GWh/yr	GWh/yr
2026	1	282.0	71.1	169.3	93.2	51.6	74.8%
2027	2	290.0	74.6	169.3	95.4	49.2	74.3%
2028	3	290.0	74.5	169.3	95.5	49.3	74.3%
2029	4	290.0	74.3	169.3	96.0	49.6	74.4%
2030	5	290.0	74.5	169.3	95.7	49.4	74.3%
2031	6	290.0	74.4	169.3	95.9	49.6	74.4%
2032	7	290.0	74.5	169.3	95.6	49.4	74.3%
2033	8	290.0	74.6	169.3	95.2	49.1	74.3%
2034	9	290.0	74.5	169.3	95.6	49.4	74.3%
2035	10	286.0	72.9	169.3	94.1	50.3	74.5%
2036	11	278.0	69.8	169.3	91.0	52.0	74.9%
2037	12	284.0	71.8	169.3	94.0	51.1	74.7%
2038	13	288.0	74.0	169.3	94.0	49.3	74.3%
2039	14	288.0	74.0	169.3	94.0	49.3	74.3%
2040	15	288.0	74.0	169.3	94.0	49.3	74.3%
2041	16	288.0	74.0	169.3	94.0	49.3	74.3%
2042	17	288.0	74.0	169.3	94.0	49.3	74.3%
2043	18	288.0	74.0	169.3	94.0	49.3	74.3%
2044	19	288.0	74.0	169.3	94.0	49.3	74.3%
2045	20	288.0	74.0	169.3	94.0	49.3	74.3%
2046	21	288.0	74.0	169.3	94.0	49.3	74.3%
2047	22	273.0	66.1	169.3	94.0	56.4	75.8%
2048	23	271.0	65.1	169.3	94.0	57.4	76.0%
2049	24	157.8	23.5	169.3	94.0	129.0	85.1%

3.3 HOMER Report Extracts

Additional extracts from the HOMER report for the scenario 2 base case are shown below, showing the power output of wind, solar and grid purchases respectively.

Figure 4 shows most of the grid purchases are at the shoulder periods of early evenings and early mornings i.e., when the solar is not producing power and the wind turbines are not generating at full capacity. Future optionality with regards to a BESS should be retained to increase renewable penetration by time-shifting otherwise exported or spilt unmet renewable energy to time of use demand. For the purposes of this report a BESS has not been considered.

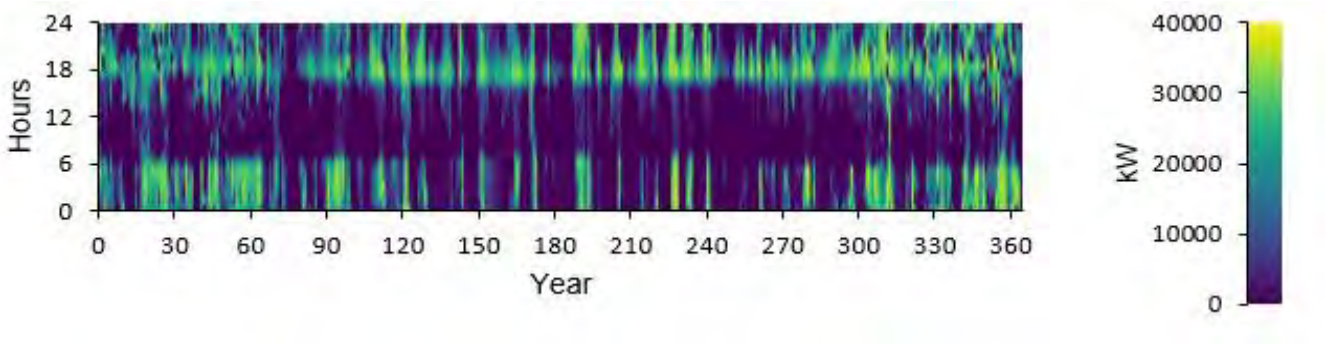


Figure 4 Power purchased from the grid across a day for one year

Given the strong diurnal relationship that exists between the site-based wind resource and contracted solar PPA, the resulting spilt or excess energy (exported) is considered optimised based on the HOMER modelling. This reinforces the intention to match forecast demand with variable renewables rather than any potential export or spilt renewable generation.

3.4 Future Optionality

As briefly discussed within the results, meaningful increase in renewable energy fraction serving the mine load above the current Scenario 2 case would require some form of energy storage to capture spilt/exported renewable energy and time shift this to periods of low renewable generation to displace grid purchases. Major load increases due to future mine expansion, electrification (including of fleet) or other major capital projects would also benefit from an energy storage system, or alternatively increased renewables in the form of additional wind or solar. These test cases / sensitivities are outside the scope of this report.

4.0 Conclusion

The modelling results indicate that the addition of 48MW of behind-the-meter wind generation to the Dugald River power supply system is the optimal solution for serving mine load when implemented in conjunction with the existing solar PPA and grid connection.

The Dugald River location demonstrates an excellent diurnal relationship between the solar PPA and wind generation particularly when matched against the life of asset demand profile.

Further upside to the renewable energy fraction serving the mine load is likely possible with the addition of a behind the meter energy storage system but is outside the scope of this study.

The analysis above indicates that that the introduction of wind energy as early as possible has greatest net benefit. AECOM recommend taking forward 48MW of wind generation into the subsequent Feasibility Study phase of the project.

APPENDIX I: Approval Letter ML 90211

Queensland Government

Department of **Resources**

Add mineral or purpose to ML

21/08/2023 MMOL activity reference: 400496

MMG Dugald River Pty Ltd
c/- Hetherington Exploration & Mining Title Services (Qld) Pty Ltd
PO Box 49 Spring Hill LPO
SPRING HILL QLD 4004 brisbane@hemtsqld.com.au

Dear Sir/Madam

We are pleased to advise that pursuant to section 298 of the *Mineral Resources Act 1989* approval add an additional purpose to mining lease number 90211 is given.

Additional Purpose: Ancillary Power Generation

Note: The installation of wind turbines and transmission lines on Mining Lease 90211 is for power generation to support the mining operations. Should you wish to export power to the grid you will need to investigate the necessary approvals required as this is not an authorised activity on the mining lease.

Note: The Department will, at all times, insist on strict compliance with all terms and conditions of the mining lease.

We recommend this letter be kept as a record that the application for additional minerals/purpose has been approved and recorded on the register.

Where do I find more information?
There are a range of useful resources and support materials available to assist you from our website www.business.qld.gov.au/industry/mining. You can also download guidelines and policies on your resource permit obligations, land access and native title as it applies to mining and exploration activities.

If you have questions about this letter, or specific detail relating to the above permit contact the Mineral Assessment Hub on MineralHub@resources.qld.gov.au or 07 4447 9230.

Regards

Anthony Chapman
Senior Mining Registrar
Minerals and Coal
Department of Resources

Department of Resources
Level 9, Verde Tower, 445 Flinders Street, Townsville QLD 4810
PO Box 1752, Townsville QLD 4810
Telephone 07 4447 9230
Email: mineralhub@resources.qld.gov.au
www.resources.qld.gov.au
ABN 59 020 847 551

APPENDIX J: Approval Letter ML 90213

Queensland Government

Department of **Resources**

Add mineral or purpose to ML

21/08/2023 MMOL activity reference: 400497

MMG Dugald River Pty Ltd
c/- Hetherington Exploration & Mining Title Services (Qld) Pty Ltd
PO Box 49 Spring Hill LPO
SPRING HILL QLD 4004 brisbane@hemtsqld.com.au

Dear Sir/Madam

We are pleased to advise that pursuant to section 298 of the *Mineral Resources Act 1989* approval add an additional purpose to mining lease number 90213 is given.

Additional Purpose: Ancillary Power Generation

Note: The installation of wind turbines and transmission lines on Mining Lease 90213 is for power generation to support the mining operations. Should you wish to export power to the grid you will need to investigate the necessary approvals required as this is not an authorised activity on the mining lease.

Note: The Department will, at all times, insist on strict compliance with all terms and conditions of the mining lease.

We recommend this letter be kept as a record that the application for additional purpose has been approved and recorded on the register.

Where do I find more information?
There are a range of useful resources and support materials available to assist you from our website www.business.qld.gov.au/industry/mining. You can also download guidelines and policies on your resource permit obligations, land access and native title as it applies to mining and exploration activities.

If you have questions about this letter, or specific detail relating to the above permit contact the Mineral Assessment Hub on MineralHub@resources.qld.gov.au or 07 4447 9230.

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ABN 59 020 847 551

APPENDIX K: Ecological Assessment Report (WTS, 2023)



ECOLOGICAL ASSESSMENT REPORT

DUGALD RIVER WINDFARM

MMG DUGALD RIVER PTY LTD



NOVEMBER 2023

WULGURU TECHNICAL SERVICES

Contact Details	
Company	Wulguru Technical Services Pty Ltd
Project Manager	Delwyn Windridge
Email	delw@wulgurutechservices.com.au
Mail	PO Box 2553 IDALIA QLD 4810
ABN	79 644 301 655

Disclaimer

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Document Control and History

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V1.1	22 April 2024	Amendment 1	Harry Bonnell	

Citation

Wulguru Technical Services, 2023, *MMG - Dugald River Windfarm Ecological Assessment Report*, Prepared by Wulguru Technical Services Pty Ltd for MMG Dugald River Pty Ltd.

WTS acknowledge the work of EcoSmart Ecology for their ongoing commitment to ecological survey and monitoring at MMGs Dugald River Mine and for the preparation of a summary of survey effort since 2013 to support this assessment.

Executive Summary

The Dugald River Mine project (DRM) is a predominantly zinc mining operating under Environmental Authority EPML00731213 (the EA) held by MMG Dugald River Pty Ltd (MMG). MMG are seeking approval to establish a wind farm (the Project) and associated ancillary infrastructure to support the DRM's goal of achieving net zero by 2050. The preliminary phase of the Project proposes to install eight wind turbines on the Knapdale Range in the area to the west of the primary mining infrastructure and south of the tailings dam within the existing mine leases (Figure 1).

The Project will require the establishment of roads and infrastructure sufficient to accommodate transport of wind turbines and ancillary equipment to the proposed locations for installation as well as other infrastructure such as transmission towers and laydown areas.

Wulguru Technical Services Pty Ltd (WTS) was engaged by MMG Dugald River Pty Ltd (MMG), to prepare an assessment for impacts against relevant matters under the *Environment Protection and Biodiversity Conservation (EPBC) Act 1999*, with regard to proposed Project activities at DRM.

Extensive ecological assessments have been undertaken on the DRM MLs and surrounding areas, commencing with investigations by AustralAsian Resource Consultants in 2008 to support the Environmental Impact Statement. Ecological assessment has been ongoing since that time with the conditioned monitoring requirements of DRM and survey and assessments undertaken by EcoSmart Ecology to support ongoing works and expansions at the mine including commencing Bird and Bat Utilisation Surveys of the proposed Project area in May 2023. WTS undertook vegetation and habitat assessments of the proposed Project area in October 2023 to supplement the existing information and ensure currency of information to support the proposed action.

The purpose of this report is to: describe the proposed action; assess the impacts of the proposed action against conservation significant matters and to identify management actions to avoid, manage and mitigate impacts to the same; and to provide supporting information in relation to the EPBC referral and assessment process and the proposed EA amendment for the DRM windfarm project.

While the Project is to be assessed under the *Environmental Protection Act 1994* (EP Act), Performance Outcomes (PO) under State code 23: Wind farm development were considered as part of this impact assessment to ensure adherence to current Queensland Government standards of assessment. This ecological assessment report has been provided in line with the requirements of the code.

Summary of potential impacts

The Project area has been studied extensively since many Suitably Qualified and Experienced personnel represented by multiple organisations over the last 14 years. This is considered to be a robust dataset for the proposed development and more than sufficient to adequately assess the potential impacts of the Project.

While multiple species of various classifications under the NCA, EPBC etc have been mapped as potentially occurring within the area, the data available indicates that only two conservation significant species, PNRW and the short-beaked echidna are known within the proposed disturbance footprint. A total of 75ha of disturbance is proposed, however this resents only 1.5 % of the entire Knapdale Range. It is important to note that at the time of the original submission in July2023, only 11.9 ha of the proposed disturbance area was mapped as essential habitat, however

following a mapping release on 22 November 2023, now the entire Knapdale Range has been mapped as essential habitat.

The Dugald River Mine proposed Windfarm requires additional disturbance area of 75 Ha, less than 2% of the total area of the Knapdale Range.

As category B regulated remnant vegetation is mapped for the whole of the Knapdale Range, the project will require impacts to 75 Ha of category B remnant vegetation.

Most of the proposed disturbance area has a biodiversity status of no concern at present however Endangered Regional Ecosystem (ERE) 1.3.7b: *Eucalyptus camaldulensis* fringing woodland, usually with *Lophostemon grandiflorus* and *Melaleuca bracteata* and/or *M. dissitiflora* was confirmed present within the proposed footprint. Ground-truthing surveys delineating the category B ESA - ERE 1.3.7b indicate that only 1.04 Ha of the ESA will be impacted as a result of the Project. This RE is least concern under the *Vegetation Management Act 1999* (VM Act) and as such is not assessable under the significant residual impact criteria for regulated vegetation.

Total approximate area of regional ecosystem intersecting a watercourse within the proposed disturbance area is 3.5 ha (section 3.1.6.1.4). Impacts to regulated vegetation intersecting a watercourse exceed criteria 1 and 3 of the significant residual impact test of table 1 of the guidelines (Department of the Environment, 2013) (see section 4.1.1). While the total area of impact for the project exceeds the criteria, each individual area of disturbance is minimal and unavoidable.

The proposed Project will impact 68.7 Ha of regulated vegetation essential habitat for the Purple-necked Rock wallaby (PNRW). A significant residual impact assessment for disturbance to PNRW habitat determined that significant residual impacts to the PNRW as a result of Project related disturbance will be unlikely based on the disturbance of essential habitat alone (see section 4.1.2).

Threats specific to the construction of a wind farm, and associated impacts, are:

- Wind turbine structures, primarily rotor blades and associated Rotor-swept Area (RSA), causing;
    - Collisions between flying fauna and wind turbine rotor blades or other structures, or barotrauma as a result of flight close to rotor blades, resulting in injury or fatality;
    - Displacement and barriers effects resulting in greater energetic cost to fauna flying through the area;
- Noise pollution and pressure and vibrations from the operation of the wind turbines;
    - Confusing/disorientating flying fauna increasing risk of collision; or
    - Disturbing surrounding habitat making it less preferable for native species or conditioning avoidance and affecting normal distribution patterns.

The Project was determined to have potential for significant residual impacts to the vulnerably listed (*Nature Conservation Act 1996*) PNRW due to the unknown effects of turbine operation on the rock-wallaby directly and breeding, feeding and dispersal behaviours as a result of operation with particular respect responses to noise and vibrations. Potential impacts to the PNRW are assessed against the significant residual impact criteria for protected wildlife habitat in section 4 of this report.

The significant residual impact assessments concluded that the project is unlikely to have a significant impact on any additional conservation significant species assessed.

Additional least concern species and populations identified as potentially being impacted during the operation phase of the project were also assessed. While impacts from the various phases of the Project are unlikely to have residual impacts to the following least concern species populations, localised impacts may be possible for the following bird and bat species populations in the Project area:

- Birds
    - Australian Hobby (*Falco longipennis*)
    - Black Kite (*Milvus migrans*)
    - Black-breasted Buzzard (*Hamirostra melanosternon*)
    - Black-faced Woodswallow (*Artamus cinereus*)
    - Black-shouldered Kite (*Elanus axillaris*)
    - Brown Falcon (*Falco berigora*)
    - Brown goshawk (*Accipiter fasciatus*)
    - Collared Sparrowhawk (*Accipiter cirrocephalus*)
    - Fairy Martin (*Petrochelidon ariel*)
    - Little woodswallow (*Artamus minor*)
    - Masked woodswallow (*Artamus personatus*)
    - Nankeen Kestrel (*Falco cenchroides*)
    - Spotted harrier (*Circus assimilis*)
    - Varied Lorikeet (*Psitteuteles versicolor*)
    - Wedge-tailed eagle (*Aquila audax*)
    - Whistling kite (*Haliastur sphenurus*)
    - White-breasted woodswallow (*Artamus leucorhynchus*)
    - White-browed woodswallow (*Artamus superciliosus*)
    - White-necked heron (*Ardea pacifica*)
- Bats
    - Finlayson's Cave Bat (*Vespadelus finlaysoni*)
    - Gould's Wattled Bat (*Chalinolobus gouldii*)
    - Hoary Wattled Bat (*Chalinolobus nigrogriseus*)
    - Inland Broad-nosed Bat (*Scotorepens balstoni*)
    - Inland Forest Bat (*Vespadelus baverstocki*)
    - Little Broad-nosed Bat (*Scotorepens greyii*)
    - Northern Freetail Bat (*Chaerophon jobensis*)
    - Northern Free-tailed Bat (*Ozimops lumsdenae*)
    - White-striped Freetail Bat (*Austronomus australis*)
    - Yellow-bellied Sheathtail Bat (*Saccolaimus flaviventris*)

The possibility of a local impact on the above species is due to their flight behavious from their aerial nature and their likelihood to occur in the RSA.

Recommendations

The following monitoring strategies are recommended to monitor the impacts of the project and inform implementation and adjustment of management strategies:

- Ongoing fauna monitoring and maintaining records of any fauna interactions on site, through vigilance and carrion surveying;
- Maintaining records of aerial fauna movement through the project area;
- Air quality, Noise and Vibration monitoring and management performed as per DRM Air Quality, Noise and Vibration Management Plan.
- Bird and Bat Management Plan (BBMP) – A bird and bat management plan outlining the species potentially impacted by the operation of the wind farm and how these species will be managed and monitored during operations. This BBMP is subject to ongoing assessment and will be refined following ongoing monitoring of bird and bat activity.

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Definitions

Term	Definition
AARC	AustralAsian Resource Consultants
ALA	Atlas of Living Australia
DRM	Dugald River Mine
EAAFP	East Asian-Australasian Flyway Partnership
ERE	Endangered Regional Ecosystem
ESA	Environmentally Sensitive Area
LOO	Likelihood of Occurrence
MMG	MMG Limited
MNES	Matters of National Environmental Significance
MSES	Matters of State Environmental Significance
PMAV	Property Map of Assessable Vegetation
PMST	Protected Matters Search Tool
PNRW	Purple-necked Rock-wallaby
RE	Regional Ecosystem
RSA	Rotor-swept Area
SIT	Significant Residual Impact
WTS	Wulguru Technical Services

1. Introduction

The Dugald River Mine (DRM) operation is a predominantly zinc mining operating under Environmental Authority EPML00731213 (the EA) held by MMG Dugald River Pty Ltd (MMG). MMG are seeking approval to establish a wind farm (the Project) and associated ancillary infrastructure to support the DRM's goal of achieving net zero by 2050. Furthermore, the DRM operation is currently powered by the Diamantina Power Station in Mount Isa which is subject to volatility in gas prices, directly impacting the mines viability and therefore employment. The Project proposes to install eight wind turbines on the Knapdale Range in the area to the west of the primary mining infrastructure and south of the tailings dam within the existing mine leases (Figure 1).

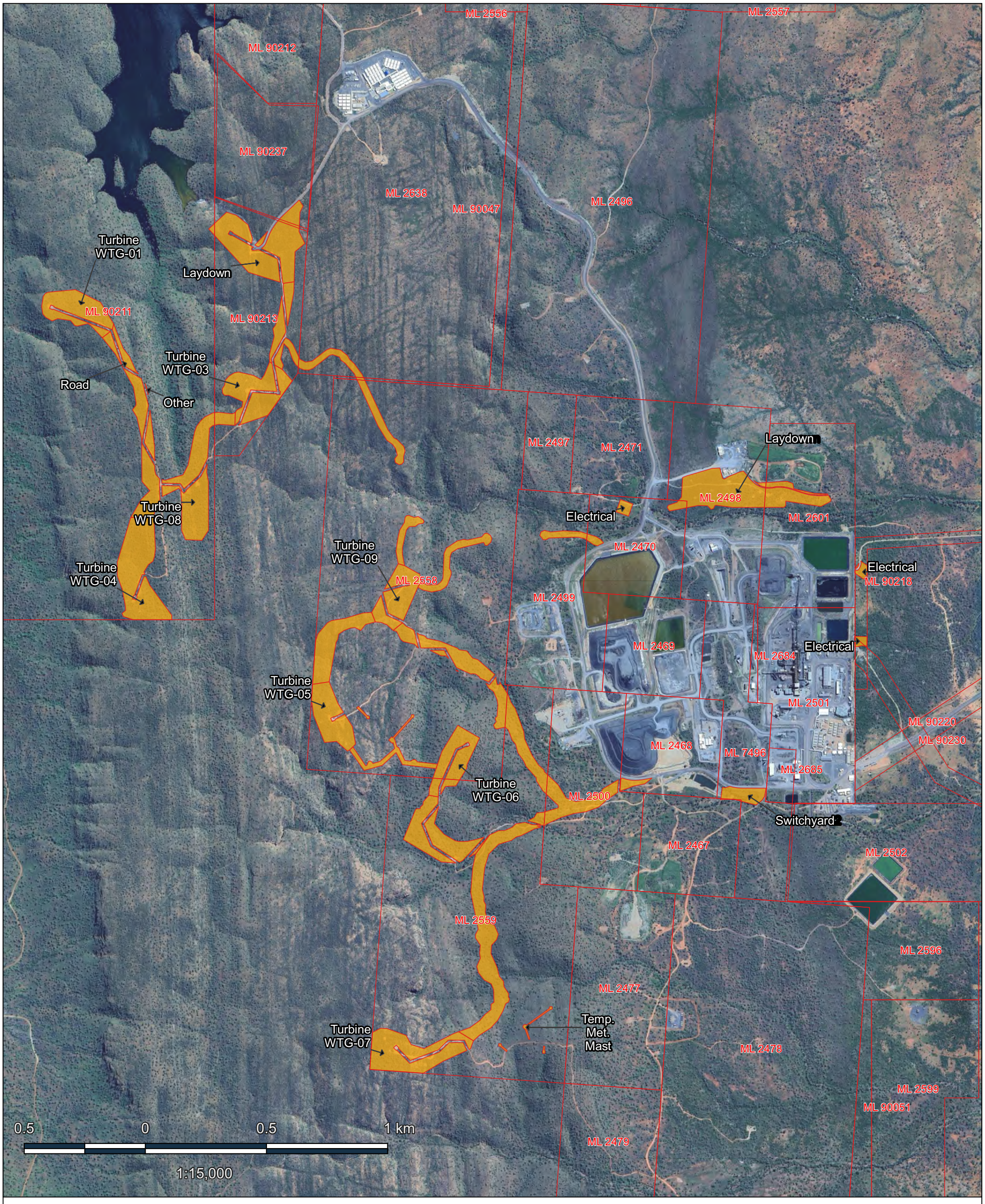
The Project will require the establishment of roads and infrastructure sufficient to accommodate transport of wind turbines and ancillary equipment to the proposed locations for installation as well as other infrastructure such as transmission towers and laydown areas.

Wulguru Technical Services Pty Ltd (WTS) was engaged by MMG Dugald River Pty Ltd (MMG), to prepare an assessment for impacts against relevant matters under the *Environment Protection and Biodiversity Conservation (EPBC) Act 1999*, with regard to proposed Project activities at DRM.

Extensive ecological assessments have been undertaken on the DRM Mining Leases (ML) and surrounding areas, commencing with investigations by AustralAsian Resource Consultants in 2008 to support the Environmental Impact Statement. Ecological assessment has been ongoing since that time with the conditioned monitoring requirements of DRM and survey and assessments undertaken by EcoSmart Ecology to support ongoing works and expansions at the mine including commencing Bird and Bat Utilisation Surveys of the proposed Project area in May 2023. WTS undertook vegetation and habitat assessments of the proposed Project area in October 2023 to supplement the existing information and ensure currency of information to support the proposed action.

The purpose of this report is to: describe the proposed action; assess the impacts of the proposed action against conservation significant matters and to identify management actions to avoid manage and mitigate impacts to the same; and to provide supporting information in relation to the EPBC referral and assessment process and the proposed EA amendment for the DRM windfarm project.

While the Project is to be assessed under the EP Act, Performance Outcomes (PO) under State code 23: Wind farm development were considered as part of this impact assessment to ensure adherence to standards of assessment outlined by the Queensland Government. This ecological assessment report has been provided in line with the requirements of the code.



Client: Dugald River Pty Ltd
Project number: 2023.03002
CRS: GDA2020 EPSG: 7844
Date: 26 April 2024

Print as A3

Figure 1. Dugald River Mine Proposed Wind Farm

Legend

- Mine Lease
- Proposed Windfarm Features

Google Satellite

Disclaimer:
Whilst every effort and care has been taken to ensure the accuracy of this report, Wulguru Technical Services Pty Ltd makes no representations or warranties about its accuracy, reliability, completeness or suitability for any particular purpose and disclaims all responsibility and all liability (including without limitation, liability in negligence) for all expenses, losses, damages (including indirect or inconsequential damage) and costs which you might incur as a result of the product being inaccurate or incomplete in any way and for any reason.
Digital data for this report is available on the Queensland Government Spatial Portal at https://qldspatial.information.qld.gov.au.

WULGURU TECHNICAL SERVICES

1.1. Project Description

Construction of DRM was completed in 2017 with ore first being transported in November of the same year. It is predicted that DRM will export 170,000 – 190,000 tonnes of zinc as zinc concentrate annually via the Port of Townsville over the Life of Mine (LOM).

MMG are actively seeking to achieve a net zero emissions target by 2050 and in keeping with this goal, a conversion to renewable energy is being pursued with the establishment of a windfarm and ancillary supporting infrastructure, referred to herein as the Project.

The current DRM EA authorises mining related activities for 40 mining leases and also includes one mineral development lease to the southern end of the Knapdale Range.

MMG are seeking to develop a windfarm on the Knapdale Range to provide a sustainable energy source for mine related activities. Eight turbines are planned for the area to the east of the mine and within the ML's.

Table 1: Property description

Company Name	MMG Dugald River Mine Pty Ltd
Lot on Plan	59TG40, 35B15753, 92SP303378, 36AP23793, 1AP23793, 27B15753, 36B15753
Mining Lease	MDL79, ML2502, ML90213, ML2467, ML2556, ML90218, ML2468, ML2557, ML90220, ML2469, ML2558, ML90230, ML2470, ML2559, ML90237, ML2471, ML2596, ML2477, ML2599, ML2478, ML2601, ML2479, ML2638, ML2480ML2684, ML2481 ML2685, ML2482, ML7496, ML2496, ML90047, ML2497, ML90049, ML2498ML90050, ML2499, ML90051, ML2500, ML90211, ML2501, ML90212
ML Area	2968.566 ha
Local Government Area	Cloncurry Shire
Bioregion/Subregion	Mount Isa Inlier of the Northwest Highlands
Drainage basin/sub-area	Leichhardt Basin and Flinders Basin
Existing approved disturbance area	297.542 Hectares
Proposed additional disturbance of the Project	75.029 Hectares

1.2. Site Description

DRM is located approximately 70km northwest of Cloncurry in western Queensland and situated adjacent to the Knapdale Range. Other infrastructure such as the mine camp are located on the range itself along with the valley fill tailings dam which is situated in the northern one-third of the range. The mine falls within the Cloncurry Shire Council region and maintains a policy of sourcing locally where possible.

While the main mine infrastructure lies adjacent to the Knapdale Range the footprint for the proposed windfarm is situated in the higher elevation areas of the Knapdale Range in *Eucalyptus leucophloia* dominant habitat.

The Knapdale Range lies within the Mount Isa Inlier subregion of the Northwest Highlands bioregion which is characterised largely by the tilted metamorphic hills and ranges evident on the Knapdale. Weather in the region tends towards mild to cool winters and hot summers often with heavy tropical and intense rain events.

DRM sits at approximately 200m AHD on relatively flat, grassy plains. To the west the Knapdale Range, which reaches maximum elevation of approximately 300m AHD (Queensland Globe, 2023). The proposed wind turbine pads are located at between 270-290m elevation.

DRM lies between the Leichhardt Basin and the Flinders Basin. Watercourses in the project area range between stream orders one and two. Two major rivers flow either side of the DRM, but do not enter the project area: Cabbage Tree Creek in the northwest, a 5th order stream flowing south and draining into the Leichardt basin, and Dugald River in the southeast, another 5th order streaming flowing south and draining into the Flinders Basin.

Streams and drainage lines are ephemeral. Numerous rocky water holes are known to retain water for varying lengths of time into the dry season, and some may be deep and large enough to subsist through the dry season in wetter years.

Vegetation of the Project area consists of low open woodland and open Spinifex dominant grasslands, with moderate to sparse Acacia dominant shrub layers throughout. Soil types range from rocky, skeletal soil types to shallow -moderate sandy loam towards the eastern base of the range.

The rocky habitat of Knapdale Range supports populations of Purple-necked Rock-wallaby (PNRW) (*Petrogale purpuriecolis*) which is considered a vulnerable species under the NC Act. Local populations are currently monitored under the MMG DRM Purple-necked Rock-wallaby Monitoring Program and reported annually to DES in accordance with the EA.

1.3. Proposed Works

Nine locations across the Knapdale Range were selected for geotechnical investigations with the intended purpose of installation of wind turbines. Construction of turbine pads and access tracks requires 75 ha of additional land clearing within the lease footprint. There will be eight turbines, with the ninth turbine pad being used as a laydown area. The Rotor-swept Area (RSA, i.e. referring to the height range within which the blades of operating wind turbines move (Brett Lane & Associates Pty Ltd, 2005)) was considered at the largest dimensions possible to allow for design adjustments. The Goldwind GW 165-5.2/5.6/6.0MW with a 130m hub height and 165m rotor blade diameter calculates to an RSA between 47.5 m - 212.5 m height above ground level with blade rotation area of 21,382m^2. This assessment has been based on these criteria in consideration of the Precautionary Principle and in accordance with accepted methodology and conditioning style adopted through State Code 23.

The project will consist of a clearing phase, a construction phase, an operation phase, and a decommissioning phase following mine closure.

1.4. Potential Impacts of the project

Potential impacts have been considered for flora and various fauna types across each phase of the Project.

1.4.1. Clearing and Construction Phase (also applicable to decommissioning phase)

- Introduction and/or spread of weed species (such as Prickly Acacia (*Vachellia nilotica*) and Buffel Grass (*Cenchrus* spp.)) due to vehicles or machinery moving across the landscape;
    - Modifying the habitat of native species; or
    - Outcompeting threatened native flora (*Ipomoea antonschmidii*);
- Introduction of infection, diseases or parasites in the project area;
    - Facilitating the infection of native species with diseases/parasites (e.g. hydatid disease (*Echinococcus granulosus*) or toxoplasmosis (*Toxoplasmosis gondii*)); or
- Contaminants and waste (e.g. fuel or oil spills, or litter);
    - Directly harming native fauna (e.g. ingestion of litter causing injury or death); or
    - Indirectly harming native fauna through habitat degradation;
- Noise, dust, light pollution, and vibrations from clearing and construction (especially during night-time works);
    - Light confusing/disorientating native birds increasing risk of interaction (risk has been nullified by design adjustments – lighting will not be present on the turbines); or
    - Disturbing surrounding habitat making it less preferable for native species or conditioning avoidance and affecting normal distribution patterns;
- Construction/clearing activities;
    - Causing injury/fatality of native fauna; or
    - Destruction of habitat of native fauna (specifically important in the case of rocky habitat/sub-habitat due to high profile native fauna species reliant on such habitat); or
    - Creating barriers to distribution; or

- Creating barriers to downstream flow;
- Active work areas including pits, trenches, stockpiles, and other hazardous areas;
  - Causing injury/fatality of native fauna;

1.4.2. Operation Phase – Terrestrial fauna

- Noise pollution, and pressure and vibrations from the operation of the wind turbines;
  - Disturbing surrounding habitat making it less preferable for native species or conditioning avoidance and affecting normal distribution patterns.

1.4.3. Operation Phase – Aerial fauna

- Wind turbine structures, primarily rotor blades and associated RSA, causing;
  - Collisions between flying fauna and wind turbine rotor blades or other structures, or barotrauma as a result of flight close to rotor blades, resulting in injury or fatality. The likelihood of a collision is dependent on a range of factors, including:
    - Design characteristics, such as:
      - the type of wind turbine; and
      - the layout of the wind farm;
    - site characteristics, including:
      - the ecosystems on the wind farm site;
      - proximity to bird concentrations;
      - the numbers of birds moving across the wind farm site;
      - the behaviours of birds and bats (e.g. soaring at RSA height); and
      - weather conditions (Brett Lane & Associates Pty Ltd, 2005).
  - Displacement and barriers effects resulting in greater energetic cost to fauna flying through the area;
- Noise pollution, pressure, and vibrations from the operation of the wind turbines;
  - Light confusing/disorientating aerial fauna increasing risk of collision (risk has been nullified by design adjustments – lighting will not be present on the turbines); or
  - Disturbing surrounding habitat making it less preferable for native species or conditioning avoidance and affecting normal distribution patterns.

1.5. Legislative context

Environmental Protection Act 1994 (Queensland)

The *Environmental Protection Act 1994* (EP Act) is Queensland's primary piece of environmental legislation. The objective of the EP Act is to 'protect Queensland's environment while allowing for development that improves the total quality of life, both now and in the future, in a way that maintains the ecological processes on which life depends'. The EP Act ensures adherence to the protection and conservation of protected matters listed in Queensland's other key pieces of legislation such as the *Nature Conservatio*n Act *1992,* the *Water Act 2000,* and the *Vegetation Management* Act *1999.*

The undertaking of an environmentally relevant activity (ERA) in Queensland requires and Environmental Authority (EA) under the EP Act. An ERA is any industrial, resource or intensive agricultural activities with the potential to release contaminants into the environment and may include activities such as mining and resource activities, aquaculture, and sewage treatment.

The holder of an EA can apply for an amendment to the EA should they wish to undertake activities outside of the scope of the existing EA. MMG are required to submit an application to amend the current EA to include activities associated with the proposed DRM windfarm and to obtain approval from the Department of Environment and Science prior to commencement of works. The Environmental Authority (EA) amendment will include the installation of eight wind turbines and ancillary infrastructure along with vegetation clearing required for, and construction of associated roads, tracks, pads, and infrastructure disturbance areas.

In accordance with sections 125 and section 226 of the EP Act an application for an e EA includes an assessment of the likely impact of each environmentally relevant activity on environmental values. Environmental values that should be considered and addressed in an EA application include:

- Category A and category B environmentally sensitive areas (ESAs) as defined under Schedule 19 of the Environmental Protection Regulation 2019 (EP Regulation);
- Category C ESAs where defined in a relevant model conditions document1 or ERA standard2 ; and
- Matters of State environmental significance (MSES) as defined in Schedule 2 of the Environmental Offsets Regulation 2014 (EO Regulation) (Departement of Environment and Science, 2020).

Environment Protection and Biodiversity Conservation Act 1999 (Commonwealth)

The *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) is the Commonwealth Government's key piece of environmental legislation. It provides a legal framework to protect and manage nationally and internationally important flora, fauna, ecological communities, and heritage places — defined in the EPBC Act as Matters of National Environmental Significance (MNES).

MNES under the EPBC Act are:

- World Heritage Properties;
- National Heritage Places;
- Wetlands of international importance (listed under the Ramsar Convention);
- Nationally threatened species and ecological communities;
- Migratory species;

- Commonwealth marine areas;
- The Great Barrier Reef Marine Park;
- Nuclear actions (including uranium mining); and
- A water resource, in relation to coal seam gas and large coal mining developments.

Actions that have, will have or are likely to have a significant impact on MNES are called “controlled actions” and require approval under the Act.

Nature Conservation Act 1992

The *Nature Conservation Act 1992* (NCA), the Nature Conservation (Animals) Regulation 2020 and the Nature Conservation (Plants) Regulation 2020 provide a legislative framework for the protection and conservation of Queensland’s native plants and animals.

Under the framework, species of conservation significance are assessed and categorised with respect to population, distribution and potential threats and impacts.

The objectives of the NCA are achieved through an integrated and comprehensive conservation strategy that protects and conserves threatened and special interest species and their habitat, and protected areas.

State Code 23: Wind farm development

The DRM Wind farm project is to be assessed under the EP Act however as no criteria for assessment within the legislation relates to the construction of a wind farm the Department of Environment and Science have indicated that an assessment of the Project using performance outcomes of state development code State Code 23: Wind farm development will be sufficient for the application.

The purpose of State Code 23 is to ensure that the impacts arising from the construction, operation, and decommissioning of wind farms do not result in unacceptable adverse impacts on individuals, communities, and the natural environment. Under State code 23, the relevant Performance Outcomes (PO) were considered as part of the impact assessment to ensure adherence to standards of assessment. The following relevant PO were considered as part of this assessment.

- PO1 Development is designed and sited to ensure that threatened species and associated habitats and areas of high environmental value are protected from adverse impacts;
- PO2 Development is constructed to ensure that threatened species and associated habitats, and areas of high environmental value are protected from adverse impacts;
- PO3 Development operations ensure that threatened species and birds and bats are protected from adverse impacts;
- PO4 Development operations ensure that areas cleared for the construction of a wind farm are replanted to the maximum extent possible following construction without impeding operations and maintenance of the wind farm;
- PO5 ensures that the wind farm, including ancillary infrastructure, is designed and sited to minimise crossings of and interference with natural drainage lines and watercourses;

1.6. Qualifications and Experience

Data collated to inform this report has been drawn from several sources. Various ecological surveys have been undertaken at the mine and in surrounding areas since investigations first commenced in 2008. All surveys have been undertaken by suitably qualified persons for the purpose of undertaking ecological surveys.

Terrestrial Flora and Fauna surveys were undertaken by AustralAsian Resource Consultants (AARC) between 2008 and 2011. The Project Manager was Andrew Pearce (Environmental Scientist) and survey report authors were Brendan Massy (Environmental Scientist) and Julie Byrd (Environmental Scientist) (AustralAsian Resource Consultants Pty Ltd, 2011).

EcoSmart Ecology have been undertaking the delivery of ecological services and monitoring programs at DRM since 2014. Lead by Director and Principal Ecologist Mark Sanders, who has over 20 years' experience in terrestrial ecology, EcoSmart Ecology surveys and monitoring have been conducted by ecologists suitably qualified and experienced in the undertaking of ecological surveys (Ecosmart Ecology, 2023). Details of qualifications and experience are provided in Table 1.1 of APPENDIX J: Eco Smart Report

WTS surveys and reporting were led by Delwyn Windridge who has more than 10 years' experience in the undertaking of ecological surveys and impact assessments. The WTS ecology team involved in field data collection and collating data and information for the report included spatial ecologist Haley Harding with 3 years ecological experience, and junior ecologists Jamie Smith and Harry Bonnell.

2. Methodology

A significant cumulative sum of technical and ecological studies has been undertaken with regard to the MMG DRM project site and provide the information to which this report largely refers. Available information dates back to 2008 with the commencement of environmental assessments for the EIS which was submitted for approval in 2011. More recent assessments and monitoring surveys relating to the requirements of the EA and ongoing development of the mine bring to currency the information used to support the desktop component of this report. EcoSmart Ecology additionally commenced the undertaking of Bird and Bat Utilisation Surveys in 2023 to support the environmental assessments relating to the Project approvals applications.

WTS undertook supplementary assessments of vegetation and habitat assessments of the Project footprint area in October 2023 to ensure compliance with the requirements for currency of information and due diligence of process.

The following sections summarise the methods used in the undertaking of the various surveys relating to the available information. More comprehensive information can be found in the relevant supporting document.

2.1. Desktop Analysis

A comprehensive desktop analysis was undertaken to identify potential environmental values, constraints, and potential impacts within the Project area and to enhance understanding of the ecology of the area and its relationship to and connectivity with the surrounding landscape. A search radius of 50 km is recommended in the Terrestrial ecology – EIS (Environmental Impact Statement) information guideline when considering migratory, rare, threatened, or cryptic species, or in areas where few field studies have been undertaken (Department of Environment and Science, 2022). Despite the area being extensively studied, the Precautionary Principle was again applied, and species and protected matters searches were undertaken using, at minimum, the recommended 50 km search buffer from a central point (Latitude: -20.24531, Longitude: 140.13467) within the Project area. Other localised constraints were assessed using the default search tool radius.

The assessment included a literature search and review of currently available information and mapping. It should be noted that EcoSmart Ecology have been the primary provider of ecological services at DRM since 2013 and have provided a comprehensive summary of survey and monitoring efforts and results to inform this impact assessment. The other ecological assessment report of note is the Terrestrial Flora and Fauna Assessment report prepared for the Dugald River Project EIS which provided pre-disturbance information.

Of principal interest to this assessment is the potential for impacts to matters of both commonwealth and state conservation significance including. Table 2 identifies the core sources used to inform the desktop assessment for this report.

Table 2: Search tools used to prepare Ecology Desktop Scoping report

Search/Resource	Source	Search Criteria	Output	Date of Retrieval / Accessed
MNES database (Matters of National Environmental Significance)	Protected Matters Search Tool (PMST) https://www.environment.gov.au/epbc/protected-matters-search-tool	50 km radius from central point of AOI	Possible presence of species or species habitats for environmentally significant species	October 2023
MSES database (Matters of State Environmental Significance)	https://www.qld.gov.au/environment/pollution/management/environmental-reports-online	2 km radius from central point of AOI, or relevant ML	Possible presence of species or species habitats for environmentally significant species	November 2023
Vegetation management regulated vegetation management map - version 7.00. Released 22 Nov 2023	https://qldspatial.information.qld.gov.au/catalogue/custom/detail.page?fid={9CC053EC-585B-4C41-A713-E1D04543CCC2}	Cloncurry Shire	Mapped regulated vegetation categories	November 2023
Vegetation management regional ecosystem map - version 13.00. Released 22 Nov 2023	https://qldspatial.information.qld.gov.au/catalogue/custom/detail.page?fid={BCFBDC29-85AF-46B5-85E3-41C5A4B2057A}	Cloncurry Shire	Mapped regional ecosystems and statuses	November 2023
Vegetation management essential habitat map no attribute - version 12.00. Released 22 Nov 2023	https://qldspatial.information.qld.gov.au/catalogue/custom/detail.page?fid={8739E87A-4EDD-4E20-A377-1EE0445B00A0}	Cloncurry Shire	Mapped essential habitat as defined in the VM Act	November 2023
ESAs database (Environmentally Sensitive Areas)	https://environment.des.qld.gov.au/management/maps-of-environmentally-sensitive-areas	2 km radius from central point of AOI	Maps of environmentally sensitive areas if present	November 2023
Vegetation management report	https://www.resources.qld.gov.au/qld/environment/land/vegetation/vegetation-map-request-form	Lot and Plan	Regulated Vegetation, Protected Plants Flora Survey Trigger Map, Koala habitat	November 2023
Wildnet Species List	https://apps.des.qld.gov.au/report-request/species-list/	50 km radius from central point of AOI	Point records for species	November 2023
WetlandInfo	https://wetlandinfo.des.qld.gov.au/wetlandmaps/	polygon drawn on interactive map	Locations of MSES such as Ramsar wetlands, nationally important wetlands, groundwater-dependent ecosystems, protected areas of Qld	delete row if not required

Queensland Globe	https://qldglobe.information.qld.gov.au/	Relevant ML and surrounds	Surface geology, regulated vegetation, protected plants flora survey trigger map, essential habitat map	November 2023
Modelled potential habitat for select threatened species - Queensland	https://www.data.qld.gov.au/dataset/potential-habitat-models-2022-queensland-series	2 km radius from central point of AOI	Spatial layer showing modelled potential habitat for threatened flora and fauna species	November 2023
Atlas of Living Australia (ALA)	Area report – interactive https://spatial.ala.org.au/	50 km radius from central point of AOI	Point records for species of interest e.g., Threatened species	
East Asian-Australasian Flyway Partnership (EAAFP) Site Information Sheets	https://www.eaaflyway.net/australia/	N/A	Species lists for a network of internationally important sites for migratory bird species	November 2023
Wildnet Database Species Profile Search	https://apps.des.qld.gov.au/species-search/	Species Name	NC ACT listed species information	November 2023
Terrestrial Flora and Fauna Assessment report	AustralAsian Resource Consultants	N/A	Terrestrial Flora and Fauna survey results from 2008-2011	November 2023
Dugald Roiver Wind Farm Fauna Survey Results 2023	EcoSmart Ecology	~ 15 Ha Survey effort to date	Summary of Terrestrial Flora and Fauna survey results from 2014-2023	November 2023

2.1.1.Likelihood of Occurrence Analysis

During the desktop phase, each species of conservation significance was assessed against the criteria described in Table 3 to determine likelihood of occurrence within the project area. The likelihood of occurrence for each species was examined post-survey and amended taking into consideration the observed habitat values and ecological assessments. Results of desktop analysis are discussed in the section 3 of this report.

Table 3: Likelihood of occurrence criteria

Status	Definition
Known	Species known to occur from recent reliable records* within the study area.
Likely	Recent reliable records of the species within 1 km of the study area and/or preferred habitat known to be present, and recent reliable records within 5 km.
Possible	Species recorded× within 50 km of the study area and/or suitable habitat mapped as present.
Unlikely	Species not recorded within 50 km of the study area and suitable habitat not mapped as present.

*Records less than 20 years old and from reputable sources using vetted data (primarily Wildnet)

×May include older and unconfirmed records

2.2. Historical Survey Effort

2.2.1.AARC Surveys 2008-2011

AARC undertook terrestrial flora and fauna surveys from 2008-2011 to inform the DRM EIS.

Flora surveys were undertaken accordance with the Queensland Herbarium's *Methodology for survey and mapping of regional ecosystems and vegetation communities in Queensland* (Nelder, Wilson, Thompson, & Dellewaard, 2005) to 1:25,000 Scale for Vegetation Mapping. The surveys consisted of 37 secondary and 245 quaternary level transects in representative vegetation communities. Assessment of aerial/satellite imagery was used to extrapolate the data across the remainder of the mapped area. Where habitat suitable for conservation significant flora species was identified, targeted species survey meanders were conducted.

Fauna surveys were undertaken in accordance with *Recommended Fauna Survey Methodology for Environmental Impact Assessments* (Department of Environment and Resource Management, 2009). Six primary transects and eight secondary transects were surveyed in 2008 and an additional six fauna monitoring sites established in 2011.

Further details regarding the methodology can be found in section 5.0 and survey effort maps shown in Figures 5 and 6 of APPENDIX K: AARC Report.

2.2.2.EcoSmart Ecology Surveys 2013-2023

EcoSmart Ecology have undertaken flora and fauna survey and monitoring activities within the DRM MLs and adjacent area over the last 11 years and have collect considerable amounts of data particularly with respect to fauna and faunal assemblages and PNRW populations of the area. Several survey and targeted monitoring techniques have been used for the detection of fauna including but not limited to:

- Survey meanders
- Bird survey transects
- White-flash remote camera surveys
- Black-flash camera surveys
- Elliot and pitfall trapping
- BBUS Anabat (2023)
- BBUS Bird Survey (2023)

Incidental species records were additionally captured during surveying and monitoring.

Bird and Bat Utilisation Surveys (BBUS) were undertaken by EcoSmart Ecology in 2023 to assess potential impacts of the windfarm. BBUS survey methodology is discussed further in section 2.3 below.

Total EcoSmart Ecology fauna survey effort is summarised in Table 4 and further details can be found in section 2.0 of APPENDIX J: EcoSmart Report and Figures of survey locations provided in Figures 2.1-2.3.

Table 4: EcoSmart total fauna survey effort 2013-2023

Method	Unit	TOTAL
BBUS – Anabat	Anabat-nights	16 Anabat-nights
BBUS – Bird Survey	Person hours	16 person hours
Bird Survey Transect	Person hours	28.5 person hours
PNRW white-flash camera	Trap-nights	1525 trap-nights
PSEUD white-flash camera	Trap-nights	3149 trap-nights
Pest black-flash camera	Trap-nights	200 trap-nights
Elliott Trap	Trap-nights	2000 trap-nights
Pitfall Trap	Trap-nights	30 trap-nights
Foot traverses	Person hours	2424 person hours

EcoSmart Ecology additionally undertook regional ecosystem ground-truthing surveys in 2021 to inform an application for changes to the regulated vegetation regional ecosystem mapping via a Property Map of Assessable Vegetation (PMAV). A total of 32 quaternary surveys were completed across the DRM project area to inform and delineate the location of RE 1.3.7: Eucalyptus camaldulensis woodland on channels and levees which is allocated a Biodiverstiy Status of endangered due to its importance as seasonal water bird habitat; regional corridor for fauna.

2.2.3.Supplementary Ground-truthing

Vegetation ground-truthing surveys and habitat assessments of the Project area were undertaken by WTS in October 2023 to supplement the existing data and ensure currency of available information.

Regional ecosystem ground-truthing was undertaken in accordance with the *Methodology for Survey and Mapping of Regional Ecosystems and Vegetation Communities in Queensland. Version 3.1* (Nelder, et al., 2022). 24 Secondary and quaternary surveys were conducted across the site at locations relevant to the proposed disturbance. Survey locations have been provided in Figure 3.

Habitat assessments were undertaken at all eight of the potential turbine pad locations and the proposed laydown/rigging areas and locations of other proposed ancillary infrastructure related to electrical current transport and storage. Habitat values were recorded as per the *Basic Site Information* field sheet provided in *Terrestrial Vertebrate Fauna Survey Assessment Guidelines for Queensland: Field Data Sheets. Version 1.4* (Eyre T. J., et al., 2022(2)). Data from the assessments was used to inform likelihood of occurrence and significant impact assessments, to develop habitat mapping for relevant conservation significant fauna.

2.3. Bird and Bat Surveys

EcoSmart Ecology commenced BBUS monitoring within the Project area in May of 2023 and have since conducted a second monitoring round in September 2023. Of the eight potential turbine locations identified by MMG, four were selected as permanent locations for the ongoing monitoring and four comparable control locations were also established. Impact and control sites are to be monitored twice yearly, once post-wet season and once pre-wet season during construction and operational phases of the project. Two surveys have so far been conducted, one in May 2023, and one in September 2023. Surveys include bird monitoring and bat monitoring. Level one bird surveys were conducted as per the approved method outlined in *Wind Farms and Birds: Interim Standards For Risk Assessment* by Brett Lane & Associates (Brett Lane & Associates Pty Ltd, 2005) and analysis and reporting largely follow those recommended in the same document (Ecosmart Ecology, 2023).

Bats were monitored at each BBUS monitoring site using Anabat passive high-frequency sound recorders to capture microbats calls. Anabat units are deployed for two consecutive nights per monitoring period. Bat call analysis to identify microbat species present was undertaken by Greg Ford of Balance Environmental.

Details of survey methodology and locations of the BBUS monitoring is available ins section 2.2.9 of APPENDIX J.

2.4. Habitat spatial analysis

Spatial habitat analyses were undertaken to inform habitat values and likelihood of occurrence within the project area using available existing data with regard to species habitat preferences, records, and habitat values for relevant threatened and species of interest. Analyses were undertaken for the PNRW and migratory birds. All other threatened and species of interest identified in the desktop assessment were determined to be unlikely to occur based on available records and ground-truthed habitat of the Project area.

2.4.1. Purple-necked rock-wallaby

Known occurrences of PNRW) within the Knapdale Range, along with the 18 confirmed PNRW active denning locations, were used to infer denning, foraging, and dispersal habitat across the lesser surveyed Project area and the range extent. Dens were found to be located in rocky gorges in the upper reaches of drainage lines of the Knapdale Range, and visual assessment of available high resolution satellite imagery was used to determine additional denning areas. A 16 ha buffer was added around the known and proposed dens representing home range (foraging area), based on known home ranges from closely related and morphologically similar rock-wallaby species (Horsup, 1994). PNRW rarely venture into flat plains due to a lack of shelter (Mittermeier & Wilson, 2015) and it is therefore assumed that any areas adjacent to habitat and of medium to high slope is possible dispersal habitat for the species.

2.4.2. Migratory bird mapping

Using the relevant East Asian-Australasian Flyway Partnership (EAAFP) flyway sites, species records were extracted from the available information sheets for each relevant site to develop an overall species list. Two sites, EAF017 and EAF136 were disregarded for the analysis. Due to their position of these sites on the western

coast it is likely species using these sites will migrate north-south following the coastline and thus not relevant to the Project area. For each species, flight paths were drawn between each site in which they are recorded creating the shortest possible flight paths between known occurrences. While it is more than likely that individuals divert to some degree from the straight flight paths to seek suitable refugia, the drawn flight paths serve as a measure of likelihood for presence in the region of the Project. Additionally, BirdLife International reports that it is likely that only a minority of birds fly north-south across the Australian continent and that the most records and mapped migratory routes reflect a coastal or near coastal trend (BirdLife International). Atlas of Living Australia records were also overlayed to identify places of refugia during migration.

3. Results

3.1. Desktop Analyses

3.1.1. Regional Context and Climate

The Project is situated centrally on the Knapdale Range which falls within the Northwest Highlands bioregion, and is surrounded North, East, and West by the Gulf Plains bioregion.

The Project area lies on the boundary of the Leichhardt Basin and the Flinders Basin. Drainage from the Knapdale range flows to stream order five watercourse Cabbage Tree Creek of the Leichhardt River sub-basin to the north and west and to stream order five watercourse Dugald River of the Cloncurry River sub-basin to the east and south. Watercourses in the Project area itself are unnamed stream order one and two and are typically non-perennial though rocky waterholes that may persist through the dry season are known to occur in the upper catchments of these smaller drainage features.

A summary of data from weather station 0291411 at the Cloncurry Airport indicate that temperatures in the region tend towards mild to cool dry winters with lowest mean minimums temperatures around 10°C in July. December is the month with the highest mean maximum temperature of 38.7°C. Summers are typically hot and wet summers and heavy tropical and flashy rain events are common in this period. Mean annual rainfall for the region is 500 mm.

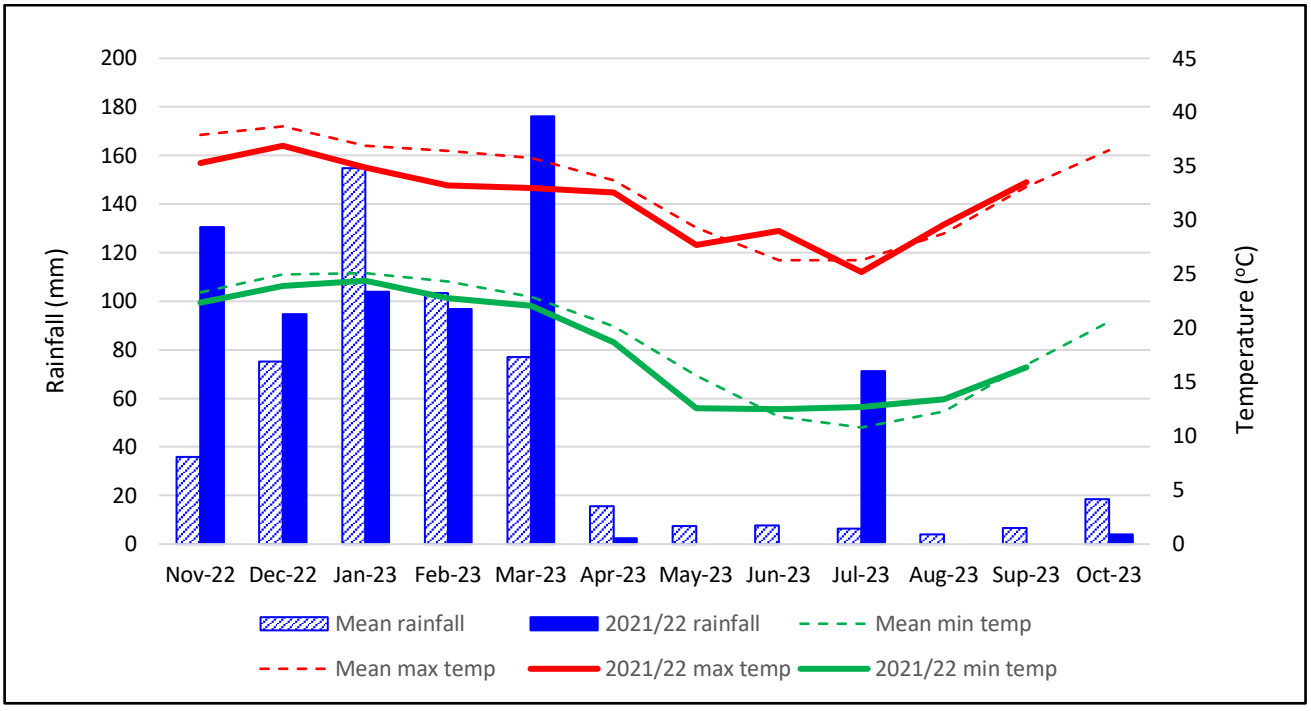


Figure 2: Climate statistics in at Cloncurry Airport weather station (029141) 2022-2023

3.1.2.Geology and Soils

The geology of the Knapdale Range is characterized by the fine-grained pink and white Knapdale Quartzites. It is bordered to the west by Lady Clayre Formation siltstones and dolostone and Coocerina Formation mudstone and bound by Mount Roseby Schist intermingled with poorly consolidated sediment and to the east.

The Dugald River Mine infrastructure is located at on grassy plains approximately 200 m (Australian Height Datum (AHD)) elevation. The rolling hills of the Knapdale Range reach maximum elevations of approximately 300 m AHD (Queensland Globe, 2023), declining in all directions into grassy plains. The wind farm is proposed to be located on the Knapdale Range at elevations between 270-290 m AHD.

3.1.3.Landzones

The Knapdale Range and immediate surrounding area is mapped as Land zone 11: Mesozoic/Proterozoic metamorphosed sediments and interbedded volcanics. At a local scale this is intersected by Land zone 3: alluvial soils associated with the smaller drainage line features associated with the range.

3.1.4.Flora and Vegetation Communities

3.1.4.1. Regional Ecosystems

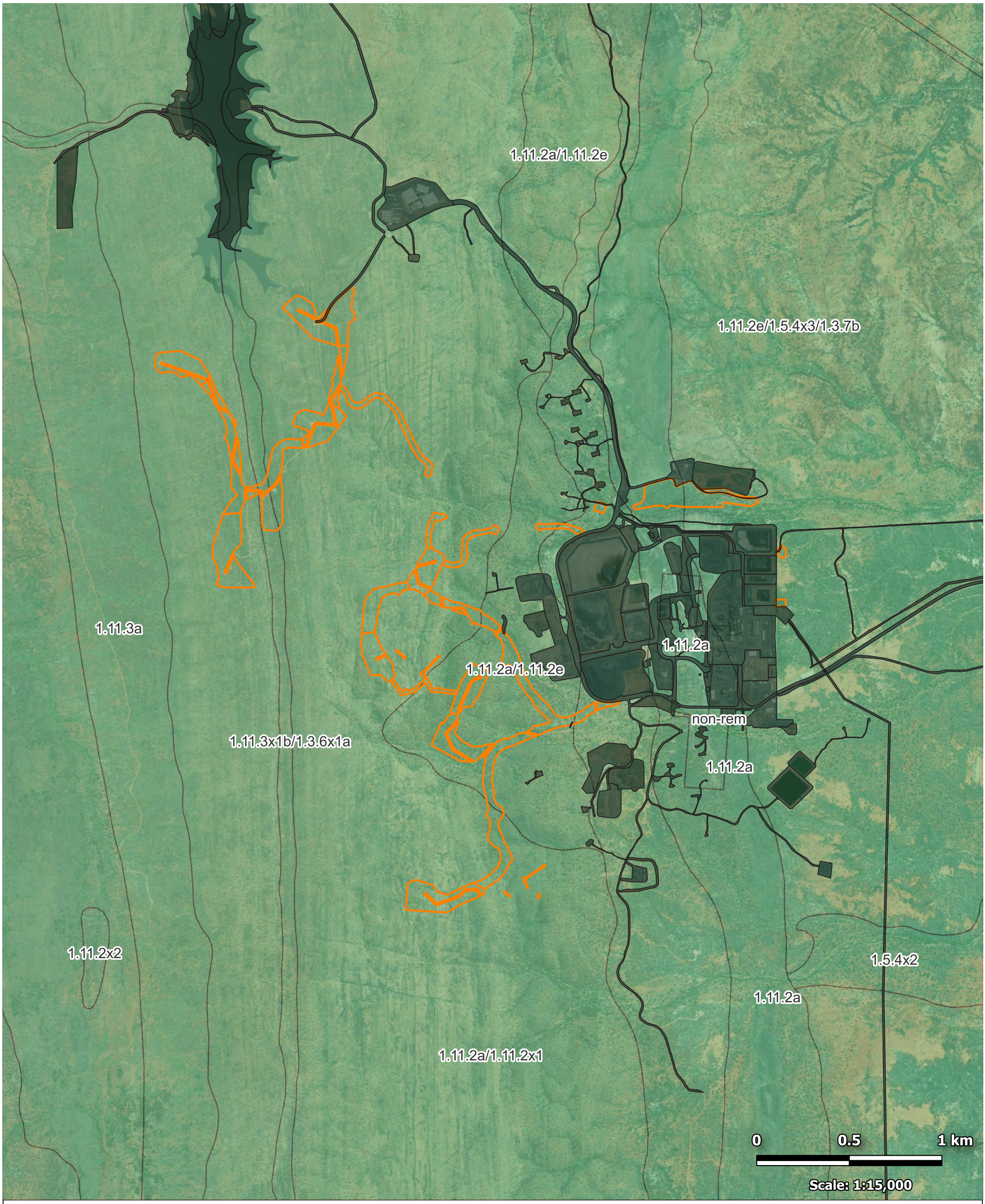
Regional Ecosystems (REs) mapped for the Project Area are largely heterogeneous (mixed) REs comprised of 1.11.2a/1.11.2x1 (at 70/30%) and 1.11.3x1b/1.3.6x1a (at 90/10%): 1.11.2.a/1.11.2e (at 50/50%: 1.11.22/1.5.4x3/1.3.7b (at 70/25/5%). A section of homogenous RE 1.11.2a is also mapped for the proposed eastern most laydown area. While RE1.3.7b: *Eucalyptus camaldulensis* fringing woodland, usually with *Lophostemon grandiflorus* and *Melaleuca bracteata* and/or *M. dissitiflora* is considered least concern under the Vegetation Management Act 1999 (VM Act) it has a biodiversity status of endangered due to its importance as seasonal water bird habitat and a regional corridor for fauna and is therefore a category B Environmentally Sensitive Area (ESA) under Schedule 19 of the *Environmental Protection Regulation 2019*. 1.3.7 is mapped as a subdominant RE at an estimated 5% of the total mapped area, and, except for some lower elevation areas, are largely outside of the proposed disturbance footprint of the wind farm.'. AARC and Ecosmart Ecology survey reports have provided maps delineating 1.3.7b (Figure 7 of APPENDIX I and APPENDIX B of APPENDIX J). Table 5 provides descriptions of each RE, *Vegetation Management Act 1999* (VM Act) class, Biodiversity Status, and any listed special values as per the Regional Ecosystem Description Database (Queensland Herbarium, 2023). Figure 3 shows the biodiversity status of mapped REs for the Project area.

Table 5: Regional Ecosystems mapped for the project area

Regional Ecosystems	Long Description	VM Status*	BD Status#	Special Values
1.3.6x1a Now 1.3.13a	This vegetation community is now mapped as 1.3.13a. Eucalyptus leucophylla and/or Eucalyptus pruinosa subsp. pruinosa woodland often with Corymbia terminalis, Eucalyptus camaldulensis and Acacia cambagei with a sparse mixed shrub layer and a sparse ground layer dominated by Bothriochloa ewartiana and Sehima nervosum, often with Triodia longiceps.	LC	OC	1.3.13: Potential habitat for NCA listed species: Ipomoea antonschmidii, Ptilotus maconochiei.

	Occurs on ephemeral watercourses with active beds. Not a Wetland.			
1.3.7	Eucalyptus camaldulensis fringing woodland, usually with Lophostemon grandiflorus and Melaleuca bracteata and/or M. dissitiflora. Occurs on recent levees and channel deposits of medium and smaller tributaries which are dry for most of the year; alluvial soils. Riverine.	LC	E	1.3.7: Important seasonal water bird habitat; regional corridor for fauna.
1.5.4x3 now 1.5.15	*Aristida contorta* annual grasslands, usually with *Aristida inaequiglumis*, that are bare for most of the year and can be dominated by forbs. Occurs on older alluvium and residual soils. Not a Wetland. (BVG1M: 31b).	LC	NC	None specified
1.11.2a	*Eucalyptus leucophloia* low open woodland or low woodland, sometimes with *Eucalyptus ludophilia*, *Corymbia terminalis*, *Corymbia aparrerinja* or *Eucalyptus normantonensis* usually with a *Acacia* spp. dominated shrub layer and *Triodia* spp. and/or tussock grass understorey. Treeless areas common. Occurs on hills and ranges on strongly folded metamorphic pre-Cambrian rocks; soils skeletal, some red earths. Not a Wetland. (BVG1M: 19a).	LC	NC	1.11.2: Potential habitat for NCA listed species: *Eucalyptus nudicaulis*, *Ipomoea antonschmidii*, *Solanum carduiforme*, *Trachymene glandulosa*.
1.11.2e now 1.11.3a	See 1.11.3a	LC	NC	
1.11.2x1 now 1.7.7a	Low open woodland of *Corymbia capricornia*, commonly with *Eucalyptus leucophloia*. *Eucalyptus miniata*, *Eucalyptus herbertiana* and *Corymbia* ferruginea are commonly present in the north. Mixed shrub layer usually including *Grevillea wickhamii*. Ground layer of *Triodia* spp. and *Schizachyrium* fragile. Occurs on silcrete. Not a Wetland. (BVG1M: 19a).	LC	NC	1.7.7: Potential habitat for NCA listed species: *Ipomoea antonschmidii*.
1.11.3a	Low open woodland of *Corymbia terminalis* and/or *Eucalyptus leucophylla* with *Acacia* spp. dominated shrub layer and ground layer of *Triodia* spp. and/or tussock grasses. Includes areas of *Acacia* spp. shrubland and *Triodia* spp. grassland. Occurs on metabasalts and dolerites; some felsic metavolcanics; skeletal soils, some shallow loams. Not a Wetland. (BVG1M: 19b).	LC	NC	1.11.3: Potential habitat for NCA listed species: *Eucalyptus nudicaulis*.
1.11.3x1b now 1.11.3a	See 1.11.3a	LC	NC	

VM Status = status under the Vegetation Management Act: BD Status# = Biodiversity Status: L – Least Concern. NC – No concern at present, OC – Of concern, E – Endangered.*



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Project Number: 2023.03002
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Spatial Reference
PCS: GDA2020 MGA Zone 54
GCS: GDA2020
Datum: GDA2020

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Figure 3. Biodiversity status of mapped regional ecosystems of the Project area

Legend

- Mine Features
- Proposed Windfarm Features

Regional Ecosystem Biodiversity Status

- Remnant Least Concern
- Non-remnant

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3.1.5. Environmentally Sensitive Areas

A large area of category B Environmentally Sensitive Area (ESA) is mapped for the area north and west of the Knapdale range (APPENDIX A). The ESA relates to the mapped heterogeneous RE 1.11.22/1.5.4x3/1.3.7b (at 70/25/5%) of which, 5% is estimated to be comprised of Endangered Regional Ecosystem (ERE) 1.3.7b: *Eucalyptus* camaldulensis fringing woodland, usually with *Lophostemon grandiflorus* and *Melaleuca bracteata* and/or *M. dissitiflora*. While the mapped ESA does not occur within the proposed Project area, ground-truthed mapping undertaken by both AARC (Figure 7 of APPENDIX K: AARC Report) and EcoSmart (Appendix B of APPENDIX J: EcoSmart Report) indicate that ERE 1.3.7 was present in association with, at minimum, the lower elevation drainage features that occur within the Project area.

3.1.6. Matters of State Environmental Significance

Matters of state environmental significance (MSES), as referred to in Schedule 2 of the Environmental Offsets Regulation 2014, include the following:

- Regulated vegetation;
- Connectivity areas;
- Wetlands and watercourses;
- Designated precinct in a strategic environmental area;
- Protected wildlife habitat;
- Protected areas;
- Protected marine areas and habitat; and
- Legally secured offset areas.

3.1.6.1. Regulated vegetation

3.1.6.1.1. Regulated Vegetation Mapping

Vegetation management regulated vegetation management map - version 7.00 maps the entire Project area as category B remnant vegetation.

3.1.6.1.2. Regulated vegetation – endangered or of concern regional ecosystem

There are no endangered or of concern REs as defined under the VM Act are mapped as present within the Project area.

3.1.6.1.3. Regulated vegetation – Regional Ecosystem intersecting a wetland

There are no vegetation management wetlands mapped within the project area and therefore no REs intersecting a wetland.

3.1.6.1.4. Regulated vegetation – Intersecting a watercourse

There are nine instances (646 m) of stream order 1 and 2 regulated vegetation watercourse mapped within the proposed disturbance area of the Project. Table 1 shows the distance from a defining bank that specifies the

extent to which a prescribed RE is intersecting a regulated vegetation watercourse based on the bioregion and stream order (Department of Environment and Science, 2020).

It is important to note that the watercourses are mapped as linear features rather than representative width of the defined bank which is described in the clearing for infrastructure code as:

- the bank that confines the seasonal flows, but which may be inundated by flooding from time to time, and can be either:
    - the bank or terrace that confines the water before the point of flooding;
    - or where there is no bank, the seasonal high water line that represents the point of flooding (Department of Resources., 2023).

The width of the stream needs to be considered and ground-truthed in order to accurately identify the total area of regulated vegetation. For the purposes of this report an assumed average watercourse width of 2 m was used to calculate an estimate only of the extent of the disturbance of regional ecosystems within a defined distance from the defining banks of a relevant watercourse. The total approximate area of regional ecosystem intersecting a watercourse is 4.57 ha (Figure 4). Impacts to regulated vegetation intersecting a watercourse exceed criteria 1 and 3 of the significant residual impact test of table 1 of the guidelines (Department of the Environment, 2013). See section 4 for the impact assessment details. While the total area of impact for the project exceeds the criteria, each individual area of disturbance is minimal and unavoidable.

Table 6: Distance from the defining banks of watercourses based on bioregion and stream order

Watercourse steam order	Distance from the defining bank (m)
Coastal bioregions	
1 or 2	10
3 or 4	25
5 or greater	50
Non-coastal bioregions and sub-regions	
1 or 2	25
3 or 4	50
5 or greater	100

Table 7: Area of regional ecosystem within a defined distance from a watercourse within the Projects proposed disturbance area

Stream order	Length (m)	Area (ha)*
1 and 2	788.46	4.1
Total	**788.46**	**4.1**

**Area calculated using an estimated average watercourse width of 2 m and the defined distance of 25 m as per Table 6*

3.1.6.1.5. Regulated vegetation - Essential habitat

Essential habitat, for protected wildlife, is defined in section 20AC of the VM Act as:

> A category A area, a category B area or category C area shown on the regulated vegetation management map—

(a) that has at least 3 essential habitat factors for the protected wildlife that must include any essential habitat factors that are stated as mandatory for the protected wildlife in the essential habitat database; or

(b) in which the protected wildlife, at any stage of its life cycle, is located.

With the exception of areas related to the DRM tailings storage facility in the norther section of the Knapdale Range, the entire range and other locally connected areas are mapped as essential habitat on the *Vegetation management essential habitat map no attribute - version 12.00.* Version 12.00 of the essential habitat mapping was released 22 November 2023 and increases the area of mapped habitat significantly from that previously mapped. Changes to essential habitat mapping increase the disturbance area of mapped essential habitat from 11.9 ha to 68.7 ha (Figure 4).

0 0.5 1 km

Scale: 1:15,000

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PCS: GDA2020 MGA Zone 54
GCS: GDA2020
Datum: GDA2020

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Figure 4. Regulated vegetation intersecting a watercourse and mapped essential habitat

Legend

- Mine Features
- Proposed Windfarm Features
- Essential habitat
- Regulated vegetation - intersecting a watercourse

Watercourse - Stream Order
- 1
- 2
- 3

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3.1.6.2. Connectivity areas

Due to the remote nature of the proposed disturbance, the relative lack of existing disturbance and the linear nature of the proposed disturbance it is considered to be unlikely that disturbance relating to the proposed wind farm will impact connectivity of fauna in the region. The Knapdale Range occupies an area of approximately 6000 ha of which only 75 ha (<1.5%) is proposed for development, increasing the total area associated with DRM to 373 ha (~6.2%). The Knapdale Range is a relatively standalone geological entity in the region and species dispersal among the range is unlikely to be hindered due to the availability of habitat surrounding the proposed disturbance. Those species dispersing away from the range to other potential populations remain largely unhindered with the exception of the existing mine infrastructure. Connectivity via riparian vegetation communities will remain largely unhindered due to the linear nature of the infrastructure footprint.

3.1.6.3. Wetlands and watercourses

The project area lies on the boundary of the Leichhardt Basin and the Flinders Basin. Drainage from the Knapdale range flows to stream order 5 watercourse Cabbage Tree Creek of the Leichhardt River sub-basin to the north and west and to stream order 5 watercourse Dugald River of the Cloncurry River sub-basin to the east and south. Watercourses in the Project area itself are unnamed stream order 1 and 2 drainage features and are typically ephemeral, though rocky waterholes that may persist through the dry season are known to occur in the upper catchments of these smaller drainage features (Figure 4).

There are no Ramsar internationally important wetlands or DIWA (Directory of Important Wetlands in Australia) nationally important wetlands mapped within a 2 km radius of the Project area.

3.1.6.4. Designated precinct in a strategic environmental area

The Project area does not fall within a designated precinct in a strategic environmental area.

3.1.6.5. Protected wildlife and habitat

Several NC ACT listed species were identified in the desktop search using available Wildnet records and a 50 km search radius (APPENDIX B) including:

- 6 fauna species listed as threatened;
- 2 flora species listed as threatened; and
- 4 species of fauna listed as Special least concern.

A likelihood of assessment was undertaken for all NC Act species of conservation significance (APPENDIX D). This assessment found the following species to have a likelihood of occurrence of possible, likely or known. Impact assessments for these species are provided in section 4 of this report.

- Purple-necked rock-wallaby (*Petrogale purpureicollis*):V (NC Act) - Known
- Short-beaked echidna (*Tachyglossus aculeatus*): SL (NC Act) – Known
- Australian painted-snipe (*Rostratula australis*): E, Ma (EPBC), E (NC Act) – Possible
- Caspian tern (*Hydroprogne caspia*): M,Ma (EPBC), SL (NC Act) – Possible
- Common greenshank (*Tringa nebularia*): M,Ma (EPBC), SL (NC Act) – Possible

- Fork-tailed swift (*Apus pacificus*): M,Ma (EPBC), SL (NC Act) – Possible
- Glossy ibis (*Plegadis falcinellus*): M,Ma (EPBC), SL (NC Act) – Possible
- Latham's snipe (*Gallinago hardwickii*): M,Ma (EPBC), SL (NC Act) – Possible
- Sharp-tailed sandpiper (*Calidris acuminata*): M,Ma (EPBC), SL (NC Act) – Possible
- White-bellied sea-eagle (*Haliaeetus leucogaster*): M,Ma (EPBC), SL (NC Act) – Possible

The Carpentarian grasswren (*Amytomis dorotheae*) (E, Ma (EPBC), E (NC Act)) was determined to be unlikely due to no records of the species within the last 14 years of surveys and the lack of hummocking spinifex grasslands with which the it is typically associated with which have not been recorded on the Knapdale Range (Ecosmart Ecology, 2023).

The painted honeyeater (*Grantiella picta*) (V (EPBC), V (NC Act)) was determined to be unlikely due to a lack of records within the last 14 years of surveys and the absence of suitable mistletoe species of which the honeyeater is a specialist (Ecosmart Ecology, 2023).

The grey falcon (*Falco hypoleucos*) (V (EPBC), V (NC Act)) was determined to be due to the lack of records and the fact that most of the range is open woodland, whereas the grey falcon prefers sparsely treed grasslands (Ecosmart Ecology, 2023).

3.1.6.5.1. Protected plant habitat

The Flora Survey Trigger Mapping – version 8.0 displays no high-risk areas near the project area.

3.1.6.5.2. Mapped habitat values

As described in section 3.1.6.1.5 the entire area of the Knapdale Range and surrounding relevant areas is mapped as essential habitat for the PNRW.

Modelled potential habitat (from the Modelled potential habitat for select threatened species V2 – Queensland spatial layer) for EVNT flora and fauna species is mapped to occur within the AOI. Potential habitat for the following conservation significant fauna species is modelled within 2km of the project area:

- Australian painted snipe (*Rostratula australis*)
- Carpentarian Grasswren (*Amytornis dorotheae*)
- Ghost Bat (*Macroderma gigas*)
- Gouldian Finch (*Erythrura gouldiae*)
- Painted Honeyeater (*Grantiella picta*)
- Purple-necked Rock-wallaby (*Petrogale purpureicollis*)
- Yellow Chat (*Epthianura crocea crocea*)

3.1.6.6. Protected areas

There are no protected areas (including all classes of protected area except coordinated conservation areas) as defined under the NC ACT, mapped within the 2 km search radius of the Project area.

3.1.6.7. Protected marine areas and habitat

There are no protected marine areas or habitat mapped within a 2 km radius of the Project area.

3.1.6.8. Legally secured offset areas

There are no legally secured offset areas mapped within a 2 km radius of the Project area.

3.1.7.Matters of National Environmental Significance

The Protected Matters Search Tool (PMST) lists those Matters of National Environmental Significance (MNES) which require consideration with regards to the Project area based on the selected search area used (in this case 50 km radius) (APPENDIX A: EPBC Act Protected Matter Report). MNES include:

- World Heritage Properties;
- National Heritage Places;
- Wetlands of International Importance (Ramsar);
- Great Barrier Reef Marine Park;
- Commonwealth Marine Area;
- Listed Threatened Ecological Communities;
- Listed Threatened Species; and
- Listed Migratory or Marine species;

3.1.7.1. World Heritage Properties

There are no World Heritage Properties present within the potential impact area of the Project.

3.1.7.2. National Heritage Places

There are no National Heritage Places present within the potential impact area of the Project.

3.1.7.3. Wetlands of International Importance (Ramsar)

There are no Ramsar wetlands present within the potential impact area of the Project.

3.1.7.4. Great Barrier Reef Marine Park

The Project area is not within the Great Barrier Reef Marine Park buffer zone.

3.1.7.5. Commonwealth Marine Area

The Project area is not within the Commonwealth Marine Park buffer zone.

3.1.7.6. Listed Threatened Ecological Communities

There are no Threatened Ecological Communities considered to be present or potentially present within the potential impact area of the Project.

3.1.7.7. Conservation significant species

The desktop assessment identified the following MNES conservation significant species (via the Protected Matters Search Tool (PMST)) as having potential to occur within a 50 km radius of the project area:

- 1 species of flora listed as threatened under the EPBC Act; and
- 15 species of fauna listed as threatened under the EPBC Act.
- 14 species of fauna listed as migratory under the EPBC Act.
- 19 species of fauna listed as marine under the EPBC Act.

3.1.7.8. Pre-survey Likelihood of Occurrence

A pre survey likelihood of occurrence (LOO) assessment was undertaken for listed threatened, migratory, and marine species using available desktop resources (APPENDIX D). Notes and discussion on habitat preference, ecology, and LOO for these species can be found in section 4 and in APPENDIX D of this report.

3.2. Field Survey Results

3.2.1. Vegetation Communities

Vegetation communities were assessed for the proposed Project disturbance area of the Project in October 2023 and found to be largely consistent with that of the previous 2011 (AustralAsian Resource Consultants Pty Ltd, 2011) and 2021 (EcoSmart Ecology, 2021) survey results. Table provides details of the ground-truthed REs, the disturbance area, and a summary of the total area of impact to each vegetation community present. The total disturbance of remnant ERE 1.3.7b (endangered biodiversity status) is 1.04 ha. As this RE is least concern under the VM Act it is not assessable under the significant residual impact criteria for regulated vegetation. Figure 6 shows the ground-truthed regional ecosystems of the disturbance areas.

Table 8: Regional ecosystem descriptions

Regional Ecosystems	Long Description	VM Status*	BD Status#	Special Values	Area of impact (ha)
1.3.7b	*Eucalyptus camaldulensis* fringing woodland, usually with *Lophostemon grandiflorus* and *Melaleuca bracteata* and/or *M. dissitiflora*. Occurs on recent levees and channel deposits of medium and smaller tributaries which are dry for most of the year; alluvial soils. Riverine.	LC	E	1.3.7: Important seasonal water bird habitat; regional corridor for fauna.	1.04
1.5.4a (was 1.5.4x2)	1.5.4a: *Corymbia terminalis* low open woodland, scattered shrub layer of *Carissa lanceolata* and tussock grass ground layer. Eucalyptus pruinosa is commonly present in the north. Occurs on older alluvial and residual soils with significant clay content.	LC	NC	1.5.4: Potential habitat for NCA listed species: Ipomoea antonschmidii.	6.71
1.11.2a	*Eucalyptus leucophloia* low open woodland or low woodland, sometimes with *Eucalyptus leucophylla*, *Corymbia terminalis*, *Corymbia aparrerinja* or *Eucalyptus normantonensis* usually with a *Acacia* spp. dominated shrub layer and *Triodia* spp. and/or tussock grass understorey. Treeless areas common. Occurs on hills and ranges on strongly folded metamorphic pre-Cambrian rocks; soils skeletal, some red earths.	LC	NC	1.11.2: Potential habitat for NCA listed species: *Eucalyptus nudicaulis*, *Ipomoea antonschmidii*, *Solanum carduiforme*, *Trachymene glandulosa*.	48.96
1.11.3a (was 1.11.2e)	Low open woodland of *Corymbia terminalis* and/or *Eucalyptus leucophylla* with *Acacia* spp. dominated shrub layer and ground layer of *Triodia* spp. and/or tussock grasses. Includes areas of *Acacia* spp. shrubland and *Triodia* spp. grassland. Occurs on metabasalts and dolerites; some felsic metavolcanics; skeletal soils, some shallow loams.	LC	NC	1.11.3: Potential habitat for NCA listed species: *Eucalyptus nudicaulis*.	18.32
Total area					75.03

VM Status = status under the Vegetation Management Act: BD Status# = Biodiversity Status: L – Least Concern. NC – No concern at present, OC – Of concern, E – Endangered.*

3.2.2.Environmentally Sensitive Areas

The ESA relates to the mapped heterogeneous RE 1.11.22/1.5.4x3/1.3.7b. Ground-truthing surveys delineating the ERE 1.3.7b indicate that only 1.04 Ha of the ESA will be impacted as a result of the Project. As this RE is least concern under the VM Act it is not assessable under the significant residual impact criteria for regulated vegetation

3.2.3.Regulated vegetation

3.2.3.1. Regulated Vegetation Mapping

The project will impact 75 Ha of category B remnant vegetation.

3.2.3.2. Regulated vegetation – Intersecting a watercourse

Total approximate area of regulated vegetation intersecting a watercourse proposed to be impacted by the Project disturbance area is 3.5 ha (Figure 5). Impacts to regulated vegetation intersecting a watercourse exceed criteria 1 and 3 of the significant residual impact test of table 1 of the guidelines (Department of the Environment, 2013). See section 4 for the impact assessment details.

3.2.3.3. Regulated vegetation – Essential habitat

Total approximate area of regulated vegetation essential habitat proposed to be impacted by the Project disturbance area is 68.7 ha (Figure 5). Impacts to regulated vegetation essential habitat for the PNRW are considered unlikely as a result of disturbance to areas of essential habitat due to the relatively small footprint and availability of habitat within the Knapdale Range.

3.2.3.4. Conservation significant flora

A likelihood of assessment was undertaken post ground-truthing of habitat within the Project area and with consideration given to the comments of EcoSmart Ecology who have undertaken significant assessment of fauna within the Knapdale Range and surrounding areas. The results of this assessment found indicated that the following species are possible, likely or known to occur within the Project area:

- *Ipomoea antonschmidii*; NT (NC Act) – possible



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Project Number: 2023.03002
Publication Date: 29/11/2023

Spatial Reference
PCS: GDA2020 MGA Zone 54
GCS: GDA2020
Datum: GDA2020

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Figure 5. Ground-truthed Regional Ecosystems of the proposed Project disturbance area

Legend

Mine Features

Regional Ecosystem Biodiversity Status
- Endangered
- Endangered Subdominant
- Least Concern

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0 0.5 1 km

Scale: 1:10,000

Client: MMG Dugald River Pty Ltd
Project Number: 2023.03002
Publication Date: 29/11/2023

Spatial Reference
PCS: GDA2020 MGA Zone 54
GCS: GDA2020
Datum: GDA2020

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Figure 6. Regulated vegetation intersecting a watercourse and mapped essential habitat of the Project disturbance area

Legend

- Mine Features
- Proposed windfarm features
- Regulated vegetation - Intersecting a watercourse
- Essential habitat

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3.2.4.Fauna and Habitat

3.2.4.1. Ground-truthed Habitat Values

Regional Ecosystems	Long Description	Habitat values	Area of impact (ha)
1.3.7b	*Eucalyptus camaldulensis* fringing woodland, usually with *Lophostemon grandiflorus* and *Melaleuca bracteata* and/or *M. dissitiflora*. Occurs on recent levees and channel deposits of medium and smaller tributaries which are dry for most of the year; alluvial soils. Riverine.	Some hollows and tree stags Fallen logs common Some coarse and fine litter Grasses common on banks and sand islands Stones common Boulders occasional Rocky waterholes present, some persisting well into the dry season. 1.3.7 is also important seasonal water bird habitat; regional corridor for fauna.	1.04
1.5.4a (was 1.5.4x2)	1.5.4a: *Corymbia terminalis* low open woodland, scattered shrub layer of *Carissa lanceolata* and tussock grass ground layer. Eucalyptus pruinosa is commonly present in the north. Occurs on older alluvial and residual soils with significant clay content.	Few hollows and stags Occasional fallen logs Coarse and fine litter common Grasses abundant 1.5.4 is also potential habitat for NCA listed species: Ipomoea antonschmidii.	6.71
1.11.2a	*Eucalyptus leucophloia* low open woodland or low woodland, sometimes with *Eucalyptus leucophylla*, *Corymbia terminalis*, *Corymbia aparrerinja* or *Eucalyptus normantonensis* usually with a *Acacia* spp. dominated shrub layer and *Triodia* spp. and/or tussock grass understorey. Treeless areas common. Occurs on hills and ranges on strongly folded metamorphic pre-Cambrian rocks; soils skeletal, some red earths.	Tree hollows rare, stags occasional Fallen logs rare Coarse and fine litter occasional Grasses common, spinifex tufting not hummocking species Stones common Boulders and large boulders found regularly throughout the range in gorges at the top of drainage lines. Rocky waterholes common at the bottom of gorges, some persisting well into the dry season. *Lysiana spathulate* (Mistletoe) common throughout 1.11.2 is also listed as potential habitat for NCA listed species: *Eucalyptus nudicaulis*, *Ipomoea antonschmidii*, *Solanum carduiforme*, *Trachymene glandulosa*.	48.96
1.11.3a (was 1.11.2e)	Low open woodland of *Corymbia terminalis* and/or *Eucalyptus leucophylla* with *Acacia* spp. dominated shrub layer and ground layer of *Triodia* spp. and/or tussock grasses. Includes areas of *Acacia* spp. shrubland and *Triodia* spp. grassland. Occurs on metabasalts and dolerites; some felsic metavolcanics; skeletal soils, some shallow loams.	Tree hollows rare, stags occasional Fallen logs rare Coarse and fine litter occasional Grasses common, spinifex tufting not hummocking species Stones common Boulders and large boulders found regularly throughout the range in gorges at the top of drainage lines. Intersected by drainage lines that may contain rocky waterholes with some persisting well into the dry season.. *Lysiana spathulate* (Mistletoe) common throughout	18.32

		1.11.3: Potential habitat for NCA listed species: *Eucalyptus nudicaulis*.	
Total area			75.03

3.2.4.2. Ground-truthed essential habitat

Ground-truth surveys and records of the PNRW within the Knapdale Range confirm the presence of values meeting the criteria for essential habitat for the PNRW as per section 20AC (2b): a category A area, a category B area or category C area shown on the regulated vegetation management map— (b) in which the protected wildlife, at any stage of its life cycle, is located.

The total area of essential habitat impacted by the proposed Project area is 68.7 ha. Potential impacts to essential habitat and the PNRW are assessed against the significant residual impact criteria for protected wildlife habitat in section 4 of this report.

3.2.4.3. Post-survey Likelihood of Occurrence

A post survey Likelihood Of Occurrence (LOO) assessment was undertaken post ground-truthing of habitat within the Project area, and with consideration given to the comments of EcoSmart Ecology who have undertaken significant assessment of fauna within the Knapdale Range and surrounding areas.

The Knapdale Range is confirmed suitable habitat for the vulnerably listed (NC Act) Purple-necked rock-wallaby (PNRW). Large bouldery rocky gorges form suitable habitat for denning and contain potentially perennial rocky waterholes. Surrounded areas are grassy woodland suitable for foraging. Spatial analysis of the ground-truthed habitat values extrapolated denning, foraging and dispersal habitat for the area within the Knapdale Range (Figure 7). Potential habitat beyond the range was not considered in this assessment. EcoSmart Ecology estimate the current PNRW population within the Knapdale range could be as high as 270 (Ecosmart Ecology, 2023).

The special least concern species the short-beaked echidna (*Tachyglossus aculeatus*) and is known to occur within the Knapdale Range (Ecosmart Ecology, 2023). Habitat across the range is likely to be widespread with the exception of the steeper rocky gorges and is unlikely to be impacted by the project.

EcoSmart describe the habitat within the range as suboptimal for other potential species: the grey falcon and painted honeyeater, due to the lack of sparsely treed areas preferred by the grey falcon and the lack of suitable mistletoe species of which the honeyeater is a specialist. Additionally the Carpentarian grasswren is typically associated with hummocking spinifex grasslands which have not been recorded on the Knapdale Range. None of these species have been observed during the many years of survey effort in the area (Ecosmart Ecology, 2023).

The results of the post survey LOO indicated that the following threatened species remain possible, likely or known to occur within the Project area:

- Australian painted-snipe (*Rostratula australis*): E, Ma (EPBC), E (NC Act) – Possible
- Purple-crowned Fairy-wren (Malurus coronatus): V (EPBC), NL (NC Act) - Possible
- Purple-necked rock-wallaby (*Petrogale purpureicollis*): V (NC Act) - Known

- Short-beaked echidna (*Tachyglossus aculeatus*): SL (NC Act) – Known
- White-bellied sea-eagle (*Haliaeetus leucogaster*): M,Ma (EPBC), SL (NC Act) – Known

The results of the post survey LOO indicated that the following migratory species remain possible, likely or known to occur within the Project area:

- Caspian tern (*Hydroprogne caspia*): M,Ma (EPBC), SL (NC Act) – Possible
- Common greenshank (*Tringa nebularia*): M,Ma (EPBC), SL (NC Act) – Possible
- Glossy ibis (*Plegadis falcinellus*): M,Ma (EPBC), SL (NC Act) – Possible
- Latham's snipe (*Gallinago hardwickii*): M,Ma (EPBC), SL (NC Act) – Possible
- Sharp-tailed sandpiper (*Calidris acuminata*): M,Ma (EPBC), SL (NC Act) – Possible
- White-bellied sea-eagle (*Haliaeetus leucogaster*): M,Ma (EPBC), SL (NC Act) – Possible

The results of the post survey LOO indicated that the following marine species remain possible, likely or known to occur within the Project area:

- Australian painted-snipe (*Rostratula australis*): E, Ma (EPBC), E (NC Act) – Possible
- Australian pelican (*Pelecanus conspicillatus*): Ma (EPBC) - Known
- Black-eared cuckoo (*Chalcites osculans*): Ma (EPBC) - Known
- Black-faced cuckoo-shrike (*Coracina novaehollandiae*): Ma (EPBC) – Known
- Cattle egret (*Bubulcus ibis*): Ma (EPBC) – Known
- Horsfield's bronze cuckoo (*Chalcites basalis*): Ma (EPBC) – Known
- Magpie-lark (*Grallina cyanoleuca*): Ma (EPBC) – Known
- Rainbow bee-eater (*Merops ornatus*): Ma (EPBC) – Known
- Sacred kingfisher (*Todiramphus sanctus*): Ma (EPBC) – Known
- Spotted nightjar (*Eurostopodus argus*): Ma (EPBC) – Known
- Stubble quail (*Coturnix pectoralis*): Ma (EPBC) – Known
- Whistling kite (*Haliastur sphenurus*): Ma (EPBC) – Known

The results of the post survey LOO indicated that the following species are unlikely to occur within the Project area.

- The Carpentarian grasswren (*Amytomis dorotheae*) (E, Ma (EPBC), E (NC Act)) was determined to be unlikely due to no records of the species within the last 14 years of surveys and the lack of hummocking spinifex grasslands with which the it is typically associated with which have not been recorded on the Knapdale Range (Ecosmart Ecology, 2023).
- The painted honeyeater (*Grantiella picta*) (V (EPBC), V (NC Act)) was determined to be unlikely due to a lack of records within the last 14 years of surveys and the absence of suitable mistletoe species of which the honeyeater is a specialist (Ecosmart Ecology, 2023).
- The grey falcon (*Falco hypoleucos*) (V (EPBC), V (NC Act)) was determined to be unlikely due to the lack of records and the fact that most of the range is open woodland, whereas the grey falcon prefers sparsely treed grasslands (Ecosmart Ecology, 2023).

1 0 1 2 km

1:30,000

Client: MMG Dugald River Pty Ltd
Project number: 2023.03001
CRS: GDA2020 EPSG:7844
Date: 20 November 2023

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Figure 7. Purple-necked Rock Wallaby Habitat Mapping

Legend

- Proposed Disturbance
- Approved Disturbance
- Probable Den
- Known Den
- Petrogale Purpureicollis Records
- Foraging Habitat
- Dispersal Habitat

Google Satellite

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3.2.5.Bird and Bat Utilisation Surveys

3.2.5.1. Impacts to Birds

The EcoSmart Ecology BBUS identified collision risk from the wind turbine RSA for the following species due to their flight habits in relation to the determined heights of the RSA:

- Little Woodswallow (*Artamus minor*)
- Black-faced Woodswallow (*Artamus cinereus*)
- Fairy Martin (*Petrochelidon ariel*)
- Brown Falcon (*Falco berigora*)
- White-necked Heron (*Ardea pacifica*)
- Wedge-tailed Eagle (*Aquila audax*)
- Black-shouldered Kite (*Elanus axillaris*)
- Whistling Kite (*Haliastur sphenurus*)
- Black Kite (*Milvus migrans*)
- Varied Lorikeet (*Psitteuteles versicolor*)

Other species recorded by EcoSmart Ecology within the Knapdale Range, but not recorded in the BBUS surveys and which have similar behaviours and therefore similar collision risk include:

- Masked Woodswallow (*Artamus personatus*)
- White-browed Woodswallow (*Artamus superciliosus*)
- White-breasted Woodswallow (*Artamus leucorhynchus*)
- Collared Sparrowhawk (*Accipiter cirrocephalus*)
- Brown Goshawk (*Accipiter fasciatus*)
- Spotted Harrier (*Circus assimilis*)
- Nankeen Kestrel (*Falco cenchroides*)
- Australian Hobby (*Falco longipennis*)
- Black Falcon (Falco *subniger*)
- Black-breasted Buzzard (*Hamirostra melanosternon*)

A comprehensive species list and table of records within and outside RSA has been provided in table 3.2 of the EcoSmart Ecology report (APPENDIX H).

3.2.5.2. Impacts to Bats

Little data is available with regards to how high bat species fly to be able to adequately inform impacts. EcoSmart Ecology have provided a list of species identified as present within the Project area (Table 10) (Table 3.3, Section 3.2.6 of the EcoSmart Ecology report (APPENDIX H)). Their findings were that while discussion can be had around the species and potential and known habitat areas of the site, actual impact due to risk of collision with turbine blades is difficult to determine and requires continued data collection throughout the life of the project.

Table 9. Ranked[3] list of bat species recorded across four impact and four control sites (Ecosmart Ecology, 2023)

Confidence	*Scientific Name* Common Name	Status*		Number of calls		
		NCA	EPBC	May	Sep	Total
Positive Identification	*Chalinolobus gouldii* Gould's Wattled Bat	LC		1204	2349	3553
	Taphozous sp.			352	1114	1466
	Chaerephon jobensis Northern Freetail Bat	LC		749	465	1214
	Saccolaimus flaviventris Yellow-bellied Sheathtail Bat	LC		79	698	777
	Scotorepens greyii Little Broad-nosed Bat	LC		51	571	622
	Vespadelus baverstocki Inland Forest Bat	LC		21	254	275
	Chalinolobus nigrogriseus Hoary Wattled Bat	LC		21	36	57
	Vespadelus finlaysoni Finlayson's Cave Bat	LC		31	10	41
	Ozimops lumsdenae Northern Free-tailed Bat	LC		30	10	40
	Scotorepens balstoni Inland Broad-nosed Bat	LC		8	14	22
	Ozimops sp.			13	3	16
	Austronomus australis White-striped Freetail Bat	LC		4	1	5
	Nyctophilus sp.			1	3	4
Uncertain Identification	*C. gouldii* or *Ozimops* sp.			505	133	638
	C. nigrogriseus or *S. greyii*			11	73	84
	S. greyii or *V. baverstocki*			21	51	72
	C. gouldii or *S. balstoni*			30	10	40
	O. lumsdenae or *Taphozous* sp.			2	6	8
	S. balstoni or *Ozimops* sp.			3	5	8

#Species are ranked by total number of calls across two surveys (NB: this is not equivalent to a total count of individuals).

* NCA = *Nature Conservation Act 1992*; EPBC = *Environment Protection and Biodiversity Conservation Act 1999*; CR = Critically Endangered; EN = Endangered; VU = Vulnerable; NT = Near Threatened; SLC = Special Least Concern; LC = Least Concern; Mig = Migratory

.

4. Impact Assessment

An assessment for significant impacts was undertaken for MSES and MNES ground-truthed as present along with NC Act and EPBC Act listed threatened species and listed migratory species under the EPBC Act returning a likelihood of occurrence value of possible, likely, or known. MSES were assessed in accordance with the *Significant Residual Impact Guideline* (Department of Environment and Heritage Protection, 2014) and MNES were assessed in accordance with the *Matters of National Environmental Significance Significant impact guidelines 1.1* (Department of the Environment, 2013).

While the Project is to be assessed under the EP Act, the Performance Outcomes (PO) under the State code 23: Wind farm development were considered as part of this impact assessment to ensure adherence to the standards of assessment set by the Queensland Government. As such impacts were assessed the following relevant PO were considered as part of this assessment.

- PO1 Development is designed and sited to ensure that:
    - threatened species and associated habitats; and
    - areas of high environmental value are protected from adverse impacts.
- PO2 Development is constructed to ensure that the following are protected from adverse impacts:
    - threatened species and associated habitats; and
    - areas of high environmental value
- PO3 Development operations ensure that threatened species and birds and bats are protected from adverse impacts.
- PO4 Areas cleared for the construction of a wind farm are replanted to the maximum extent possible following construction without impeding operations and maintenance of the wind farm.
- PO5 The wind farm, including ancillary infrastructure, is designed and sited to minimise crossings of and interference with natural drainage lines and watercourses.

Threatened species, raptors and migratory birds, and bats known to occur or deemed likely or possible to occur in the project area (in APPENDIX X and APPENDIX Y) were assessed against impact criteria relevant to their status and the relevant governing legislation to the determined potential impacts of the project. The purpose of this is to determine whether or not the Project is likely to have a significant impact on the species to inform the Preliminary Impact Management Plans.

4.1. Regulated Vegetation

4.1.1. Regulated Vegetation intersecting a watercourse

Total approximate area of regulated vegetation intersecting a watercourse proposed to be impacted by the Project disturbance area is 3.5 ha (Figure 5). Impacts are unavoidable due to the required engineering and maximisation for the use of existing slopes and level ground. Impacts to regulated vegetation intersecting a watercourse exceed criteria 1 and 3 of the significant residual impact test of table 1 of the guidelines (Department of the Environment, 2013).

Table 10. Significant residual impact test – criteria for impacts to regulated vegetation

		Clearing in a regional ecosystem that is within the defined distance of a watercourse
1	**For clearing for linear infrastructure:** - greater than 25m wide in a grassland (structural category) regional ecosystem; or - greater than 20m wide in a sparse (structural category) regional ecosystem; or - greater than 10m wide in a dense to mid-dense (structural category) regional ecosystem. **For clearing other than clearing for linear infrastructure:** - area greater than 5 ha where in a grassland (structural category) regional ecosystem; or - - area greater than 2 ha where in a sparse (structural category) regional ecosystem; or - - area greater than 0.5 ha where in a dense to mid-dense(structural category) regional ecosystem.	✓
2	Clearing within 50m of the defining bank	N/A
3	Clearing within 5m of the defining bank	✓

NOTES:

For a prescribed activity to have a significant residual impact on a regional ecosystem that lies within a mapped wetland, criteria 1 and 2 must be exceeded.

For a prescribed activity to have a significant residual impact on a regional ecosystem that is within the defined distance of watercourses, criteria 1 and 3 must be exceeded.

The values of the wetland and watercourses themselves are not covered in this section (only the vegetation associated with these natural features) —the values of the wetland and watercourses themselves are considered in section

4.1.2.Regulated Vegetation Essential Habitat

Impacts to regulated vegetation essential habitat relate to the habitat for the PNRW located on the Knapdale Range. Impacts are unavoidable due to the required engineering and maximisation for the use of existing slopes and level ground. A significant residual impact assessment for the PNRW has been provided in section 4.6. The below assessment relates to impacts to essential habitat and determines that significant residual impacts to the PNRW as a result of the project will be unlikely based on the disturbance of essential habitat alone.

Is there a chance or possibility that an action will?	Response
Lead to a long-term decrease in the size of an important population of the species; or	**Unlikely:** Project works in the site are unlikely to lead to a long-term decrease in the size of an important population of the species. There are 611 records of the PNRW on the site over 12 years. There are multiple confirmed and multiple speculated dens around the site, including several along the Knapdale Range near the project area. The Knapdale Range occupies an area of approximately6000 ha of which only 75 ha (<1.5%) is proposed for development, increasing the total area associated with DRM to 373 ha (~6%). Though total impacts to essential habitat areas is <70 ha, the disturbance area are relatively small and disturbed areas are likely to recruit fodder suitable for foraging by the rock-wallaby

Is there a chance or possibility that an action will?	Response
Reduce the area of occupancy of an important population; or	**Unlikely:** Project works in the site are unlikely to reduce the area of occupancy of an important population. There are 611 records of the PNRW on the site over 12 years. There are multiple confirmed and multiple speculated dens around the site, including several along the Knapdale Range near the project area. The Knapdale Range occupies an area of approximately6000 ha of which only 75 ha (<1.5%) is proposed for development, increasing the total area associated with DRM to 373 ha (~6%). Though total impacts to essential habitat areas is almost <70 ha, the disturbance area are relatively small and disturbed areas are likely to recruit fodder suitable for foraging by the rock-wallaby
Fragment an existing important population into two or more populations; or	**Unlikely:** Project works in the site are unlikely to fragment an existing important population. There are 611 records of this species on the site over 12 years. There are multiple confirmed and multiple speculated dens around the site, including several along the Knapdale Range near the project area. The small subpopulations in the denning habitat areas confirmed along the Knapdale Range can be collectively considered as a single population. Temporary disturbance to a subpopulation associated with the clearance and construction phase of the project is unlikely to significantly impact the population as a whole. Due to the relatively low ground disturbance associated with wind farms, the small size of the proposed disturbance footprint, the connectivity of the surrounding habitat, and the small range of rock-wallabies, works within the site are unlikely to fragment any existing populations.
Adversely affect habitat critical to the survival of the species; or	**Unlikely:** Project works in the site are unlikely to adversely affect habitat critical to the survival of the species. There are 611 records of this species on the site over 12 years. There are multiple confirmed and multiple speculated dens around the site, including several along the Knapdale Range near the project area. The purple-necked rock wallaby favours habitat which includes boulder piles, rocky slopes, cliffs and gorges in limestone areas, and sandstone and quartzite outcrops amongst dry Eucalyptus and Acacia woodlands. It also inhabits spinifex grasslands in association with the rocky areas (Rowland, 2012). The ongoing noise pressure and vibrations produced during the operation phases of the project have an unknown potential to disturb surrounding habitat, making it less preferable for rock-wallabies. There may be a risk of conditioning avoidance and affecting normal distribution patterns of rock-wallabies on site. However, due to the small size of the project area and the large area of local habitat available, works within the site are unlikely to adversely affect habitat critical to the survival of the species. Additionally PNRW population numbers have not declined in response to the current mining operations which includes the deposition of tailings within the TSF and ongoing exploratory resource definition drilling which occurs year-round which has occurred year-round since project commencement.
Disrupt the breeding cycle of an important population;	**Unlikely:** It is unlikely that the disturbance associated with project works in the site could disrupt the breeding cycle of an important population. There are 611 records of this species on the site over 12 years. There are multiple confirmed and multiple speculated dens around the site, including several along the Knapdale Range near the project area. The small subpopulations in the denning habitat areas confirmed along the Knapdale Range can be collectively considered as a single population. Temporary disturbance to a subpopulation associated with the clearance and construction phase of the project is unlikely to significantly impact the

Is there a chance or possibility that an action will?	Response
	population as a whole. Additionally MMG will deploy fauna spotter/catchers during clearing operations in accordance with the EA.
Modify, destroy, remove, or isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline; or	**Unlikely:** It is unlikely that the disturbance associated with project works in the site could impact habitat to the extent that the species is likely to decline. There are 611 records of this species on the site over 12 years. There are multiple confirmed and multiple speculated dens around the site, including several along the Knapdale Range near the project area. The PNRW favours habitat which includes boulder piles, rocky slopes, cliffs and gorges in limestone areas, and sandstone and quartzite outcrops amongst dry Eucalyptus and Acacia woodlands. It also inhabits spinifex grasslands in association with the rocky areas (Rowland, 2012). The small subpopulations in the denning habitat areas confirmed along the Knapdale Range can be collectively considered as a single population. Disturbance areas avoid denning areas of the PNRW and temporary disturbance to a subpopulation associated with the clearance and construction phase of the project is unlikely to significantly impact the population as a whole. Additionally MMG will deploy fauna spotter/catchers during clearing operations in accordance with the EA.
Result in invasive species that are harmful to a vulnerable species becoming established in the vulnerable species' habitat; or	**Unlikely:** Project works in the site are unlikely to introduce and/or allow a harmful invasive species to become established in the habitat of the species. Feral cats and European Red Foxes are recognised threats to several similar species and have been detected on site. Several species of invasive flora have been detected on site and have the potential to modify the species' habitat. The project will operate under the *Biosecurity Act 2014* and follow the General Biosecurity Obligation (GBO) to identify and manage any potential invasive species. Weed and Seed and pest management processes are well established for the mine. There is not likely to be an introduction and establishment of a harmful invasive species in the habitat of the species.
Introduce disease that may cause the species to decline; or	**Unlikely:** Project works are unlikely to introduce novel diseases to the site. Hydatid disease (*Echinococcus granulosus*) and Toxoplasmosis (*Toxoplasmosis gondii*) are both recognised diseases that have the potential to threaten rock-wallaby populations. The project will operate under the Biosecurity Act (2014) and follow the General Biosecurity Obligation (GBO) to identify and manage detrimental diseases or pathogens if present. There is not likely to be an introduction of a novel diseases to the rock-wallaby population on site.
Interfere substantially with the recovery of the species.	**Unlikely:** Project works in the site are unlikely to interfere substantially with the recovery of the species. There are 611 records of this species on the site over 12 years. There are multiple confirmed and multiple speculated dens around the site, including several along the Knapdale Range near the project area. Due to the relatively low ground disturbance associated with wind farms, the small size of the site, and the connectivity of the surrounding habitat, works within the site are unlikely to interfere with the recovery of the species.

4.2. Potential Threatened Birds

4.2.1. Australian painted snipe *(Rostratula australis)*

EPBC – Endangered, Marine. NCA – Endangered

The Australian painted snipe (*Rostratula australis*) is a cryptic species that is largely seasonal, following wet season inundations. It is a stocky, wading shore bird with a shorter beak than other snipe species and distinctive white comma-shaped eye markings (Pizzey & Knight, The Field Guide to the Birds of Australia, 2012). Unlike other snipe species in Australia, the Australian painted snipe does not seasonally migrate outside of Australia, though migration within the country does occur. The species generally inhabits shallow terrestrial freshwater (occasionally brackish) wetlands, including temporary and permanent lakes, swamps and claypans. They also use inundated or waterlogged grassland or saltmarsh, dams, rice crops, sewage farms, and bore drains. Typical sites include those with emergent tussocks of grass, sedges, rushes or reeds, or samphire; often with scattered clumps of lignum, Muehlenbeckia, canegrass, or sometimes tea-tree (Melaleuca). The Australian Painted Snipe sometimes utilises areas that are lined with trees, or that have some scattered fallen or washed-up timber (Marchant & Higgins, 1993).

One record exists approximately 40 km southwest of the site. Due to the habitat requirements of this species, there is no suitable habitat within the ML, however low quality suitable habitat exists in in pockets along Dugald River and Cabbage Tree Creek. No suitable breeding habitat is found near the site as the species has specific breeding habitat requirements. There is the potential for the species to transit through the site to reach suitable habitat elsewhere.

Australian Painted Snipe breeding habitat requirements may be quite specific: shallow wetlands with areas of bare wet mud and mixed heights of low vegetation. Nest records are all, or nearly all, from or near small islands in freshwater wetlands, with a combination of very shallow water, exposed mud, dense low cover and sometimes some tall dense cover (Rogers, et al., 2005). Gilgai micro relief, comprising extensive systems of small mounds (e.g. 1 to 3 m in diameter) and hollows (e.g. up to 0.5 m deep), is especially suitable; wetlands with gilgai are abundant in seasonal and other temporary wetlands of Australia, especially in the Murray Darling, arid and savannah regions on clay soils. The Australian Painted Snipe can use modified habitats, such as low-lying woodlands converted to grazing pasture, rice farms, sewage farms, dams, bores, and irrigation schemes, however they do not necessarily breed in such habitats (Marchant & Higgins, 1993).

The Australian painted snipe is well distributed across the country, though the bulk of the records for this species are along the southeast coast of Australia, from Brisbane to Adelaide (Atlas of Living Australia, 2023). The species has a historical population stronghold in the Murray-Darling basin, with a much patchier distribution in the north of its range, generally relying on water and rainfall events (TSSC, 2013; Pizzey & Knight, The Field Guide to the Birds of Australia, 2012).

The Australian painted snipe is primarily threatened by habitat degradation. This is particularly evident in one of the most important habitat areas for this species, the Murray-Darling basin. A history of water mismanagement for irrigation, wetland degradation, and drought in recent years has significantly reduced suitable habitat for the species (DSEWPC 2013). Climate change is also implicated is exacerbating these

negative effects and is predicted to increase in severity. This species is also threatened by grazing, introduced predators, and invasion of weeds in wetland habitats (TSSC, 2013).

The Australian painted snipe has previously been included as a subspecies of the greater painted snipe (*Rostratula benghalensis*), a related species that occurs in Africa and Asia. The species is listed "marine" under this alternate naming. The name *Rostratula australis* is considered most appropriate here, as the species is distinguishable from *R. benghalensis* on morphology (TSSC, 2013). The Australian painted snipe is cryptic, secretive, and usually difficult to detect. Appearance in northern Australia is considered seasonal, following wet season inundations.

Table 11: SRI assessment for the Australian painted snipe (*Rostratula australis*)

Is there a chance or possibility that an action will?	Response
Lead to a long-term decrease in the size of an important population of the species; or	**Unlikely:** Project works in the site are unlikely to lead to a long-term decrease in the size of an important population of the species. There were no individuals observed during the last 10 years of surveys. There is a record of a single individual ~40km southwest of the site. There is not likely to be an impact on the population by works in the site.
Reduce the area of occupancy of an important population; or	**Unlikely:** Project works in the site are unlikely to reduce the area of occupancy of an important population. There were no individuals observed during the last 10 years of surveys. There is a record of a single individual ~40km southwest of the site. There is not likely to be an impact on the population by works in the site.
Fragment an existing important population into two or more populations; or	**Unlikely:** Project works in the site are unlikely to fragment an existing important population. There were no individuals observed during the last 10 years of surveys. There is a record of a single individual ~40km southwest of the site. Due to the small size of the site and connectivity of the surrounding habitat, works within the site are unlikely to fragment any existing populations.
Adversely affect habitat critical to the survival of the species; or	**Unlikely:** Project works in the site are unlikely to adversely affect habitat critical to the survival of the species. There are no identified areas of important habitat in Queensland. There were no individuals observed during the last 10 years of surveys. There is a record of a single individual ~40km southwest of the site. This species is heavily associated with water. Waterholes on site are ephemeral and are fed by streams flowing from the ridgeline. All of the waterholes are small and surrounded by rocks, unsuitable habitat for the species. Due to the small size of the site and connectivity of the surrounding habitat, works within the site are unlikely to impact habitat critical to the survival of the species.
Disrupt the breeding cycle of an important population; or	**Unlikely:** Project works in the site are unlikely to disrupt the breeding cycle of an important population of the species. There were no individuals observed during the last 10 years of surveys. There is a record of a single individual ~40km southwest of the site. There are no known important populations in the vicinity of the site. Due to the small size of the site and connectivity of the surrounding habitat, works within the site are unlikely to impact the breeding cycle of the species.
Modify, destroy, remove, or isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline; or	**Unlikely:** Project works in the site are unlikely to impact habitat to the extent that the species is likely to decline. There are no identified areas of important habitat in Queensland. There were no individuals observed during the last 10 years of surveys. There is a record of a single individual ~40km southwest of the site.

Is there a chance or possibility that an action will?	Response
	This species is heavily associated with water. Waterholes on site are ephemeral and are fed by streams flowing from the ridgeline. All of the waterholes are small and surrounded by rocks, unsuitable habitat for the species. Due to the absence of suitable habitat, the small size of the site, and connectivity of the surrounding habitat, works within the site are unlikely to modify habitat to the extent that the species is likely to decline.
Result in invasive species that are harmful to a vulnerable species becoming established in the vulnerable species' habitat; or	**Unlikely:** Project works in the site are unlikely to introduce and/or allow a harmful invasive species to become established in the habitat of the species. Feral cats and European Red Foxes are recognised threats to this species and have been detected on site. Several species of invasive flora have been detected on site and have the potential to modify the species' habitat. The project will operate under the *Biosecurity Act* (2014) and follow the General Biosecurity Obligation (GBO) to identify and manage any potential invasive species.
Introduce disease that may cause the species to decline; or	**Unlikely:** Project works are unlikely to introduce novel diseases to the site. There are currently no known diseases that may cause the species to decline. The project will operate under the *Biosecurity Act* (2014) and follow the General Biosecurity Obligation (GBO) to identify and manage detrimental diseases or pathogens if present. There were no individuals observed during recent surveys. There is a record of a single individual ~40km southwest of the site, this will not be affected by works within the site.
Interfere substantially with the recovery of the species.	**Unlikely:** Project works in the site are unlikely to interfere substantially with the recovery of the species. There were no individuals observed during recent surveys. There is a record of a single individual ~40km southwest of the site. Due to the small size of the site and connectivity of the surrounding habitat, works within the site are unlikely to interfere with the recovery of the species.

4.2.2.Purple-crowned Fairy-wren (*Malurus coronatus*)

EPBC – Not listed. NCA – Vulnerable.

The Purple-crowned Fairy-wren (*Malurus coronatus*) is a small bird that is warm-brown above, and white below, with a long blue tail, dark bill, dark eyes, and brownish legs and feet (Higgins et al. 2001). Adult females have a dark grey forehead, crown, and nape, and a chestnut mask around the bill and eyes with contrasting white eye-rings. During the non-breeding season, adult males look much the same, except the mask is usually dark and the eye-rings more grey than white. In the breeding season, males develop a purple colouring on the forehead, crown, and nape, with a black spot in the centre of the crown and the mask becoming completely black (Higgins et al. 2001; Rowley & Russell 1993). It is probable the record ~42km north of the Project area was the eastern subspecies (*Malurus coronatus macgillivrayi*), which occurs along most rivers draining into south-western and southern Gulf of Carpentaria from Roper River in Northern Territory to Leichhardt and Flinders Rivers in Queensland. A natural biogeographic barrier of approximately 300 km of unsuitable habitat separates this subspecies from the western subspecies (*Malurus coronatus coronatus*).

Table 12: SRI assessment for the Purple-crowned Fairy-wren (*Malurus coronatus*)

Is there a chance or possibility that an action will?	Response
Lead to a long-term decrease in the size of an important population of the species; or	**Unlikely:** Project works in the site are unlikely to lead to a long-term decrease in the size of an important population of the species. There were no individuals observed during the last 10 years of surveys. There is a record of a single individual within 50km of the site. There is not likely to be an impact on the population by works in the site.
Reduce the area of occupancy of an important population; or	**Unlikely:** Project works in the site are unlikely to reduce the area of occupancy of an important population. There were no individuals observed during the last 10 years of surveys. There is a record of a single individual within 50km of the site. There is not likely to be an impact on the population by works in the site.
Fragment an existing important population into two or more populations; or	**Unlikely:** Project works in the site are unlikely to fragment an existing important population. There were no individuals observed during the last 10 years of surveys. There is a record of a single individual within 50km of the site. Due to the small size of the site and connectivity of the surrounding habitat, works within the site are unlikely to fragment any existing populations.
Adversely affect habitat critical to the survival of the species; or	**Unlikely:** Project works in the site are unlikely to adversely affect habitat critical to the survival of the species. There are no identified areas of important habitat in Queensland. There were no individuals observed during the last 10 years of surveys. There is a record of a single individual within 50km of the site. Vegetation along the Dugald river and smaller order streams that run through the site may provide potential habitat for the species. Due to the small size of the site and connectivity of the surrounding habitat, works within the site are unlikely to impact habitat critical to the survival of the species.
Disrupt the breeding cycle of an important population; or	**Unlikely:** Project works in the site are unlikely to disrupt the breeding cycle of an important population of the species. There were no individuals observed during the last 10 years of surveys. There is a record of a single individual within 50km of the site. There are no known important populations in the vicinity of the site. Due to the small size of the site and connectivity of the surrounding habitat, works within the site are unlikely to impact the breeding cycle of the species.

Is there a chance or possibility that an action will?	Response
Modify, destroy, remove, or isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline; or	**Unlikely:** Project works in the site are unlikely to impact habitat to the extent that the species is likely to decline. There are no identified areas of important habitat in Queensland. There were no individuals observed during the last 10 years of surveys. There is a record of a single individual within 50km of the site. Vegetation along the Dugald river and smaller order streams that run through the site may provide potential habitat for the species. Due to the small size of the site, and connectivity of the surrounding habitat, works within the site are unlikely to modify habitat to the extent that the species is likely to decline.
Result in invasive species that are harmful to a vulnerable species becoming established in the vulnerable species' habitat; or	**Unlikely:** Project works in the site are unlikely to introduce and/or allow a harmful invasive species to become established in the habitat of the species. Feral cats and European Red Foxes are recognised threats to this species and have been detected on site. Several species of invasive flora have been detected on site and have the potential to modify the species' habitat. The project will operate under the *Biosecurity Act* (2014) and follow the General Biosecurity Obligation (GBO) to identify and manage any potential invasive species.
Introduce disease that may cause the species to decline; or	**Unlikely:** Project works are unlikely to introduce novel diseases to the site. There are currently no known diseases that may cause the species to decline. The project will operate under the *Biosecurity Act* (2014) and follow the General Biosecurity Obligation (GBO) to identify and manage detrimental diseases or pathogens if present. There were no individuals observed during recent surveys. There is a record of a single individual within 50km of the site, this will not be affected by works within the site.
Interfere substantially with the recovery of the species.	**Unlikely:** Project works in the site are unlikely to interfere substantially with the recovery of the species. There were no individuals observed during recent surveys. There is a record of a single individual within 50km of the site. Due to the small size of the site and connectivity of the surrounding habitat, works within the site are unlikely to interfere with the recovery of the species.

4.3. Potential migratory birds

A spatial analysis of potential flight paths for migratory birds was conducted as per the methodology detailed in section 2.4.2. The results of the spatial analysis informed impact assessments for species with potential to fly within the Project area. Mapping is provided in APPENDIX G.

It should be noted that limited information is available regarding the flight heights for most species and more particularly with regard to the Project location itself, as. Of particular note is the absence of local perennial water sources in close proximity to the proposed Project area.

4.3.1. Bar-tailed Godwit (Limosa lapponica)

EPBC – Migratory, Marine. NCA – Special least concern

The Bar-tailed Godwit (*Limosa lapponica*) is a large wader with a long neck and very long upturned bill. They are slightly larger and stockier than the Black-tailed Godwit, with a shorter neck and legs and a more upturned and pointier bill. They are distinguishable from other Godwits by the dark barring on the lower white rump, uppertail, and lining of the underwing. They have been recorded in the coastal areas of all Australian states. The Bar-tailed Godwit is found mainly in coastal habitats such as large intertidal sandflats, banks, mudflats, estuaries, inlets, harbors, coastal lagoons, and bays. It is rarely found on inland wetlands (Marchant & Higgins, 1993). However, in the vicinity of the Project area, they are known to occur at Lake Moondarra (ALA, 2023). The Bar-tailed Godwit breeds in the Northern hemisphere and moves south for the Northern hemisphere winter. The subspecies *Limosa lapponica baueri* and *Limosa lapponica menzbieri* are migrants to Australia. They arrive in northern Australia in August. The majority move to the east coast and travel down to south-east Australia, which they reach by September, however some remain on the north coast. Inland records suggest there is some passage overland from October-December. Generally, numbers slowly decline between February and April as birds leave to return to breeding sites in the northern hemisphere (Marchant & Higgins, 1993). Impact assessment relies on an understanding of flight height which varies depending on the phase of flight however, no information regarding flight heights was found for this species.

In Australia there are several threats common to most migratory shorebirds, including this species, such as Habitat loss due to land clearing, inundation, infilling or draining; disturbance from residential and recreational activities including boating, noise and night lighting; and direct mortality as a result of human activities around migration pathways and at foraging and roosting sites, such as the construction of wind farms in migration or movement pathways (DEWHA, 2009).

Table 13: SRI assessment for the Bar-tailed Godwit (*Limosa lapponica*)

Is there a chance or possibility that an action will?	Response
Substantially modify (including by fragmenting, altering fire regimes, altering nutrient cycles, or altering hydrological cycles), destroy, or isolate an area of important habitat for a migratory species; or	**Unlikely:** Project works in the site are unlikely to substantially modify, destroy, or isolate an area of important habitat for this species. There is no suitable habitat for this species within the site and it is likely the species is only transient through this area. Due to the lack of suitable habitat, it is unlikely project works in the site will substantially modify, destroy, or isolate an area of important habitat for this species.

Result in an invasive species that is harmful to the migratory species becoming established in an area of important habitat for the migratory species; or	**Unlikely:** Project works in the site are unlikely to introduce and/or allow a harmful invasive species to become established in the habitat of the species. Feral cats and European Red Foxes are recognised threats to several similar species and have been detected on site. Several species of invasive flora have been detected on site and have the potential to modify the species' habitat. The project will operate under the *Biosecurity Act* (2014) and follow the General Biosecurity Obligation (GBO) to identify and manage any potential invasive species. There is not likely to be an introduction and establishment of a harmful invasive species in the habitat of the species.
Seriously disrupt the lifecycle (breeding, feeding, migration, or resting behaviour) of an ecologically significant proportion of the population of a migratory species.	**Unlikely:** Project works in the site are unlikely to seriously disrupt the lifecycle of an ecologically significant proportion of the population of this species. No information regarding flight heights was found for this species. Whilst there are several records and mapped flightpaths within the vicinity of the project area, these do not represent an ecologically significant proportion of the population. Therefore it is unlikely project works in the site will seriously disrupt the lifecycle of an ecologically significant proportion of the population of this species.

4.3.2. Black-tailed Godwit (*Limosa limosa*)

EPBC – Migratory, Marine. NCA – Special least concern

The Black-tailed Godwit (*Limosa limosa*) is a large, long legged wading shorebird with a long, slightly upturned bill that is pink in colour with a black tip. The species breeds in the northern hemisphere from Mongolia to Siberia, migrating to Australia in September before leaving again in May. It utilises a wide range of habitats, both coastal and inland, including estuaries, beaches, mudflats, swamps, and larger inland water bodies (Pizzey & Knight, The Field Guide to the Birds of Australia, 2012). Scattered records in inland areas suggests the species uses inland waterways during passage. Most birds that arrive in Australia after migrating from the breeding grounds in the northern hemisphere stay in the north of Australia. The few that travel south may cross the continent, often through the Mt Isa region (DCCEEW, 2023). In the vicinity of the Project area, they are known to congregate at Lake Moondarra, and there are records at Rifle Creek Dam, and to the northeast of Cloncurry near Taldora (ALA, 2023). Impact assessment relies on an understanding of flight height which varies depending on the phase of flight however, no information regarding flight heights was found for this species.

This species may be susceptible to a range of threats, though habitat degradation is considered to be the most significant. This is particularly evident at staging areas in the east Asian region, where large scale loss of mudflats is implicated in the declines of many migratory shorebirds. Direct mortality as a result of human activities, such as the construction of wind farms in migration or movement pathways, is also a recognised threat to this species (DCCEEW, 2023).

Table 14: SRI assessment for the Black-tailed Godwit (*Limosa limosa*)

Is there a chance or possibility that an action will?	Response
Substantially modify (including by fragmenting,	**Unlikely:** Project works in the site are unlikely to substantially modify, destroy, or isolate an area of important habitat for this species.

altering fire regimes, altering nutrient cycles, or altering hydrological cycles), destroy, or isolate an area of important habitat for a migratory species; or	There is no suitable habitat for this species within the site and it is likely the species is only transient through this area. Due to the lack of suitable habitat, it is unlikely project works in the site will substantially modify, destroy, or isolate an area of important habitat for this species.
Result in an invasive species that is harmful to the migratory species becoming established in an area of important habitat for the migratory species; or	**Unlikely:** Project works in the site are unlikely to introduce and/or allow a harmful invasive species to become established in the habitat of the species. Feral cats and European Red Foxes are recognised threats to several similar species and have been detected on site. Several species of invasive flora have been detected on site and have the potential to modify the species' habitat. The project will operate under the *Biosecurity Act* (2014) and follow the General Biosecurity Obligation (GBO) to identify and manage any potential invasive species. There is not likely to be an introduction and establishment of a harmful invasive species in the habitat of the species.
Seriously disrupt the lifecycle (breeding, feeding, migration, or resting behaviour) of an ecologically significant proportion of the population of a migratory species.	**Unlikely:** Project works in the site are unlikely to seriously disrupt the lifecycle of an ecologically significant proportion of the population of this species. No information regarding flight heights was found for this species.Whilst there are several records and mapped flightpaths within the vicinity of the project area, these do not represent an ecologically significant proportion of the population. Therefore it is unlikely project works in the site will seriously disrupt the lifecycle of an ecologically significant proportion of the population of this species.

4.3.3.Broad-billed Sandpiper (*Limicola falcinellus*)

EPBC – Migratory, Marine. NCA – Special least concern.

The Broad-billed Sandpiper (*Limicola falcinellus*) is a small, stint-like wader with short legs and a long straight black bill that is flattened and kinked downwards at the tip. From above the bill appears broad with parallel sides, tapering sharply to a point (Higgins & Davies, 1996). In Australia, the species is most common along the north and north-west coasts. There are scattered records in the south and south-east Gulf of Carpentaria. The Broad-billed Sandpiper breeds in the northern hemisphere, moving south for the non-breeding season. The subspecies *Limicola falcinellus sibirica* visits Australia in the non-breeding season. They occur in sheltered parts of the coast, favoring estuarine mudflats but also occasionally occur on saltmarshes, shallow freshwater lagoons, saltworks and sewage farms, and in areas with large soft intertidal mudflats, which may have shell or sandbanks nearby. Occasionally they occur on reefs or rocky platforms. They are rarely recorded inland. There are no records in the vicinity of the Project area (ALA, 2023). Impact assessment relies on an understanding of flight height which varies depending on the phase of flight however, no information regarding flight heights was found for this species

In Australia there are several threats common to most migratory shorebirds, including this species, such as Habitat loss due to land clearing, inundation, infilling or draining; disturbance from residential and recreational activities including boating, noise and night lighting; and direct mortality as a result of human activities around migration pathways and at foraging and roosting sites, such as the construction of wind farms in migration or movement pathways (DEWHA, 2009).

Table 15: SRI assessment for the Broad-billed Sandpiper (*Limicola falcinellus*)

Is there a chance or possibility that an action will?	Response
Substantially modify (including by fragmenting, altering fire regimes, altering nutrient cycles, or altering hydrological cycles), destroy, or isolate an area of important habitat for a migratory species; or	**Unlikely:** Project works in the site are unlikely to substantially modify, destroy, or isolate an area of important habitat for this species. There is no suitable habitat for this species within the site and it is likely the species is only transient through this area. Due to the lack of suitable habitat, it is unlikely project works in the site will substantially modify, destroy, or isolate an area of important habitat for this species.
Result in an invasive species that is harmful to the migratory species becoming established in an area of important habitat for the migratory species; or	**Unlikely:** Project works in the site are unlikely to introduce and/or allow a harmful invasive species to become established in the habitat of the species. Feral cats and European Red Foxes are recognised threats to several similar species and have been detected on site. Several species of invasive flora have been detected on site and have the potential to modify the species' habitat. The project will operate under the *Biosecurity Act* (2014) and follow the General Biosecurity Obligation (GBO) to identify and manage any potential invasive species. There is not likely to be an introduction and establishment of a harmful invasive species in the habitat of the species.
Seriously disrupt the lifecycle (breeding, feeding, migration, or resting behaviour) of an ecologically significant proportion of the population of a migratory species.	**Unlikely:** Project works in the site are unlikely to seriously disrupt the lifecycle of an ecologically significant proportion of the population of this species. No information regarding flight heights was found for this species. Whilst there are mapped flightpaths within the vicinity of the project area, these do not represent an ecologically significant proportion of the population. Therefore it is unlikely project works in the site will seriously disrupt the lifecycle of an ecologically significant proportion of the population of this species.

4.3.4. Caspian Tern (Hydroprogne caspia)

EPBC – Migratory, Marine. NCA – Special least concern

The Caspian Tern (*Hydroprogne caspia*) is the largest tern in Australia with an easily distinguished heavy, red bill. They are gregarious during breeding season and mostly single or in small groups outside of breeding. Occasionally groups of up to 30 can occur, often in fishing areas or whilst roosting. This species can aggregate into flocks during migration (Higgins and Davies 1996).

In Queensland, distribution is widespread in coastal regions, but they have been recorded in western districts such as Lake Eyre Drainage Basin, north-west to the Gulf Country, north to Mt Isa and Cloncurry. There are also scattered accounts or central Queensland (Higgins & Davies, 1996). In the vicinity of the Project area, they are known to congregate at Lake Moondarra, East Leichhardt Dam and at Chinaman Dam in Cloncurry; additionally there are several scattered records in the areas within and around both Mt Isa City and Cloncurry (ALA, 2023).

Preferred habitat includes sheltered coastal embayment and those with sandy or muddy margins. They will also use artificial water sources including reservoirs, sewage ponds and saltworks (Higgins & Davies, 1996). There is a known dispersal pattern of adult and juvenile birds moving from a large breeding colony at Lake Moondarra, near Mt Isa, east and south up to approximately 1500km (Birds Australia, 2010). Impact

assessment relies on an understanding of flight height which varies depending on the phase of flight however, no information regarding flight heights was found for this species

Some of the threats to Caspian terns include habitat loss and degradation through the introduction of exotic plant species, human disturbance and trampling by livestock of breeding sites and exposure to contaminants (Birdlife International, 2023).

Table 16: SRI assessment for the Caspian Tern (Hydroprogne caspia)

Is there a chance or possibility that an action will?	Response
Substantially modify (including by fragmenting, altering fire regimes, altering nutrient cycles, or altering hydrological cycles), destroy, or isolate an area of important habitat for a migratory species; or	**Unlikely:** Project works in the site are unlikely to substantially modify, destroy, or isolate an area of important habitat for this species. There is no suitable habitat for this species within the site and it is likely the species is only transient through this area. Due to the lack of suitable habitat, it is unlikely project works in the site will substantially modify, destroy, or isolate an area of important habitat for this species.
Result in an invasive species that is harmful to the migratory species becoming established in an area of important habitat for the migratory species; or	**Unlikely:** Project works in the site are unlikely to introduce and/or allow a harmful invasive species to become established in the habitat of the species. Feral cats and European Red Foxes are recognised threats to several similar species and have been detected on site. Several species of invasive flora have been detected on site and have the potential to modify the species' habitat. The project will operate under the *Biosecurity Act* (2014) and follow the General Biosecurity Obligation (GBO) to identify and manage any potential invasive species. There is not likely to be an introduction and establishment of a harmful invasive species in the habitat of the species.
Seriously disrupt the lifecycle (breeding, feeding, migration, or resting behaviour) of an ecologically significant proportion of the population of a migratory species.	**Unlikely:** Project works in the site are unlikely to seriously disrupt the lifecycle of an ecologically significant proportion of the population of this species. No information regarding flight heights was found for this species. Whilst there are several records within the vicinity of the project area, these do not represent an ecologically significant proportion of the population, and there is no evidence of movement over the project area. Therefore it is unlikely project works in the site will seriously disrupt the lifecycle of an ecologically significant proportion of the population of this species.

4.3.5.Common Greenshank/ Greenshank (*Tringa nebularia*)

EPBC – Migratory, Marine. NCA – Special least concern

The Common Greenshank (*Tringa nebularia*) is a heavily-built wading bird with a long bill that is slightly upturned. This species is seen both singly and in large flocks in coastal and inland wetlands. It does not breed within Australia but does occur in all types of wetlands and has the widest distribution of any shorebird (Higgins & Davies, 1996). Long distance flight within and across Australia is generally limited to arrival from or departure to overseas breeding sites. Typical habitat includes large mudflats and saltmarsh, mangroves, or seagrass. They can also utilize permanent and ephemeral terrestrial wetlands including swamps, lakes, dams, rivers, creeks, and billabongs as well as artificial wetlands. In the vicinity of the Project area, they are known to congregate at Lake Moondarra, Corella Dam and around Mt Isa City; additionally there are records at

Chinaman Dam and around Cloncurry (ALA, 2023). Impact assessment relies on an understanding of flight height which varies depending on the phase of flight however, no information regarding flight heights was found for this species

Threats include loss and modification of habitat and silt pollution, weeds, and pest invasion (AGDEH, 2005).

Table 17: SRI assessment for the Common Greenshank (*Tringa nebularia*)

Is there a chance or possibility that an action will?	Response
Substantially modify (including by fragmenting, altering fire regimes, altering nutrient cycles, or altering hydrological cycles), destroy, or isolate an area of important habitat for a migratory species; or	**Unlikely:** Project works in the site are unlikely to substantially modify, destroy, or isolate an area of important habitat for this species. There is no suitable habitat for this species within the site and it is likely the species is only transient through this area. Due to the lack of suitable habitat, it is unlikely project works in the site will substantially modify, destroy, or isolate an area of important habitat for this species.
Result in an invasive species that is harmful to the migratory species becoming established in an area of important habitat for the migratory species; or	**Unlikely:** Project works in the site are unlikely to introduce and/or allow a harmful invasive species to become established in the habitat of the species. Feral cats and European Red Foxes are recognised threats to several similar species and have been detected on site. Several species of invasive flora have been detected on site and have the potential to modify the species' habitat. The project will operate under the Biosecurity Act (2014) and follow the General Biosecurity Obligation (GBO) to identify and manage any potential invasive species. There is not likely to be an introduction and establishment of a harmful invasive species in the habitat of the species.
Seriously disrupt the lifecycle (breeding, feeding, migration, or resting behaviour) of an ecologically significant proportion of the population of a migratory species.	**Unlikely:** Project works in the site are unlikely to seriously disrupt the lifecycle of an ecologically significant proportion of the population of this species. No information regarding flight heights was found for this species. Whilst there are several records and mapped flightpaths within the vicinity of the project area, these do not represent an ecologically significant proportion of the population. Therefore it is unlikely project works in the site will seriously disrupt the lifecycle of an ecologically significant proportion of the population of this species.

4.3.6.Curlew Sandpiper (*Calidris ferruginea*)

EPBC – Critically endangered, Migratory, Marine. NCA – Critically endangered

The Curlew Sandpiper (*Calidris ferruginea*) is a migratory species of wading shorebird. It has a downward curving dark bill and an obvious white eyebrow. The curlew sandpiper migrates in the summer months to the southern hemisphere, including Australia, with some individuals known to occasionally overwinter here. In Australia, the curlew sandpiper is known predominantly from coastal reaches, though it does travel further inland given suitable conditions. It prefers mudflats, wetlands, marshes, and similar wading habitats across its range. In the vicinity of the Project area, they are known to congregate at Lake Moondarra and around Mt Isa City (ALA, 2023). Impact assessment relies on an understanding of flight height which varies depending on the phase of flight however, no information regarding flight heights was found for this species

The curlew sandpiper has undergone a significant reduction in population recently, leading to it being listed as critically endangered. A population decline of over 80% across Australia in the last three decades (Department of the Environment, 2015). The driving factors for these extensive declines are not entirely known, though habitat degradation both in Australia and elsewhere in the species migration route is considered to be the most significant threat to this species. In particular, large-scale loss of mudflats and other habitats in the Yellow Sea of eastern Asia is of concern with regards to the curlew sandpiper (Department of the Environment, 2015). Habitat degradation significant to the curlew sandpiper may be caused by human development, water course modification, pollution, and invasion of habitats by introduced weeds.

Table 18: SRI assessment for the Curlew Sandpiper (*Calidris ferruginea*)

Is there a chance or possibility that an action will?	Response
Substantially modify (including by fragmenting, altering fire regimes, altering nutrient cycles, or altering hydrological cycles), destroy, or isolate an area of important habitat for a migratory species; or	**Unlikely:** Project works in the site are unlikely to substantially modify, destroy, or isolate an area of important habitat for this species. There is no suitable habitat for this species within the site and it is likely the species is only transient through this area. Due to the lack of suitable habitat, it is unlikely project works in the site will substantially modify, destroy, or isolate an area of important habitat for this species.
Result in an invasive species that is harmful to the migratory species becoming established in an area of important habitat for the migratory species; or	**Unlikely:** Project works in the site are unlikely to introduce and/or allow a harmful invasive species to become established in the habitat of the species. Feral cats and European Red Foxes are recognised threats to several similar species and have been detected on site. Several species of invasive flora have been detected on site and have the potential to modify the species' habitat. The project will operate under the *Biosecurity Act* (2014) and follow the General Biosecurity Obligation (GBO) to identify and manage any potential invasive species. There is not likely to be an introduction and establishment of a harmful invasive species in the habitat of the species.
Seriously disrupt the lifecycle (breeding, feeding, migration, or resting behaviour) of an ecologically significant proportion of the population of a migratory species.	**Unlikely:** Project works in the site are unlikely to seriously disrupt the lifecycle of an ecologically significant proportion of the population of this species. No information regarding flight heights was found for this species.Whilst there are several records and mapped flightpaths within the vicinity of the project area, these do not represent an ecologically significant proportion of the population. Therefore it is unlikely project works in the site will seriously disrupt the lifecycle of an ecologically significant proportion of the population of this species.

4.3.7.Eastern Curlew (Numenius madagascariensis)

EPBC – Critically Endangered, Migratory, Marine. NCA – Endangered.

The Eastern Curlew (*Numenius madagascariensis*) is Australia's largest shorebird and long-haul flyer. It has a distinctive long down-curved bill, long neck, and long legs. The head and neck are dark brown and streaked with darker brown (Higgins & Davies, 1996). Eastern Curlews breed in Russia, Mongolia, and north-eastern China. Approximately 73% of the population (~28,000 individuals) spends the non-breeding season in Australia. Within Australia, the Eastern Curlew is distributed along the coasts, primarily in the north-west, east, and south-east regions. Many birds arriving in north-eastern Australia move south along the coast whilst birds

arriving in north-west Australia will generally stay there. Population numbers become stable at the north-western and south-eastern roosting sites between December and February indicating that migration has finished (Lane, 1987). They are most commonly associated with sheltered coasts, especially estuaries, bays, harbors, inlets, and coastal lagoons, with large intertidal mudflats or sandflats, often with beds of seagrass (Marchant & Higgins, 1993). Most curlews leave Australia between late February and April (Lane, 1987). In the vicinity of the Project area, the only records are two records at Lake Moondarra (ALA, 2023). Impact assessment relies on an understanding of flight height which varies depending on the phase of flight however, no information regarding flight heights was found for this species

Threats in Australia, especially eastern and southern Australia, include ongoing human disturbance, habitat loss and degradation from pollution, changes to the water regime and invasive plants (Rogers, Piersma, & Hassell, 2006) (DEWHA, 2009) (Garnett, Szabo, & Dutson, The Action Plan for Australian Birds 2010, 2011).

Table 19: SRI assessment for the Eastern Curlew (*Numenius madagascariensis*)

Is there a chance or possibility that an action will?	Response
Substantially modify (including by fragmenting, altering fire regimes, altering nutrient cycles, or altering hydrological cycles), destroy, or isolate an area of important habitat for a migratory species; or	**Unlikely:** Project works in the site are unlikely to substantially modify, destroy, or isolate an area of important habitat for this species. There is no suitable habitat for this species within the site and it is likely the species is only transient through this area. Due to the lack of suitable habitat, it is unlikely project works in the site will substantially modify, destroy, or isolate an area of important habitat for this species.
Result in an invasive species that is harmful to the migratory species becoming established in an area of important habitat for the migratory species; or	**Unlikely:** Project works in the site are unlikely to introduce and/or allow a harmful invasive species to become established in the habitat of the species. Feral cats and European Red Foxes are recognised threats to several similar species and have been detected on site. Several species of invasive flora have been detected on site and have the potential to modify the species' habitat. The project will operate under the *Biosecurity Act* (2014) and follow the General Biosecurity Obligation (GBO) to identify and manage any potential invasive species. There is not likely to be an introduction and establishment of a harmful invasive species in the habitat of the species.
Seriously disrupt the lifecycle (breeding, feeding, migration, or resting behaviour) of an ecologically significant proportion of the population of a migratory species.	**Unlikely:** Project works in the site are unlikely to seriously disrupt the lifecycle of an ecologically significant proportion of the population of this species. No information regarding flight heights was found for this species.Whilst there are several records and mapped flightpaths within the vicinity of the project area, these do not represent an ecologically significant proportion of the population. Therefore it is unlikely project works in the site will seriously disrupt the lifecycle of an ecologically significant proportion of the population of this species.

4.3.8.Glossy Ibis (Plegadis falcinellus)

EPBC – Marine, Migratory. NCA – Special least concern.

The Glossy Ibis (*Plegadis falcinellus*) is the smallest ibis in Australia. They are found singularly, in pairs or in small flocks. Occasionally large flocks can occur. They are often found in the company of other ibis such as

straw-necked ibis (*Threskiornis spinicollis*) or Australian White Ibis (*Threskiornis molucca*). Generally, glossy ibis are known to occur east of the Kimberley in WA and Eyre Peninsular in SA. Preferred habitat includes freshwater marshes at the edges of lakes, rivers, lagoons, flood-plains, wet meadows, swamps, and sewage ponds. The species has also been recorded in permanent wetlands and coastal areas during drought (Marchant & Higgins, Handbook of Australian, New Zealand and Antarctic Birds. Volume One - Ratites to Ducks, 1990). In the vicinity of the Project area, they are known to congregate at Lake Moondarra and in smaller numbers at the East Leichardt Dam, Corella Dam, and Chinaman Dam; they are abundant around Mt Isa City, and Cloncurry (ALA, 2023). Impact assessment relies on an understanding of flight height which varies depending on the phase of flight however, no information regarding flight heights was found for this species.

Threats to this species include wetland degradation and destruction for example water diversion and drainage, irrigation, and hydroelectric power production (Snow & Perrins, 1998). Clearing, grazing and invasion of exotic plants and fish species also pose a threat to the species through habitat modification.

Table 20: SRI assessment for the Glossy Ibis (*Plegadis falcinellus*)

Is there a chance or possibility that an action will?	Response
Substantially modify (including by fragmenting, altering fire regimes, altering nutrient cycles, or altering hydrological cycles), destroy, or isolate an area of important habitat for a migratory species; or	**Unlikely:** Project works in the site are unlikely to substantially modify, destroy, or isolate an area of important habitat for this species. Despite the presence of records of this species in the site, there is no suitable habitat for this species within the site and it is likely the species is only transient through this area. Due to the lack of suitable habitat, it is unlikely project works in the site will substantially modify, destroy, or isolate an area of important habitat for this species.
Result in an invasive species that is harmful to the migratory species becoming established in an area of important habitat for the migratory species; or	**Unlikely:** Project works in the site are unlikely to introduce and/or allow a harmful invasive species to become established in the habitat of the species. Feral cats and European Red Foxes are recognised threats to several similar species and have been detected on site. Several species of invasive flora have been detected on site and have the potential to modify the species' habitat. The project will operate under the *Biosecurity Act* (2014) and follow the General Biosecurity Obligation (GBO) to identify and manage any potential invasive species. There is not likely to be an introduction and establishment of a harmful invasive species in the habitat of the species.
Seriously disrupt the lifecycle (breeding, feeding, migration, or resting behaviour) of an ecologically significant proportion of the population of a migratory species.	**Unlikely:** Project works in the site are unlikely to seriously disrupt the lifecycle of an ecologically significant proportion of the population of this species. No information regarding flight heights was found for this species. Whilst there are several records in and around the site, these do not represent an ecologically significant proportion of the population. Therefore it is unlikely project works in the site will seriously disrupt the lifecycle of an ecologically significant proportion of the population of this species.

4.3.9. Great Knot (Calidris tenuirostris)

EPBC – Critically Endangered, Migratory, Marine. NCA – Critically Endangered.

The Great Knot (*Calidris tenuirostris*) is the largest of its genus. It has a black, very slightly down-curved bill with a green tinge on the tip, brown eyes, and dark greenish-grey legs and feet (Higgins & Davies, 1996). The Great Knot breeds in north-east Siberia. During the non-breeding season, most of the Great Knot population migrates to Australia to avoid the northern hemisphere winter. Large numbers arrive to the north-west of Australia between late August and September, most birds remain at or close to their arrival destinations throughout the non-breeding season (Lane, 1987). The Great Knot has been recorded around the entirety of the Australian coast, with a few scattered records inland (Garnett, Szabo, & Dutson, The Action Plan for Australian Birds 2010, 2011). In Australia, the species is associated with sheltered coastal habitats with large intertidal mudflats, including inlets, bays, harbors, estuaries, and lagoons. They rarely occur on inland lakes (Higgins & Davies, 1996). There is a single record in the vicinity of the Project area, at Lake Moondarra (ALA, 2023). Impact assessment relies on an understanding of flight height which varies depending on the phase of flight however, no information regarding flight heights was found for this species.

The greatest threat facing waders, including the Great Knot, is habitat loss. Staging areas such as mudflats are being reclaimed for future development. Indirectly habitat is being degraded by oil exploration, water regulation and diversion infrastructure and rises in sea level as a result of climate change (Barter M. , 2002).

Table 21: SRI assessment for the Great Knot (*Calidris tenuirostris*)

Is there a chance or possibility that an action will?	Response
Lead to a long-term decrease in the size of a population; or	**Unlikely:** Project works in the site are unlikely to lead to a long-term decrease in the size of an important population of the species. There is a single record ~60km southeast of the project area. There were no individuals observed during the last 10 years of surveys. No information regarding flight heights was found for this species. There is not likely to be an impact on the population by works in the site.
Reduce the area of occupancy of the species; or	**Unlikely:** Project works in the site are unlikely to reduce the area of occupancy of an important population. There is a single record ~60km southeast of the project area. There were no individuals observed during the last 10 years of surveys. There is not likely to be an impact on the population by works in the site.
Fragment an existing population into two or more populations; or	**Unlikely:** Project works in the site are unlikely to fragment an existing important population. There is a single record ~60km southeast of the project area. There were no individuals observed during the last 10 years of surveys. Due to the small size of the site and connectivity of the surrounding habitat, works within the site are unlikely to fragment any existing populations.
Adversely affect habitat critical to the survival of the species; or	**Unlikely:** Project works in the site are unlikely to adversely affect habitat critical to the survival of the species. There are identified areas of important habitat in Queensland at South-east Gulf of Carpentaria, Shoal Bay, Shoalwater Bay and Broad Sound, and Mackay town beach. There is a single record ~60km southeast of the project area. There were no individuals observed during the last 10 years of surveys. This species is heavily associated with water. Waterholes on site are ephemeral and are fed by streams flowing from the ridgeline. All of the waterholes are small and surrounded by rocks, unsuitable habitat for the species. Due to the small size of the site and connectivity of the surrounding habitat, works within the site are unlikely to impact habitat critical to the survival of the species.

Disrupt the breeding cycle of a population; or	**Unlikely:** Project works in the site are unlikely to disrupt the breeding cycle of an important population of the species. There is a single record ~60km southeast of the project area. There were no individuals observed during the last 10 years of surveys. There are no known important populations in the vicinity of the site. Due to the small size of the site and connectivity of the surrounding habitat, works within the site are unlikely to impact the breeding cycle of the species.
Modify, destroy remove, isolate, or decrease the availability or quality of habitat to the extent that the species is likely to decline; or	**Unlikely:** Project works in the site are unlikely to impact habitat to the extent that the species is likely to decline. There are identified areas of important habitat in Queensland at South-east Gulf of Carpentaria, Shoal Bay, Shoalwater Bay and Broad Sound, and Mackay town beach. There is a single record ~60km southeast of the project area. There were no individuals observed during the last 10 years of surveys. This species is heavily associated with water. Waterholes on site are ephemeral and are fed by streams flowing from the ridgeline. All of the waterholes are small and surrounded by rocks, unsuitable habitat for the species. Due to the absence of suitable habitat, the small size of the site, and connectivity of the surrounding habitat, works within the site are unlikely to modify habitat to the extent that the species is likely to decline.
Result in invasive species that are harmful to a critically endangered or endangered species becoming established in the endangered or critically endangered species' habitat; or	**Unlikely:** Project works in the site are unlikely to introduce and/or allow a harmful invasive species to become established in the habitat of the species. Feral cats and European Red Foxes are recognised threats to several similar species and have been detected on site. Several species of invasive flora have been detected on site and have the potential to modify the species' habitat. The project will operate under the *Biosecurity Act* (2014) and follow the General Biosecurity Obligation (GBO) to identify and manage any potential invasive species. There is not likely to be an introduction and establishment of a harmful invasive species in the habitat of the species.
Introduce disease that may cause the species to decline; or	**Unlikely:** Project works are unlikely to introduce novel diseases to the site. There are currently no known diseases that may cause the species to decline. The project will operate under the *Biosecurity Act* (2014) and follow the General Biosecurity Obligation (GBO) to identify and manage detrimental diseases or pathogens if present. There is not likely to be an introduction of a harmful disease to a population of the species.
Interfere with the recovery of the species.	**Unlikely:** Project works in the site are unlikely to interfere substantially with the recovery of the species. There is a single record ~60km southeast of the project area. There were no individuals observed during the last 10 years of surveys. No information regarding flight heights was found for this species. Due to the small size of the site and connectivity of the surrounding habitat, works within the site are unlikely to interfere with the recovery of the species.

4.3.10. Greater Sand Plover (Charadrius leschenaultii)

EPBC – Vulnerable, Migratory, Marine. NCA – Least concern

The Greater Sand Plover (*Charadrius leschenaultii*) is a medium-sized brown and white plover. Greater Sand Plovers breed in central Asia and spend the non-breeding season in coastal Australia as well as on some islands in the south-western Pacific Ocean. In Australia, the Greater Sand Plover occurs in coastal areas in all

states, though the greatest numbers occur in the north and especially the north-west (Marchant & Higgins, 1993). They arrive in northern Australia in late July. In Australia, they mainly occur on sheltered sandy, shelly, or muddy beaches with large intertidal mudflats or sandbanks, as well as sandy estuarine lagoons. From October to December, some birds will disperse from the north to sites around the coast of Australia. The scarcity of inland records within Australia suggests that movements to southern and eastern areas occur around the coastline rather than across the continent (Bamford, 1988) (Blakers, Davies, & Reilly, 1984) (Lane, 1987) (Sibson, 1948) (Stewart, Rogers, & Rogers, 2007). There is a single record in the vicinity of the Project area, at Lake Moondarra (ALA, 2023). In March they begin to congregate in northern Australia before departing for Asia by late April (Barter M. , 2002) (Lane, 1987) (Marchant & Higgins, 1993). Impact assessment relies on an understanding of flight height which varies depending on the phase of flight however, no information regarding flight heights was found for this species.

In Australia there are several threats common to most migratory shorebirds, including this species, such as Habitat loss due to land clearing, inundation, infilling or draining; disturbance from residential and recreational activities including boating, noise, and night lighting; and direct mortality as a result of human activities around migration pathways and at foraging and roosting sites (DEWHA, 2009).

Table 22: SRI assessment for the Greater Sand Plover (*Charadrius leschenaultii*)

Is there a chance or possibility that an action will?	Response
Lead to a long-term decrease in the size of an important population of the species; or	**Unlikely:** Project works in the site are unlikely to lead to a long-term decrease in the size of an important population of the species. There is a single record ~60km southeast of the project area. There were no individuals observed during the last 10 years of surveys. No information regarding flight heights was found for this species. There is not likely to be an impact on the population by works in the site.
Reduce the area of occupancy of an important population; or	**Unlikely:** Project works in the site are unlikely to reduce the area of occupancy of an important population. There is a single record ~60km southeast of the project area. There were no individuals observed during the last 10 years of surveys. There is not likely to be an impact on the population by works in the site.
Fragment an existing important population into two or more populations; or	**Unlikely:** Project works in the site are unlikely to fragment an existing important population. There is a single record ~60km southeast of the project area. There were no individuals observed during the last 10 years of surveys. Due to the small size of the site and connectivity of the surrounding habitat, works within the site are unlikely to fragment any existing populations.
Adversely affect habitat critical to the survival of the species; or	**Unlikely:** Project works in the site are unlikely to adversely affect habitat critical to the survival of the species. There are identified areas of important habitat in Moreton Bay, Bowling Green Bay, Shoalwater Bay, Great Sandy Strait, and Currawinya National Park. There is a single record ~60km southeast of the project area. There were no individuals observed during the last 10 years of surveys. This species is heavily associated with water. Waterholes on site are ephemeral and are fed by streams flowing from the ridgeline. All of the waterholes are small and surrounded by rocks, unsuitable habitat for the species. Due to the small size of the site and connectivity of the surrounding habitat, works within the site are unlikely to impact habitat critical to the survival of the species.

Is there a chance or possibility that an action will?	Response
Disrupt the breeding cycle of an important population; or	**Unlikely:** Project works in the site are unlikely to disrupt the breeding cycle of an important population of the species. There is a single record ~60km southeast of the project area. There were no individuals observed during the last 10 years of surveys. There are no known important populations in the vicinity of the site. Due to the small size of the site and connectivity of the surrounding habitat, works within the site are unlikely to impact the breeding cycle of the species.
Modify, destroy, remove, or isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline; or	**Unlikely:** Project works in the site are unlikely to impact habitat to the extent that the species is likely to decline. There are identified areas of important habitat in Moreton Bay, Bowling Green Bay, Shoalwater Bay, Great Sandy Strait, and Currawinya National Park. There is a single record ~60km southeast of the project area. There were no individuals observed during the last 10 years of surveys. This species is heavily associated with water. Waterholes on site are ephemeral and are fed by streams flowing from the ridgeline. All of the waterholes are small and surrounded by rocks, unsuitable habitat for the species. Due to the absence of suitable habitat, the small size of the site, and connectivity of the surrounding habitat, works within the site are unlikely to modify habitat to the extent that the species is likely to decline.
Result in invasive species that are harmful to a vulnerable species becoming established in the vulnerable species' habitat; or	**Unlikely:** Project works in the site are unlikely to introduce and/or allow a harmful invasive species to become established in the habitat of the species. Feral cats and European Red Foxes are recognised threats to several similar species and have been detected on site. Several species of invasive flora have been detected on site and have the potential to modify the species' habitat. The project will operate under the *Biosecurity Act* (2014) and follow the General Biosecurity Obligation (GBO) to identify and manage any potential invasive species. There is not likely to be an introduction and establishment of a harmful invasive species in the habitat of the species.
Introduce disease that may cause the species to decline; or	**Unlikely:** Project works are unlikely to introduce novel diseases to the site. There are currently no known diseases that may cause the species to decline. The project will operate under the *Biosecurity Act* (2014) and follow the General Biosecurity Obligation (GBO) to identify and manage detrimental diseases or pathogens if present. There is not likely to be an introduction of a harmful disease to a population of the species.
Interfere substantially with the recovery of the species.	**Unlikely:** Project works in the site are unlikely to interfere substantially with the recovery of the species. There is a single record ~60km southeast of the project area. There were no individuals observed during the last 10 years of surveys. No information regarding flight heights was found for this species. Due to the small size of the site and connectivity of the surrounding habitat, works within the site are unlikely to interfere with the recovery of the species.

4.3.11. Grey Plover (Pluvialis squatarola)

EPBC – Migratory, Marine. NCA – Special least concern.

The Grey Plover (*Pluvialis squatarola*) is a medium-sized plover with long legs and a short, stout bill. Grey Plovers breed in the far northern hemisphere and spend the non-breeding season on the coasts of America, southern Europe, Africa, southern Asia, and Australia (Cramp & Simmons, 1983) (de Schauensee, 1970) (de

Schauensee, The Birds of China, 1984) (Grimmett, Inskipp, & Inskipp, 1999b) (Orn. Soc. Japan, 2000) (Urban, Fry, & Keith, 1986) (Wiersma, 1996). Birds arrive in northern Australia in August and September, many then move further south in October (Lane, 1987) (Marchant & Higgins, 1993). Some of these southerly movements are overland. In Australia, Grey Plovers occur almost entirely in coastal areas, inhabiting sheltered embayments, estuaries and lagoons with mudflats and sandflats, and occasionally on rocky coasts with wave-cut platforms or reef-flats, or on reefs within muddy lagoons (Marchant & Higgins, 1993). Birds begin to move northward in March (Amiet 1957; Lane 1987). There is a single record in the vicinity of the Project area, at Lake Moondarra (ALA, 2023). Impact assessment relies on an understanding of flight height which varies depending on the phase of flight however, no information regarding flight heights was found for this species.

The greatest threat facing waders, including the Grey Plover, is habitat loss. Staging areas such as mudflats are being reclaimed for future development. Indirectly habitat is being degraded by oil exploration, water regulation and diversion infrastructure and rises in sea level as a result of climate change (Barter M. , 2002). Additionally, disturbance of birds at roosting and feeding sites as a result of human recreation is also a significant threat.

Table 23: SRI assessment for the Grey Plover (*Pluvialis squatarola*)

Is there a chance or possibility that an action will?	Response
Substantially modify (including by fragmenting, altering fire regimes, altering nutrient cycles, or altering hydrological cycles), destroy, or isolate an area of important habitat for a migratory species; or	**Unlikely:** Project works in the site are unlikely to substantially modify, destroy, or isolate an area of important habitat for this species. There is no suitable habitat for this species within the site and it is likely the species is only transient through this area. Due to the lack of suitable habitat, it is unlikely project works in the site will substantially modify, destroy, or isolate an area of important habitat for this species.
Result in an invasive species that is harmful to the migratory species becoming established in an area of important habitat for the migratory species; or	**Unlikely:** Project works in the site are unlikely to introduce and/or allow a harmful invasive species to become established in the habitat of the species. Feral cats and European Red Foxes are recognised threats to several similar species and have been detected on site. Several species of invasive flora have been detected on site and have the potential to modify the species' habitat. The project will operate under the *Biosecurity Act* (2014) and follow the General Biosecurity Obligation (GBO) to identify and manage any potential invasive species. There is not likely to be an introduction and establishment of a harmful invasive species in the habitat of the species.
Seriously disrupt the lifecycle (breeding, feeding, migration, or resting behaviour) of an ecologically significant proportion of the population of a migratory species.	**Unlikely:** Project works in the site are unlikely to seriously disrupt the lifecycle of an ecologically significant proportion of the population of this species. No information regarding flight heights was found for this species. Whilst there are several records and mapped flightpaths within the vicinity of the project area, these do not represent an ecologically significant proportion of the population. Therefore it is unlikely project works in the site will seriously disrupt the lifecycle of an ecologically significant proportion of the population of this species.

4.3.12. Grey-tailed Tattler (*Tringa brevipes*)

EPBC – Migratory, Marine. NCA – Special least concern.

The Grey-tailed Tattler (*Tringa brevipes*) is a medium-sized wader with comparatively long wings and tail. They have a medium length straight bill, short yellow legs, and are plain grey above with a white supercilium and a dark loral stripe (Higgins & Davies, 1996). The Grey-tailed Tattler breeds in the northern hemisphere, specifically north Siberia, and migrates south to Australia for the boreal winter. Grey-tailed Tattlers arrive in Australia mostly in August. In Australia, the species is found in most coastal regions, primarily along the northern coast. They prefer sheltered coasts with reefs and rock platforms or with intertidal mudflats, intertidal rocky, coral, or stony reefs as well as platforms and islets that are exposed at low tide. There are rare inland records, including Burdekin Weir, Charters Towers and Mount Isa. There are no records in the vicinity of the Project area (ALA, 2023). Grey-tailed Tattlers begin to leave Australia to return to northern breeding grounds in April (Higgins & Davies, 1996). Impact assessment relies on an understanding of flight height which varies depending on the phase of flight however, no information regarding flight heights was found for this species.

The greatest threat facing migratory shorebirds, including the Grey-tailed Tattler, is habitat loss. Staging areas such as mudflats are being reclaimed for future development. Indirectly habitat is being degraded by oil exploration, water regulation and diversion infrastructure and rises in sea level as a result of climate change (Barter M. , 2002). Other significant threats include disturbance from residential and recreational activities including boating, noise, and night lighting; and direct mortality as a result of human activities around migration pathways and at foraging and roosting sites, such as the construction of wind farms in migration or movement pathways (DEWHA, 2009).

Table 24: SRI assessment for the Grey-tailed Tattler (*Tringa brevipes*)

Is there a chance or possibility that an action will?	Response
Substantially modify (including by fragmenting, altering fire regimes, altering nutrient cycles, or altering hydrological cycles), destroy, or isolate an area of important habitat for a migratory species; or	**Unlikely:** Project works in the site are unlikely to substantially modify, destroy, or isolate an area of important habitat for this species. There is no suitable habitat for this species within the site and it is likely the species is only transient through this area. Due to the lack of suitable habitat, it is unlikely project works in the site will substantially modify, destroy, or isolate an area of important habitat for this species.
Result in an invasive species that is harmful to the migratory species becoming established in an area of important habitat for the migratory species; or	**Unlikely:** Project works in the site are unlikely to introduce and/or allow a harmful invasive species to become established in the habitat of the species. Feral cats and European Red Foxes are recognised threats to several similar species and have been detected on site. Several species of invasive flora have been detected on site and have the potential to modify the species' habitat. The project will operate under the *Biosecurity Act* (2014) and follow the General Biosecurity Obligation (GBO) to identify and manage any potential invasive species. There is not likely to be an introduction and establishment of a harmful invasive species in the habitat of the species.
Seriously disrupt the lifecycle (breeding, feeding, migration, or resting behaviour) of an ecologically significant proportion of the population of a migratory species.	**Unlikely:** Project works in the site are unlikely to seriously disrupt the lifecycle of an ecologically significant proportion of the population of this species. No information regarding flight heights was found for this species. Whilst there are mapped flightpaths within the vicinity of the project area, these do not represent an ecologically significant proportion of the population. Therefore it is unlikely project works in the site will seriously disrupt the lifecycle of an ecologically significant proportion of the population of this species.

4.3.13. Latham's snipe (Gallinago hardwickii)

EPBC – Migratory, Marine. NCA – Special least concern

Latham's snipe *(Gallinago hardwickii)* is only a medium sized wading bird, though it is the largest wader in Australia. Latham's snipes are typically found singularly or in small, loose groups of less than a dozen birds (Higgins & Davies, 1996). They are a non-breeding visitor to Australia. They arrive from overseas breeding sites to northern Australia and move slowly down to south-eastern Australia, over coastal and near coastal areas, where they spend the non-breeding season. They typically inhabit soft wet ground, or shallow waters with green or dead growth, sometimes tussocks, including wet parts of paddocks, dam seepage, irrigation, mangrove fringes, saltmarshes (Pizzey & Knight, The Field Guide to the Birds of Australia, 2012). In the vicinity of the Project area, they are known to occur at Lake Moondarra and there are scattered records in and around Mt Isa City (~70 km from site) and at Chinaman Dam in Cloncurry (~62 km from site) (ALA, 2023). Impact assessment relies on an understanding of flight height which varies depending on the phase of flight however, no information regarding flight heights was found for this species.

Threats include habitat loss caused by the drainage and modification of wetlands (Naarding, 1984).

Table 25: SRI assessment for the Latham's Snipe (*Gallinago hardwickii*)

Is there a chance or possibility that an action will?	Response
Substantially modify (including by fragmenting, altering fire regimes, altering nutrient cycles, or altering hydrological cycles), destroy, or isolate an area of important habitat for a migratory species; or	**Unlikely:** Project works in the site are unlikely to substantially modify, destroy, or isolate an area of important habitat for this species. There is no suitable habitat for this species within the site and it is likely the species is only transient through this area. Due to the lack of suitable habitat, it is unlikely project works in the site will substantially modify, destroy, or isolate an area of important habitat for this species.
Result in an invasive species that is harmful to the migratory species becoming established in an area of important habitat for the migratory species; or	**Unlikely:** Project works in the site are unlikely to introduce and/or allow a harmful invasive species to become established in the habitat of the species. Feral cats and European Red Foxes are recognised threats to several similar species and have been detected on site. Several species of invasive flora have been detected on site and have the potential to modify the species' habitat. The project will operate under the *Biosecurity Act* (2014) and follow the General Biosecurity Obligation (GBO) to identify and manage any potential invasive species. There is not likely to be an introduction and establishment of a harmful invasive species in the habitat of the species.
Seriously disrupt the lifecycle (breeding, feeding, migration, or resting behaviour) of an ecologically significant proportion of the population of a migratory species.	**Unlikely:** Project works in the site are unlikely to seriously disrupt the lifecycle of an ecologically significant proportion of the population of this species. No information regarding flight heights was found for this species. Whilst there are several records within the vicinity of the project area, these do not represent an ecologically significant proportion of the population. Therefore it is unlikely project works in the site will seriously disrupt the lifecycle of an ecologically significant proportion of the population of this species.

4.3.14. Lesser Sand Plover (*Charadrius mongolus*)

EPBC – Endangered, Migratory, Marine. NCA – Endangered.

The Lesser Sand Plover (*Charadrius mongolus*) is a small to medium-sized grey-brown and white plover with a dark eye stripe. Two Lesser Sand Plover subspecies migrate to Australia for the boreal winter; *Charadrius mongolus mongolus,* which breeds in Siberia and Mongolia, and *Charadrius mongolus stegmanni,* which breeds in Russia (Marchant & Higgins, 1993). Birds arrive in Australia between August and October and move along the northern and eastern coasts until November (Alcorn, Alcorn, & Fleming, 1994) (Marchant & Higgins, 1993) (Starks & Lane, 1987). In Australia, this species is present in coastal regions in all states but are most common in northern and eastern Australia. They are associated with large intertidal sandflats or mudflats in sheltered bays, harbors and estuaries, and occasionally sandy ocean beaches, coral reefs, wave-cut rock platforms and rocky outcrops. They are rarely recorded inland; however, they have been recorded at margins of lakes and soaks and swamps associated with artesian bores (Marchant & Higgins, 1993). Within the vicinity of the Project area, there are three records around Mt Isa City (ALA, 2023). Most birds depart Australia for their northern breeding grounds by April and June (White & Bruce, 1986). Impact assessment relies on an understanding of flight height which varies depending on the phase of flight however, no information regarding flight heights was found for this species.

The greatest threat facing migratory shorebirds, including the Grey-tailed Tattler, is habitat loss. Staging areas such as mudflats are being reclaimed for future development. Indirectly habitat is being degraded by oil exploration, water regulation and diversion infrastructure and rises in sea level as a result of climate change (Barter M. , 2002). Other significant threats include disturbance from residential and recreational activities including boating, noise, and night lighting, which can drain the birds' energy reserve required for successful migration north; and direct mortality as a result of human activities around migration pathways and at foraging and roosting sites (DEWHA, 2009).

Table 26: SRI assessment for the Lesser Sand Plover (*Charadrius mongolus*)

Is there a chance or possibility that an action will?	Response
Lead to a long-term decrease in the size of a population; or	**Unlikely:** Project works in the site are unlikely to lead to a long-term decrease in the size of an important population of the species. There are records ~90km southeast of the project area. There were no individuals observed during the last 10 years of surveys. No information regarding flight heights was found for this species. There is not likely to be an impact on the population by works in the site.
Reduce the area of occupancy of the species; or	**Unlikely:** Project works in the site are unlikely to reduce the area of occupancy of an important population. There are records ~90km southeast of the project area. There were no individuals observed during the last 10 years of surveys. There is not likely to be an impact on the population by works in the site.
Fragment an existing population into two or more populations; or	**Unlikely:** Project works in the site are unlikely to fragment an existing important population. There are records ~90km southeast of the project area. There were no individuals observed during the last 10 years of surveys. Due to the small size of the site and connectivity of the surrounding habitat, works within the site are unlikely to fragment any existing populations.

Adversely affect habitat critical to the survival of the species; or	**Unlikely:** Project works in the site are unlikely to adversely affect habitat critical to the survival of the species. There are identified areas of important habitat in Moreton Bay, Bowling Green Bay, Shoalwater Bay, Great Sandy Strait, and Currawinya National Park. There are records ~90km southeast of the project area. There were no individuals observed during the last 10 years of surveys. This species is heavily associated with water. Waterholes on site are ephemeral and are fed by streams flowing from the ridgeline. All of the waterholes are small and surrounded by rocks, unsuitable habitat for the species. Due to the small size of the site and connectivity of the surrounding habitat, works within the site are unlikely to impact habitat critical to the survival of the species.
Disrupt the breeding cycle of a population; or	**Unlikely:** Project works in the site are unlikely to disrupt the breeding cycle of an important population of the species. There is a single record ~90km southeast of the project area. There were no individuals observed during the last 10 years of surveys. There are no known important populations in the vicinity of the site. Due to the small size of the site and connectivity of the surrounding habitat, works within the site are unlikely to impact the breeding cycle of the species.
Modify, destroy remove, isolate, or decrease the availability or quality of habitat to the extent that the species is likely to decline; or	**Unlikely:** Project works in the site are unlikely to impact habitat to the extent that the species is likely to decline. There are identified areas of important habitat in Moreton Bay, Bowling Green Bay, Shoalwater Bay, Great Sandy Strait, and Currawinya National Park. There are records ~90km southeast of the project area. There were no individuals observed during the last 10 years of surveys. This species is heavily associated with water. Waterholes on site are ephemeral and are fed by streams flowing from the ridgeline. All of the waterholes are small and surrounded by rocks, unsuitable habitat for the species. Due to the absence of suitable habitat, the small size of the site, and connectivity of the surrounding habitat, works within the site are unlikely to modify habitat to the extent that the species is likely to decline.
Result in invasive species that are harmful to a critically endangered or endangered species becoming established in the endangered or critically endangered species' habitat; or	**Unlikely:** Project works in the site are unlikely to introduce and/or allow a harmful invasive species to become established in the habitat of the species. Feral cats and European Red Foxes are recognised threats to several similar species and have been detected on site. Several species of invasive flora have been detected on site and have the potential to modify the species' habitat. The project will operate under the *Biosecurity Act* (2014) and follow the General Biosecurity Obligation (GBO) to identify and manage any potential invasive species. There is not likely to be an introduction and establishment of a harmful invasive species in the habitat of the species.
Introduce disease that may cause the species to decline; or	**Unlikely:** Project works are unlikely to introduce novel diseases to the site. There are currently no known diseases that may cause the species to decline. The project will operate under the *Biosecurity Act* (2014) and follow the General Biosecurity Obligation (GBO) to identify and manage detrimental diseases or pathogens if present. There is not likely to be an introduction of a harmful disease to a population of the species.
Interfere with the recovery of the species.	**Unlikely:** Project works in the site are unlikely to interfere substantially with the recovery of the species. There are records ~90km southeast of the project area. There were no individuals observed during the last 10 years of surveys. No information regarding flight heights was found for this species.

	Due to the small size of the site and connectivity of the surrounding habitat, works within the site are unlikely to interfere with the recovery of the species.

4.3.15. Little Tern (Sterna albifrons)

EPBC – Migratory, Marine. NCA – Special least concern.

The Little Tern (*Sterna albifrons*) is a small, slender tern with narrow wings and a long, deeply forked tail. In Australia there are three distinct populations of Little Tern: two breeding populations in northern and eastern Australia and one non-breeding population that migrates from breeding grounds in Asia to avoid the winter. In Australia, Little Terns are associated with sheltered coastal environments, including lagoons, estuaries, river mouths, deltas, lakes, bays, harbors, and inlets, especially those with exposed sandbanks or sand-spits (Higgins & Davies, 1996). There are no records of this species in the vicinity of the Project area (ALA, 2023). Impact assessment relies on an understanding of flight height which varies depending on the phase of flight however, no information regarding flight heights was found for this species.

Due to the ground-nesting habit of this species, they are naturally susceptible to breeding failure as a result of predation, flooding of nesting sites and adverse weather conditions. This impact is exacerbated by the presence of introduce predators such as feral dogs, cats, and rats; as well as human disturbance flushing adults from nests and giving predators uncontended access to the eggs and chicks (Chatto, 2001) (Garnett & Crowley, 2000) (Higgins & Davies, 1996) (Hill, Bamford, Rounsevell, & Vincent, 1988) (Larkins, 1984) (Morris, 1979) (Reside, Willoughby, & Whilliance, 1989) (Smith P. , 1990b). Terns are also threatened by loss or degradation of estuarine habitats due to development or impacts on food supplies due to pollutants such as pesticide residues or oil, and over-fishing (Higgins & Davies, 1996) (Smith P. , 1990b).

Table 27: SRI assessment for the Little Tern (*Sterna albifrons*)

Is there a chance or possibility that an action will?	Response
Substantially modify (including by fragmenting, altering fire regimes, altering nutrient cycles, or altering hydrological cycles), destroy, or isolate an area of important habitat for a migratory species; or	**Unlikely:** Project works in the site are unlikely to substantially modify, destroy, or isolate an area of important habitat for this species. There is no suitable habitat for this species within the site and it is likely the species is only transient through this area. Due to the lack of suitable habitat, it is unlikely project works in the site will substantially modify, destroy, or isolate an area of important habitat for this species.
Result in an invasive species that is harmful to the migratory species becoming established in an area of important habitat for the migratory species; or	**Unlikely:** Project works in the site are unlikely to introduce and/or allow a harmful invasive species to become established in the habitat of the species. Feral cats and European Red Foxes are recognised threats to several similar species and have been detected on site. Several species of invasive flora have been detected on site and have the potential to modify the species' habitat. The project will operate under the *Biosecurity Act* (2014) and follow the General Biosecurity Obligation (GBO) to identify and manage any potential invasive species. There is not likely to be an introduction and establishment of a harmful invasive species in the habitat of the species.
Seriously disrupt the lifecycle (breeding, feeding, migration,	**Unlikely:** Project works in the site are unlikely to seriously disrupt the lifecycle of an ecologically significant proportion of the population of this species. No information regarding flight heights was found for this species.

or resting behaviour) of an ecologically significant proportion of the population of a migratory species.	Whilst there are mapped flightpaths within the vicinity of the project area, these do not represent an ecologically significant proportion of the population. Therefore it is unlikely project works in the site will seriously disrupt the lifecycle of an ecologically significant proportion of the population of this species.

4.3.16. Marsh Sandpiper (*Tringa stagnatilis*)

EPBC – Migratory, Marine. NCA – Special least concern

The Marsh Sandpiper (*Tringa stagnatilis*) is a medium sized sandpiper, often found singly or in small to large flocks. Often, they're seen with other waders such as greenshanks. Marsh sandpipers are found on coastal and inland wetlands throughout Australia. Habitat includes ephemeral wetlands including swamps, saltpans, saltmarshes, estuaries, pools on inundated floodplains, intertidal mudflats, and sewage farms. They are recorded less often at reservoirs, waterholes, bore-drain swamps and flooded inland lakes (Higgins & Davies, 1996). They are a non-breeding migrant to Australia. They arrive on the north coast of Australia in September before moving south across the continent from September-December. They leave Australia to return north in March-April (Lane, 1987). In the vicinity of the Project area, they are known to congregate at Lake Moondarra and there are abundant records in and around Mt Isa City, as well as at Corella Dam and Chinaman Dam (ALA, 2023). Impact assessment relies on an understanding of flight height which varies depending on the phase of flight however, no information regarding flight heights was found for this species.

Threats include habitat loss and degradation, disturbance by recreational activities and direct mortality.

Table 28: SRI assessment for the Marsh Sandpiper (*Tringa stagnatilis*)

Is there a chance or possibility that an action will?	Response
Substantially modify (including by fragmenting, altering fire regimes, altering nutrient cycles, or altering hydrological cycles), destroy, or isolate an area of important habitat for a migratory species; or	**Unlikely:** Project works in the site are unlikely to substantially modify, destroy, or isolate an area of important habitat for this species. There is no suitable habitat for this species within the site and it is likely the species is only transient through this area. Due to the lack of suitable habitat, it is unlikely project works in the site will substantially modify, destroy, or isolate an area of important habitat for this species.
Result in an invasive species that is harmful to the migratory species becoming established in an area of important habitat for the migratory species; or	**Unlikely:** Project works in the site are unlikely to introduce and/or allow a harmful invasive species to become established in the habitat of the species. Feral cats and European Red Foxes are recognised threats to several similar species and have been detected on site. Several species of invasive flora have been detected on site and have the potential to modify the species' habitat. The project will operate under the *Biosecurity Act* (2014) and follow the General Biosecurity Obligation (GBO) to identify and manage any potential invasive species. There is not likely to be an introduction and establishment of a harmful invasive species in the habitat of the species.
Seriously disrupt the lifecycle (breeding, feeding, migration, or resting behaviour) of an ecologically significant	**Unlikely:** Project works in the site are unlikely to seriously disrupt the lifecycle of an ecologically significant proportion of the population of this species. No information regarding flight heights was found for this species. Whilst there are several records and mapped flightpaths within the vicinity of the project area, these do not represent an ecologically significant proportion

proportion of the population of a migratory species.	of the population. Therefore it is unlikely project works in the site will seriously disrupt the lifecycle of an ecologically significant proportion of the population of this species.

4.3.17. Pacific Golden Plover (*Pluvialis fulva*)

EPBC – Migratory, Marine. NCA – Special least concern.

The Pacific Golden Plover (*Pluvialis fulva*) is a medium-sized, upright plover with long legs and a brown crown with golden streaks that become larger and more prominent in breeding plumage. They are often found in flocks of 20-50 birds (Marchant & Higgins, 1993). Pacific Golden Plovers breed in northern Siberia and Alaska, and spend the non-breeding season in Asia, Australia, and Polynesia (Grimmett, Inskipp, & Inskipp, 1999b) (de Schauensee, 1984). Pacific Golden Plovers generally arrive in northern Queensland in September and October (Lane, 1987) (Marchant & Higgins, 1993) and most birds move southwards along the coast, though some use inland routes (Blakers, Davies, & Reilly, 1984). In Australia, the species is common in coastal regions in all states, though there are also inland records in all states often along major river systems. They typically occur on beaches, mudflats and sandflats in sheltered areas including harbors, estuaries, and lagoons, and also in evaporation ponds in saltworks. Inland they usually occur on wetlands such as fresh, brackish, or saline lakes, billabongs, pools, swamps and wet claypans, favoring those with muddy margins and submerged vegetation or grass (Marchant & Higgins, 1993). In the vicinity of the Project area, there are several records at Lake Moondarra and in and around Mt Isa City (ALA, 2023). Birds depart Australia to return to northern breeding grounds in February and March; all birds follow the east coast with no overland passage occurring and no stopping in northern Australia (Lane, 1987). Impact assessment relies on an understanding of flight height which varies depending on the phase of flight however, no information regarding flight heights was found for this species.

In Australia there are several threats common to most migratory shorebirds, including this species, such as Habitat loss due to land clearing, inundation, infilling or draining; disturbance from residential and recreational activities including boating, noise, and night lighting; and direct mortality as a result of human activities around migration pathways and at foraging and roosting sites (DEWHA, 2009).

Table 29: SRI assessment for the Pacific Golden Plover (*Pluvialis fulva*)

Is there a chance or possibility that an action will?	Response
Substantially modify (including by fragmenting, altering fire regimes, altering nutrient cycles, or altering hydrological cycles), destroy, or isolate an area of important habitat for a migratory species; or	**Unlikely:** Project works in the site are unlikely to substantially modify, destroy, or isolate an area of important habitat for this species. There is no suitable habitat for this species within the site and it is likely the species is only transient through this area. Due to the lack of suitable habitat, it is unlikely project works in the site will substantially modify, destroy, or isolate an area of important habitat for this species.
Result in an invasive species that is harmful to the migratory species becoming established in an area of	**Unlikely:** Project works in the site are unlikely to introduce and/or allow a harmful invasive species to become established in the habitat of the species. Feral cats and European Red Foxes are recognised threats to several similar species and have been detected on site. Several species of invasive flora have been detected on site and have the potential to modify the species' habitat.

important habitat for the migratory species; or	The project will operate under the *Biosecurity Act* (2014) and follow the General Biosecurity Obligation (GBO) to identify and manage any potential invasive species. There is not likely to be an introduction and establishment of a harmful invasive species in the habitat of the species.
Seriously disrupt the lifecycle (breeding, feeding, migration, or resting behaviour) of an ecologically significant proportion of the population of a migratory species.	**Unlikely:** Project works in the site are unlikely to seriously disrupt the lifecycle of an ecologically significant proportion of the population of this species. No information regarding flight heights was found for this species. Whilst there are several records and mapped flightpaths within the vicinity of the project area, these do not represent an ecologically significant proportion of the population. Therefore it is unlikely project works in the site will seriously disrupt the lifecycle of an ecologically significant proportion of the population of this species.

4.3.18. Red Knot (Calidris canutus)

EPBC – Endangered, Migratory, Marine. NCA – Endangered.

The Red Knot (*Calidris canutus*) is a robust small to medium-sized wader with a short neck and a short straight bill, short legs, and long wings that extend beyond the tail. The species breeds in the Arctic and migrates to non-breeding areas that extend to south America, Africa, and Australasia (del Hoyo, Elliott, & Sargatal, 1996). They arrive on the north coast of Australia from late August, feed, and gain weight before moving east in November to the Gulf of Carpentaria. Some birds continue flying east and then south to south-eastern Australia or New Zealand, the majority remain in northern Australia (Barter M. , 1992). In Australia, Red Knots mainly inhabit intertidal mudflats, sandflats, and sandy beaches of sheltered coasts, in estuaries, bays, inlets, lagoons and harbors. They rarely use inland lakes or swamps (Higgins & Davies, 1996). New Zealand and south-east Australian birds depart to return north from February to April and might move through the Gulf of Carpentaria, or overland as suggested by inland records. However, there are no records in the vicinity of the Project area (ALA, 2023). Birds in the north depart in late March to April (Higgins & Davies, 1996) (Barter M. , 2002). Impact assessment relies on an understanding of flight height which varies depending on the phase of flight however, no information regarding flight heights was found for this species.

The greatest threat facing migratory shorebirds, including the Red Knot, is habitat loss. Staging areas such as mudflats are being reclaimed for future development. Indirectly habitat is being degraded by oil exploration, water regulation and diversion infrastructure and rises in sea level as a result of climate change (Barter M. , 2002). Other significant threats include disturbance from residential and recreational activities including boating, noise, and night lighting; and direct mortality as a result of human activities around migration pathways and at foraging and roosting sites, such as the construction of wind farms in migration or movement pathways (DEWHA, 2009).

Table 30: SRI assessment for the Red Knot (*Calidris canutus*)

Is there a chance or possibility that an action will?	Response
Substantially modify (including by fragmenting, altering fire regimes, altering nutrient cycles, or altering	**Unlikely:** Project works in the site are unlikely to substantially modify, destroy, or isolate an area of important habitat for this species. There is no suitable habitat for this species within the site and it is likely the species is only transient through this area.

hydrological cycles), destroy, or isolate an area of important habitat for a migratory species; or	Due to the lack of suitable habitat, it is unlikely project works in the site will substantially modify, destroy, or isolate an area of important habitat for this species.
Result in an invasive species that is harmful to the migratory species becoming established in an area of important habitat for the migratory species; or	**Unlikely:** Project works in the site are unlikely to introduce and/or allow a harmful invasive species to become established in the habitat of the species. Feral cats and European Red Foxes are recognised threats to several similar species and have been detected on site. Several species of invasive flora have been detected on site and have the potential to modify the species' habitat. The project will operate under the *Biosecurity Act* (2014) and follow the General Biosecurity Obligation (GBO) to identify and manage any potential invasive species. There is not likely to be an introduction and establishment of a harmful invasive species in the habitat of the species.
Seriously disrupt the lifecycle (breeding, feeding, migration, or resting behaviour) of an ecologically significant proportion of the population of a migratory species.	**Unlikely:** Project works in the site are unlikely to seriously disrupt the lifecycle of an ecologically significant proportion of the population of this species. No information regarding flight heights was found for this species. Whilst there are mapped flightpaths within the vicinity of the project area, these do not represent an ecologically significant proportion of the population. Therefore it is unlikely project works in the site will seriously disrupt the lifecycle of an ecologically significant proportion of the population of this species.

4.3.19. Red-necked Stint (*Calidris ruficollis*)

EPBC – Migratory, Marine. NCA – Special least concern.

The Red-necked Stint (*Calidris ruficollis*) the smallest shorebird in Australia. They are characterised by a small head, steep rounded forehead, and a long thickset body tapering down to a thin rear end, short legs, and a short bill that's straight or very slightly decurved, and slightly bulbous at the tip. Red-necked Stints breed in Siberia and Alaska and migrate to Australasia, primarily Australia, for the Boreal winter (Higgins & Davies, 1996). Birds arrive in northern Australia from August to September, with some continuing south either across the continent or along the coasts in the weeks following arrival. In Australia, Red-necked Stints are found mainly in sheltered inlets, bays, lagoons, and estuaries with intertidal mudflats, often near spits, islets and banks and, sometimes, on protected sandy or coralline shores. They also occur on ephemeral or permanent shallow wetlands near the coast or inland, including lagoons, lakes, swamps, riverbanks, waterholes, bore drains, dams, soaks, and pools in salt flats (Higgins & Davies, 1996). Within the vicinity of the Project area, there are several records at Lake Moondarra, in and around Mt Isa City, at Chinaman Dam, and in Cloncurry (ALA, 2023). Birds depart Australia to return north from February to April. Impact assessment relies on an understanding of flight height which varies depending on the phase of flight however, no information regarding flight heights was found for this species.

The greatest threat facing migratory shorebirds, including the Red-necked Stint, is habitat loss. Staging areas such as mudflats are being reclaimed for future development. Indirectly habitat is being degraded by oil exploration, water regulation and diversion infrastructure and rises in sea level as a result of climate change (Barter M. , 2002). Other significant threats include disturbance from residential and recreational activities including boating, noise, and night lighting; and direct mortality as a result of human activities around migration

pathways and at foraging and roosting sites, such as the construction of wind farms in migration or movement pathways (DEWHA, 2009).

Table 31: SRI assessment for the Red-necked Stint (*Calidris ruficollis*)

Is there a chance or possibility that an action will?	Response
Substantially modify (including by fragmenting, altering fire regimes, altering nutrient cycles, or altering hydrological cycles), destroy, or isolate an area of important habitat for a migratory species; or	**Unlikely:** Project works in the site are unlikely to substantially modify, destroy, or isolate an area of important habitat for this species. There is no suitable habitat for this species within the site and it is likely the species is only transient through this area. Due to the lack of suitable habitat, it is unlikely project works in the site will substantially modify, destroy, or isolate an area of important habitat for this species.
Result in an invasive species that is harmful to the migratory species becoming established in an area of important habitat for the migratory species; or	**Unlikely:** Project works in the site are unlikely to introduce and/or allow a harmful invasive species to become established in the habitat of the species. Feral cats and European Red Foxes are recognised threats to several similar species and have been detected on site. Several species of invasive flora have been detected on site and have the potential to modify the species' habitat. The project will operate under the *Biosecurity Act* (2014) and follow the General Biosecurity Obligation (GBO) to identify and manage any potential invasive species. There is not likely to be an introduction and establishment of a harmful invasive species in the habitat of the species.
Seriously disrupt the lifecycle (breeding, feeding, migration, or resting behaviour) of an ecologically significant proportion of the population of a migratory species.	**Unlikely:** Project works in the site are unlikely to seriously disrupt the lifecycle of an ecologically significant proportion of the population of this species. No information regarding flight heights was found for this species. Whilst there are several records and mapped flightpaths within the vicinity of the project area, these do not represent an ecologically significant proportion of the population. Therefore it is unlikely project works in the site will seriously disrupt the lifecycle of an ecologically significant proportion of the population of this species.

4.3.20. Ruddy Turnstone (*Arenaria interpres*)

EPBC – Migratory, Marine. NCA – Special least concern.

The Ruddy Turnstone (*Arenaria interpres*) is a stocky medium-sized wader with a short, wedge-shaped bill, and distinctive black or dark brown chest with pale patches extending from the back of the neck. It has a very distinctive white flight pattern with a stripe of white up the center of the back, along the base of the flight feathers and along the top of the wing. Ruddy Turnstones breed in coastal Europe, Asia, and North America. Their non-breeding distribution is almost cosmopolitan, they are common throughout Australasia and are widespread in Australia (Higgins & Davies, 1996). The majority of birds arrive in northern and western Australia in August and disperse around the country through October. In Australia, they are found in most coastal regions with exposed rock coast lines or coral reefs, with occasional records of inland populations in habitats such as riverbeds, and on inland lakes and adjacent farmland (Higgins & Davies, 1996). In the vicinity of the Project area, there are several records at Lake Moondarra (ALA, 2023). Birds depart from Australia from March to April and often don't stop in northern Australia but continue to South-East Asia (Higgins & Davies, 1996).

Impact assessment relies on an understanding of flight height which varies depending on the phase of flight however, no information regarding flight heights was found for this species.

The greatest threat facing migratory shorebirds, including the Ruddy Turnstone, is habitat loss. Staging areas such as mudflats are being reclaimed for future development. Indirectly habitat is being degraded by oil exploration, water regulation and diversion infrastructure and rises in sea level as a result of climate change (Barter M. , 2002). Other significant threats include disturbance from residential and recreational activities including boating, noise, and night lighting; and direct mortality as a result of human activities around migration pathways and at foraging and roosting sites, such as the construction of wind farms in migration or movement pathways (DEWHA, 2009).

Table 32: SRI assessment for the Ruddy Turnstone (*Arenaria interpres*)

Is there a chance or possibility that an action will?	Response
Substantially modify (including by fragmenting, altering fire regimes, altering nutrient cycles, or altering hydrological cycles), destroy, or isolate an area of important habitat for a migratory species; or	**Unlikely:** Project works in the site are unlikely to substantially modify, destroy, or isolate an area of important habitat for this species. There is no suitable habitat for this species within the site and it is likely the species is only transient through this area. Due to the lack of suitable habitat, it is unlikely project works in the site will substantially modify, destroy, or isolate an area of important habitat for this species.
Result in an invasive species that is harmful to the migratory species becoming established in an area of important habitat for the migratory species; or	**Unlikely:** Project works in the site are unlikely to introduce and/or allow a harmful invasive species to become established in the habitat of the species. Feral cats and European Red Foxes are recognised threats to several similar species and have been detected on site. Several species of invasive flora have been detected on site and have the potential to modify the species' habitat. The project will operate under the *Biosecurity Act* (2014) and follow the General Biosecurity Obligation (GBO) to identify and manage any potential invasive species. There is not likely to be an introduction and establishment of a harmful invasive species in the habitat of the species.
Seriously disrupt the lifecycle (breeding, feeding, migration, or resting behaviour) of an ecologically significant proportion of the population of a migratory species.	**Unlikely:** Project works in the site are unlikely to seriously disrupt the lifecycle of an ecologically significant proportion of the population of this species. No information regarding flight heights was found for this species. Whilst there are several records and mapped flightpaths within the vicinity of the project area, these do not represent an ecologically significant proportion of the population. Therefore it is unlikely project works in the site will seriously disrupt the lifecycle of an ecologically significant proportion of the population of this species.

4.3.21. Sanderling (*Calidris alba*)

EPBC – Migratory, Marine. NCA – Special least concern.

The Sanderling (*Calidris alba*) is a relatively pale sandpiper with a short, straight, broad-based black bill, short black legs with only three toes, and blackish-brown wings with broad white wing-stripes. They are typically found in small to large flocks, sometimes in the hundreds. They breed in the northern hemisphere, specifically

in northern North America, northern Russia, and islands in the Arctic Ocean. They migrate south to spend the non-breeding season on sandy coastal shores of all continents except Antarctica. Sanderlings arrive in north-western Australia during September and cross the continent to the south Australia coast through September and November arriving in Sydney from August. There are rare records of birds stopping inland on sandy shores of ephemeral brackish lakes or river-pools (Higgins & Davies, 1996). There are no records of the species in the vicinity of the Project area (ALA, 2023). They depart from south-east Australia from March to May and cross the continent, with some stopping on the north coast before continuing north (Higgins & Davies, 1996). Impact assessment relies on an understanding of flight height which varies depending on the phase of flight however, no information regarding flight heights was found for this species

The greatest threat facing migratory shorebirds, including the Sanderling, is habitat loss. Staging areas such as mudflats are being reclaimed for future development. Indirectly habitat is being degraded by oil exploration, water regulation and diversion infrastructure and rises in sea level as a result of climate change (Barter M. , 2002). Other significant threats include disturbance from residential and recreational activities including boating, noise, and night lighting; and direct mortality as a result of human activities around migration pathways and at foraging and roosting sites (DEWHA, 2009).

Table 33: SRI assessment for the Sanderling (*Calidris alba*)

Is there a chance or possibility that an action will?	Response
Substantially modify (including by fragmenting, altering fire regimes, altering nutrient cycles, or altering hydrological cycles), destroy, or isolate an area of important habitat for a migratory species; or	**Unlikely:** Project works in the site are unlikely to substantially modify, destroy, or isolate an area of important habitat for this species. There is no suitable habitat for this species within the site and it is likely the species is only transient through this area. Due to the lack of suitable habitat, it is unlikely project works in the site will substantially modify, destroy, or isolate an area of important habitat for this species.
Result in an invasive species that is harmful to the migratory species becoming established in an area of important habitat for the migratory species; or	**Unlikely:** Project works in the site are unlikely to introduce and/or allow a harmful invasive species to become established in the habitat of the species. Feral cats and European Red Foxes are recognised threats to several similar species and have been detected on site. Several species of invasive flora have been detected on site and have the potential to modify the species' habitat. The project will operate under the *Biosecurity Act* (2014) and follow the General Biosecurity Obligation (GBO) to identify and manage any potential invasive species. There is not likely to be an introduction and establishment of a harmful invasive species in the habitat of the species.
Seriously disrupt the lifecycle (breeding, feeding, migration, or resting behaviour) of an ecologically significant proportion of the population of a migratory species.	**Unlikely:** Project works in the site are unlikely to seriously disrupt the lifecycle of an ecologically significant proportion of the population of this species. No information regarding flight heights was found for this species. Whilst there are several mapped flightpaths within the vicinity of the project area, these do not represent an ecologically significant proportion of the population. Therefore it is unlikely project works in the site will seriously disrupt the lifecycle of an ecologically significant proportion of the population of this species.

4.3.22. Sharp-tailed sandpiper *(Calidris acuminata)*

EPBC – Migratory, Marine. NCA – Special least concern

The sharp-tailed sandpiper (*Calidris acuminata*) is a small-medium wader that spends the non-breeding season in Australia. The Australian population migrates mostly to the south-east and is widespread both inland and in coastal locations. Most records in Queensland are along the coast with scattered records inland, particularly in central and south-western regions (Higgins & Davies, 1996). Many of the inland records are birds on passage. In the vicinity of the Project area, they are known to congregate at Lake Moondarra and there are abundant records in and around Mt Isa City, as well as at Rifle Creek Dam, Corella Dam, and Chinaman Dam (ALA, 2023). The species typically inhabits tidal mudflats, saltmarshes, mangroves, wetlands, floodwater, irrigated agricultural land, ponds. It has a strong association with water (Pizzey & Knight, The Field Guide to the Birds of Australia, 2012). Impact assessment relies on an understanding of flight height which varies depending on the phase of flight however, no information regarding flight heights was found for this species.

Threats to this species within Australia are mostly from habitat degradation due to water pollution, invasion of mudflat weeds, changes to the hydrological regime and exposure to acid sulphate soils (Department of the Environment, Water, Heritage and the Arts, 2009).

Table 34: SRI assessment for the Sharp-tailed Sandpiper (*Calidris acuminata*)

Is there a chance or possibility that an action will?	Response
Substantially modify (including by fragmenting, altering fire regimes, altering nutrient cycles, or altering hydrological cycles), destroy, or isolate an area of important habitat for a migratory species; or	**Unlikely:** Project works in the site are unlikely to substantially modify, destroy, or isolate an area of important habitat for this species. There is no suitable habitat for this species within the site and it is likely the species is only transient through this area. Due to the lack of suitable habitat, it is unlikely project works in the site will substantially modify, destroy, or isolate an area of important habitat for this species.
Result in an invasive species that is harmful to the migratory species becoming established in an area of important habitat for the migratory species; or	**Unlikely:** Project works in the site are unlikely to introduce and/or allow a harmful invasive species to become established in the habitat of the species. Feral cats and European Red Foxes are recognised threats to several similar species and have been detected on site. Several species of invasive flora have been detected on site and have the potential to modify the species' habitat. The project will operate under the *Biosecurity Act* (2014) and follow the General Biosecurity Obligation (GBO) to identify and manage any potential invasive species. There is not likely to be an introduction and establishment of a harmful invasive species in the habitat of the species.
Seriously disrupt the lifecycle (breeding, feeding, migration, or resting behaviour) of an ecologically significant proportion of the population of a migratory species.	**Unlikely:** Project works in the site are unlikely to seriously disrupt the lifecycle of an ecologically significant proportion of the population of this species. No information regarding flight heights was found for this species. Whilst there are several records and mapped flightpaths within the vicinity of the project area, these do not represent an ecologically significant proportion of the population. Therefore it is unlikely project works in the site will seriously disrupt the lifecycle of an ecologically significant proportion of the population of this species.

4.3.23. Terek Sandpiper (*Xenus cinereus*)

EPBC – Migratory, Marine. NCA – Special least concern.

The Terek Sandpiper (*Xenus cinereus*) is a small migratory wader that is a pale brownish-grey, and has fine dark streaking on the upper body, head, and sides of the breast. They have orange-yellow feet, brown eyes, and black bill which is evenly upcurved (Geering A, 2007) (Hayman, Marchant, & Prater, 1986). Terek Sandpipers breed in the northern hemisphere, specifically Russia, Ukraine, Finland, and northern Estonia. They migrate south for the boreal winter, occurring in coastal Africa, throughout southern Asia from the Persian Gulf east to Japan, Indomalaya and Indochina, New Guinea, Australia, and New Zealand (Marchant & Higgins, 1993). The global population is estimated at 187,000, with approximately 60,000 using the East Asian-Australasian Flyway and 23,000 spending the non-breeding season in Australia (Geering A, 2007). Birds arrive in Cairns and Darwin in August and north-western Australia in September. In Australia, Tereks Sandpipers are associated with coastal areas and prefer mangroves for roosting and soft wet intertidal mudflats or sheltered estuaries, embayments, harbors or lagoons for foraging (Marchant & Higgins, 1993). Most individuals remain on Australia's north coast, however some travel south along the eastern coast and inland records suggest there is some overland migration (Blakers, Davies, & Reilly, 1984). There is a single record in the vicinity of the Project area at Lake Moondarra (ALA, 2023). Terek Sandpipers in New Zealand and Australia congregate in north-western Western Australia before departing in late April. Impact assessment relies on an understanding of flight height which varies depending on the phase of flight however, no information regarding flight heights was found for this species

The greatest threat facing migratory shorebirds, including Terek Sandpipers, is habitat loss. Staging areas such as mudflats are being reclaimed for future development. Indirectly habitat is being degraded by oil exploration, water regulation and diversion infrastructure and rises in sea level as a result of climate change (Barter M. , 2002). Other significant threats include disturbance from residential and recreational activities including boating, noise, and night lighting; and direct mortality as a result of human activities around migration pathways and at foraging and roosting sites (DEWHA, 2009).

Table 35: SRI assessment for the Terek Sandpiper (*Xenus cinereus*)

Is there a chance or possibility that an action will?	Response
Substantially modify (including by fragmenting, altering fire regimes, altering nutrient cycles, or altering hydrological cycles), destroy, or isolate an area of important habitat for a migratory species; or	**Unlikely:** Project works in the site are unlikely to substantially modify, destroy, or isolate an area of important habitat for this species. There is no suitable habitat for this species within the site and it is likely the species is only transient through this area. Due to the lack of suitable habitat, it is unlikely project works in the site will substantially modify, destroy, or isolate an area of important habitat for this species.
Result in an invasive species that is harmful to the migratory species becoming established in an area of important habitat for the migratory species; or	**Unlikely:** Project works in the site are unlikely to introduce and/or allow a harmful invasive species to become established in the habitat of the species. Feral cats and European Red Foxes are recognised threats to several similar species and have been detected on site. Several species of invasive flora have been detected on site and have the potential to modify the species' habitat.

	The project will operate under the *Biosecurity Act* (2014) and follow the General Biosecurity Obligation (GBO) to identify and manage any potential invasive species. There is not likely to be an introduction and establishment of a harmful invasive species in the habitat of the species.
Seriously disrupt the lifecycle (breeding, feeding, migration, or resting behaviour) of an ecologically significant proportion of the population of a migratory species.	**Unlikely:** Project works in the site are unlikely to seriously disrupt the lifecycle of an ecologically significant proportion of the population of this species. Whilst there are several records and mapped flightpaths within the vicinity of the project area, these do not represent an ecologically significant proportion of the population. Therefore it is unlikely project works in the site will seriously disrupt the lifecycle of an ecologically significant proportion of the population of this species.

4.3.24. Whimbrel (Numenius phaeopus)

EPBC – Migratory, Marine. NCA – Special least concern.

The Whimbrel (*Numenius phaeopus*) is a medium-sized curlew that is dark brown and varyingly palely spotted on the upper half of its body, and white with dark brown streaks on the lower half. They have a strongly patterned head with a dark brown crown and eye stripe, and bluish-grey legs (Higgins & Davies, 1996). The Whimbrel breeds in the northern hemisphere, mainly in Alaska but has also been observed breeding across northern Europe into Russia. They migrate south for the boreal winter and can occur through Central and South America, coastal Africa, the Persian Gulf, south-east Asia, New Guinea, Micronesia, Melanesia, Polynesia, and Australia. Only one subspecies, *Numenius phaeopus variegates*, occurs in the East Asian-Australasian Flyway. Birds arrive in northern Australia from August to October, they disperse widely along the coast through the non-breeding season and some inland records suggest there is some overland movement (Blakers, Davies, & Reilly, 1984). In Australia, Whimbrels are often found on the intertidal mudflats of sheltered coasts or harbors, lagoons, estuaries, and river deltas, often those with mangroves (Higgins & Davies, 1996). There are no records of the Whimbrel the vicinity of the Project area (ALA, 2023). Whimbrels being to move north within Australia from February, leaving the northern coast by late April (Alcorn R. , 1988). Impact assessment relies on an understanding of flight height which varies depending on the phase of flight however, no information regarding flight heights was found for this species.

The greatest threat facing migratory shorebirds, including Whimbrels, is habitat loss. Staging areas such as mudflats are being reclaimed for future development. Indirectly habitat is being degraded by oil exploration, water regulation and diversion infrastructure and rises in sea level as a result of climate change (Barter M. , 2002). Other significant threats include disturbance from residential and recreational activities including boating, noise, and night lighting; and direct mortality as a result of human activities around migration pathways and at foraging and roosting sites, such as the construction of wind farms in migration or movement pathways (DEWHA, 2009).

Table 36: SRI assessment for the Whimbrel (*Numenius phaeopus*)

Is there a chance or possibility that an action will?	Response
Substantially modify (including by fragmenting,	**Unlikely:** Project works in the site are unlikely to substantially modify, destroy, or isolate an area of important habitat for this species.

altering fire regimes, altering nutrient cycles, or altering hydrological cycles), destroy, or isolate an area of important habitat for a migratory species; or	There is no suitable habitat for this species within the site and it is likely the species is only transient through this area. Due to the lack of suitable habitat, it is unlikely project works in the site will substantially modify, destroy, or isolate an area of important habitat for this species.
Result in an invasive species that is harmful to the migratory species becoming established in an area of important habitat for the migratory species; or	**Unlikely:** Project works in the site are unlikely to introduce and/or allow a harmful invasive species to become established in the habitat of the species. Feral cats and European Red Foxes are recognised threats to several similar species and have been detected on site. Several species of invasive flora have been detected on site and have the potential to modify the species' habitat. The project will operate under the *Biosecurity Act* (2014) and follow the General Biosecurity Obligation (GBO) to identify and manage any potential invasive species. There is not likely to be an introduction and establishment of a harmful invasive species in the habitat of the species.
Seriously disrupt the lifecycle (breeding, feeding, migration, or resting behaviour) of an ecologically significant proportion of the population of a migratory species.	**Unlikely:** Project works in the site are unlikely to seriously disrupt the lifecycle of an ecologically significant proportion of the population of this species. No information regarding flight heights was found for this species. Whilst there are mapped flightpaths within the vicinity of the project area, these do not represent an ecologically significant proportion of the population. Therefore it is unlikely project works in the site will seriously disrupt the lifecycle of an ecologically significant proportion of the population of this species.

4.4. Known raptors

Australian Hobby (*Falco longipennis*)

EPBC – Least concern. NCA – Least concern

The Australian Hobby (*Falco longipennis*) is a small, dark falcon with rusty rufous underparts, dark grey to blackish upperparts and long, slender wings with sharp points. They have a black hood similar to the Peregrine Falcon but reduced in size. They occur in a range of open habitats and feed mainly aerially on other birds (Sullivan, et al., 2009).

Black Kite (*Milvus migrans*)

EPBC – Least concern. NCA – Least concern

The Black Kite (*Milvus migrans*) is a medium-sized raptor that appears almost black from a distance. The plumage is actually dark brown, with a light brown bar on the shoulder. The tail is forked, the eyes are dark brown, and the bill is black with a yellow cere (the skin around the nostrils). They are found in a variety of habitats and whilst usually occur in small groups, unlike other Australia raptors they can be seen flocking in thousands. They prey on lizards, small mammals, and insects. Often the flocking in thousands is brought on by a grasshopper plague or a bushfire (Marchant & Higgins, 1993) (Olsen, Crome, & Olsen, 1993).

Black-breasted Buzzard (*Hamirostra melanosternon*)

EPBC – Least concern. NCA – Least concern.

The Black-breasted Buzzard (*Hamirostra melanosternon*) is a large dark raptor with a short stubby tail and large wings with pale wing panels. They typically inhabit inland deserts but occasionally wander close to the coast (Sullivan, et al., 2009). They soar high and glide low when looking for prey such as rabbits, ground birds, lizards, and carrion. They can catch food from the air, ground, or from trees (Marchant & Higgins, 1993) (Olsen, Crome, & Olsen, 1993).

Black-shouldered Kite (*Elanus axillaris*)

EPBC – Least concern. NCA – Least concern.

The Black-shouldered Kite (*Elanus axillaris*) is a small grey and white raptor with distinctive black shoulder patches. The underparts are white with black patches on the outer half of the underwings. They have yellow legs and feet, a small black bill, and bright red eyes with black pointed markings behind. They generally occur over open grasslands, hovering to search for prey (Sullivan, et al., 2009).

Brown Falcon (*Falco berigora*)

EPBC – Least concern. NCA – Least concern.

The Brown Falcon (*Falco berigora*) is a large-headed falcon with plumage ranging from dark brown to tan. They have long grey unfeathered legs and feet and a grey beak (Sullivan, et al., 2009). Their preferred habitat is open grassland with scattered trees or structures such as telegraph poles. They are generally seen alone, watching from a perch, and swooping down when they spot a small mammal, insect, reptile, or small bird (Pizzey & Knight, 2012) (Olsen, Crome, & Olsen, 1993).

Brown goshawk (*Accipiter fasciatus*)

EPBC Act – Marine. NCA – Least concern

The brown goshawk (*Accipiter fasciatus*) is a medium sized but powerful species of raptor, abundant across most of the Australian continent. It is mostly grey, brown above, with a distinct rufous collar separating the back from a grey head. The underside of this species is mostly rufous with white and rufous barring on the underwings. The brown goshawk is a versatile species, inhabiting a broad range of habitats, including open woodlands and forests, scrubs, margins of watercourses and similar. The brown goshawk can be found across most of Australia, with some populations considered part-migratory and moving to northern Australia in winter (Pizzey & Knight, 2012).

Collared Sparrowhawk (*Accipiter cirrocephalus*)

EPBC – Least concern. NCA – Least concern.

The Collared Sparrowhawk (*Accipiter cirrocephalus*) is a small delicate raptor that is grey with orange barring on the underside. When soaring they have a straight rectangular tail with a small notch in the end. They have a small bill black bill with a yellow cere, very skinny orange legs and feet, and a blank-staring expression (Sullivan, et al., 2009). They tend to stay in closed areas such as woodlands and forests rather than soaring in open areas, relying on trees and tall shrubs to ambush prey such as small birds (Marchant & Higgins, 1993) (Olsen, Crome, & Olsen, 1993).

Grey falcon (*Falco hypoleucos*)

EPBC – Vulnerable. NCA - Vulnerable

The grey falcon (*Falco hypoleucos*) is pale grey coloured falcon with distinct yellow legs and eye ring. It is a proficient predator, predominantly of smaller birds, which it observes and pursues from elevated perches. The grey falcon breeds from June to November, typically in old raptor or covid nests which are built high in large trees such as eucalypts near water courses. As with similar species, the grey falcon inhabits a wide array of habitats, from inland plains and deserts to well-timbered watercourses. It may be sedentary, dispersive, or migratory and is considered rare to very rare throughout its range (Pizzey & Knight, The Field Guide to the Birds of Australia, 2012).

The grey falcon is considered to have numerous known and potential threats. The most significant of these are predation by feral cats, grazing and habitat degradation by introduced herbivores and climate change. These threatening processes are additionally accentuated by another factor, the overall low population size for this species. Recent estimates consider the total number of mature grey falcon adults to be less than 1000 across its entire extensive range (Threatened Species Scientific Committee, 2020).

The small overall population size and density of the grey falcon impose significant challenges to detectability (Threatened Species Scientific Committee, 2020).

Red goshawk *(Erythrotriorchis radiatus)*

EPBC – Vulnerable. NCA - Endangered

The red goshawk (*Erythrotriorchis radiatus*) is large species of goshawk with a strong rufous red colouring on the back and underwings, transitioning to the black and white barred undersides of its flight feathers. It is fast and powerful, feeding on medium to large bird species (sometimes larger than itself) which it may catch in flight or ambush. The red goshawk builds a nest of sticks in large, mature *Eucalyptus* or *Melaleuca* trees, usually breeding from April to September (Pizzey & Knight, 2012). This species exhibits a high level of sexual dimorphism, with females being much larger and more powerful than their male counterparts. The red goshawk is more abundant coastally though is also known to inhabit inland areas (ALA, 2023).

Habitat degradation in the primary threat known to have affected populations of the red goshawk. Clearing of forests for human development, agriculture and forestry have all been implicated in declines of the red goshawk. Modification of fire regimes leading to increasing density of understory vegetation and the reduction in abundance of important prey species are also considered a threat to this species (TSSC, 2015). Declines in populations of the red goshawk, particularly in the southern extent of their range are considered to be ongoing.

The red goshawk is one of the least frequently recorded birds of prey in Australia and is predicted to exist in low numbers and at low density across most of its range. In addition to this, it may be very difficult to detect and identify even when present.

Spotted Harrier (*Circus assimilis*)

EPBC – Least concern. NCA – Least concern.

The Spotted Harrier (*Circus assimilis*) is a medium-sized raptor with long legs and long slender wings. Adults are grey on the upperparts and chestnut on the underparts, both with striking white spots. They have long yellow legs, and the flight and tail feathers are strongly barred with dark brown-black. They generally inhabit drier open habitats and can often be seen flying low or perching on fence-posts (Sullivan, et al., 2009).

Wedge-tailed Eagle (*Aquila audax*)

EPBC – Least concern. NCA – Least concern.

The Wedge-tailed Eagle (*Aquila audax*) is a very large, dark eagle. Juveniles are lighter and more golden in colour and darken with age. They have long feathered legs, pale feet, a large pale bill, and brown or dark brown eyes. They prefer open woodland or forests, generally avoiding rainforests. They often soar high, at altitudes of up to 2000m, occasionally in groups, and often over mountainous terrains. In soaring their tail forms a diamond shape. When not soaring, they perch on telephone poles or stags, and frequently land to feed on carrion (Sullivan, et al., 2009). In addition to carrion, they often feed on rabbits, and less often lizards, birds, and sometimes working together can take down large mammals such as kangaroos (Marchant & Higgins, 1993) (Olsen, Crome, & Olsen, 1993).

Whistling kite (*Haliastur sphenurus*)

EPBC – Marine. NCA – Least concern

The whistling kite (*Haliastur sphenurus*) is a medium to large, sandy-coloured raptor with a long, slightly rounded tail. Its call is a loud, distinctly repeated whistle. Habitat includes open forests and foothills usually near water, timbered watercourses, lakes and swamps, tidal inlets, estuaries, and mudflats. Whistling kite are widespread across Australia.

Threats include destruction and changes to wetlands (Northern Territory Government, 2015).

White-bellied sea-eagle *(Haliaeetus leucogaster)*

EPBC – Marine. NCA – Least concern

White-bellied sea-eagles (*Haliaeetus leucogaster*) are a large raptor with long, broad wings and a wedge-shaped tail. The plumage is predominantly white and grey. They are often seen singly or in pairs. This species is distributed along the coastline of mainland Australia and Tasmania. It extends inland along some of the larger waterways. Inland limits of the species are restricted in south-central and south-western Australia, however there are scattered records from inland Queensland (Marchant & Higgins, Handbook of Australian, New Zealand and Antarctic Birds. Volume One - Ratites to Ducks, 1990).

Preferred habitat includes coastal areas, terrestrial wetlands in tropical and temperate regions. Habitats occupied by white-bellied sea eagle typically include the presence of large areas of open water (large rivers, swamps, lakes, and the ocean).

Threats include loss of habitat due to land development and the disturbance of nesting pairs (Dennis, 1996). Other threats include poisoning and shooting (Barnett, 1980).

Habitat within the Dulgald River and Cabbage Tree Creek may provide temporary habitat during dispersal to larger inland bodies of water. Records in the area are primarily around the Leichhardt River, Lake Moondarra, and other perennial water sources. The project area does not include any perennial water sources that would provide suitable habitat for the white-bellied sea eagle. The species may transit across the site, but proposed flight paths between large perennial water sources in the area do not cross the Knapdale range.

Due to the absence of conservation significant listings for the above species, the SRI criteria are not applicable. However, in lieu of other relevant impact assessment criteria, they were used.

Despite the absence of records for the White-bellied Sea Eagle, Red Goshawk, and Grey Falcon, due to their similarities with the above species the following impact assessment could be applied to them if they are recorded on site in the future.

Table 37: Impact assessment for raptors

Is there a chance or possibility that an action will?	Response
Lead to a long-term decrease in the size of an important population of the species; or	**Unlikely:** It is unlikely project works in the site could lead to a long-term decrease in the size of an important population of the above species. There are several records of the Australian Hobby (*Falco longipennis*), Black Kite (*Milvus migrans*), Black-breasted Buzzard (*Hamirostra melanosternon*), Black-shouldered Kite (*Elanus axillaris*), Brown Falcon (*Falco berigora*), Brown

Is there a chance or possibility that an action will?	Response
	goshawk (*Accipiter fasciatus*), Collared Sparrowhawk (*Accipiter cirrocephalus*), Spotted Harrier (*Circus assimilis*), Wedge-tailed Eagle (*Aquila audax*), and Whistling kite (*Haliastur sphenurus*) within 50km of the site. Records of these species indicate the presence of largely permanent populations of them on the Knapdale Range. They are frequently observed thermaling and foraging above the Project area, and five of the species have been observed in the potential RSA. These are the: Black Kite, Black-shouldered Kite, Brown Falcon, Wedge-tailed Eagle, and Whistling Kite. Due to the paired mating habit of raptors, two mature individuals could be considered a population. It is possible there will be an impact on the local populations of the above species by works in the site. However, due to the wide distribution and absence of conservation significant listings for the above species, there is unlikely to be an impact on a significant population of the above species by works in the site.
Reduce the area of occupancy of an important population; or	**Unlikely:** It is unlikely project works in the site could reduce the area of occupancy of an important population. There are several records of the Australian Hobby (*Falco longipennis*), Black Kite (*Milvus migrans*), Black-breasted Buzzard (*Hamirostra melanosternon*), Black-shouldered Kite (*Elanus axillaris*), Brown Falcon (*Falco berigora*), Brown goshawk (*Accipiter fasciatus*), Collared Sparrowhawk (*Accipiter cirrocephalus*), Spotted Harrier (*Circus assimilis*), Wedge-tailed Eagle (*Aquila audax*), and Whistling kite (*Haliastur sphenurus*) within 50km of the site. Records of these species indicate the presence of largely permanent populations of them on the Knapdale Range. They are frequently observed thermaling and foraging above the Project area, and five of the species have been observed in the potential RSA. These are the: Black Kite, Black-shouldered Kite, Brown Falcon, Wedge-tailed Eagle, and Whistling Kite. Due to the paired mating habit of raptors, two mature individuals could be considered a population. It is possible there will be an impact on the area of occupancy of the local populations of the above species by works in the site. However, due to the wide distribution and absence of conservation significant listings for the above species, there is unlikely to be an impact on a significant population of the above species by works in the site.
Fragment an existing important population into two or more populations; or	**Unlikely:** It is unlikely project works in the site could fragment an existing important population. There are several records of the Australian Hobby (*Falco longipennis*), Black Kite (*Milvus migrans*), Black-breasted Buzzard (*Hamirostra melanosternon*), Black-shouldered Kite (*Elanus axillaris*), Brown Falcon (*Falco berigora*), Brown goshawk (*Accipiter fasciatus*), Collared Sparrowhawk (*Accipiter cirrocephalus*), Spotted Harrier (*Circus assimilis*), Wedge-tailed Eagle (*Aquila audax*), and Whistling kite (*Haliastur sphenurus*) within 50km of the site. Records of these species indicate the presence of largely permanent populations of them on the Knapdale Range. They are frequently observed thermaling and foraging above the Project area, and five of the species have been observed in the potential RSA. These are the: Black Kite, Black-shouldered Kite, Brown Falcon, Wedge-tailed Eagle, and Whistling Kite. Due to the paired mating habit of raptors, two mature individuals could be considered a population. It is possible the project works will fragment the local populations of the above species. However, due to the wide distribution and absence of conservation significant listings for the above species, there is unlikely to be an impact on a significant population of the above species by works in the site.

Is there a chance or possibility that an action will?	Response
Adversely affect habitat critical to the survival of the species; or	**Unlikely:** Project works in the site are unlikely to adversely affect habitat critical to the survival of the species. There are several records of the Australian Hobby (*Falco longipennis*), Black Kite (*Milvus migrans*), Black-breasted Buzzard (*Hamirostra melanosternon*), Black-shouldered Kite (*Elanus axillaris*), Brown Falcon (*Falco berigora*), Brown goshawk (*Accipiter fasciatus*), Collared Sparrowhawk (*Accipiter cirrocephalus*), Spotted Harrier (*Circus assimilis*), Wedge-tailed Eagle (*Aquila audax*), and Whistling kite (*Haliastur sphenurus*) within 50km of the site. Records of these species indicate the presence of largely permanent populations of them on the Knapdale Range. They are frequently observed thermaling and foraging above the Project area, and five of the species have been observed in the potential RSA. These are the: Black Kite, Black-shouldered Kite, Brown Falcon, Wedge-tailed Eagle, and Whistling Kite. There is no habitat critical to the survival of any of the above species in the proposed project area, due to the small size of the site and connectivity of the surrounding habitat, works within the site are unlikely to impact habitat critical to the survival of the species.
Disrupt the breeding cycle of an important population; or	**Unlikely:** It is unlikely project works in the site could disrupt the breeding cycle of an important population of the species. There are several records of the Australian Hobby (*Falco longipennis*), Black Kite (*Milvus migrans*), Black-breasted Buzzard (*Hamirostra melanosternon*), Black-shouldered Kite (*Elanus axillaris*), Brown Falcon (*Falco berigora*), Brown goshawk (*Accipiter fasciatus*), Collared Sparrowhawk (*Accipiter cirrocephalus*), Spotted Harrier (*Circus assimilis*), Wedge-tailed Eagle (*Aquila audax*), and Whistling kite (*Haliastur sphenurus*) within 50km of the site. Records of these species indicate the presence of largely permanent populations of them on the Knapdale Range. They are frequently observed thermaling and foraging above the Project area, and five of the species have been observed in the potential RSA. These are the: Black Kite, Black-shouldered Kite, Brown Falcon, Wedge-tailed Eagle, and Whistling Kite. Due to the paired mating habit of raptors, two mature individuals could be considered a population. It is possible there will be an impact on the breeding cycle of local populations of the above species by works in the site. However, due to the wide distribution and absence of conservation significant listings for the above species, there is unlikely to be an impact on a significant population of the above species by works in the site.
Modify, destroy, remove, or isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline; or	**Unlikely:** Project works in the site are unlikely to impact habitat to the extent that the species is likely to decline. There are several records of the Australian Hobby (*Falco longipennis*), Black Kite (*Milvus migrans*), Black-breasted Buzzard (*Hamirostra melanosternon*), Black-shouldered Kite (*Elanus axillaris*), Brown Falcon (*Falco berigora*), Brown goshawk (*Accipiter fasciatus*), Collared Sparrowhawk (*Accipiter cirrocephalus*), Spotted Harrier (*Circus assimilis*), Wedge-tailed Eagle (*Aquila audax*), and Whistling kite (*Haliastur sphenurus*) within 50km of the site. Records of these species indicate the presence of largely permanent populations of them on the Knapdale Range. They are frequently observed thermaling and foraging above the Project area, and five of the species have been observed in the potential RSA. These are the: Black Kite, Black-shouldered Kite, Brown Falcon, Wedge-tailed Eagle, and Whistling Kite. There is suitable foraging habitat within and above the RSA. Due to the small size of the site, and connectivity of the surrounding habitat, works within the site are unlikely to modify habitat to the extent that the species is likely to decline.

Is there a chance or possibility that an action will?	Response
Result in invasive species that are harmful to a vulnerable species becoming established in the vulnerable species' habitat; or	**Unlikely:** Project works in the site are unlikely to introduce and/or allow a harmful invasive species to become established in the habitat of the species. Feral cats and European Red Foxes are recognised threats to most native fauna, however raptors are generally not vulnerable to them. Several species of invasive flora have been detected on site and have the potential to modify the species' habitat. The project will operate under the *Biosecurity Act* (2014) and follow the General Biosecurity Obligation (GBO) to identify and manage any potential invasive species.
Introduce disease that may cause the species to decline; or	**Unlikely:** Project works are unlikely to introduce novel diseases to the site. Psittacine beak and feather disease (PBFD) is a common highly infectious viral disease among parrots. It is Australia wide and has recently been observed in dead juvenile Red Goshawk (*Erythrotriorchis radiatus*), indicating that it is a possible threat to other similar native raptors. The project will operate under the *Biosecurity Act* (2014) and follow the General Biosecurity Obligation (GBO) to identify and manage detrimental diseases or pathogens if present.
Interfere substantially with the recovery of the species.	**Unlikely:** Project works in the site are unlikely to interfere substantially with the recovery of the species. There are several records of the Australian Hobby (*Falco longipennis*), Black Kite (*Milvus migrans*), Black-breasted Buzzard (*Hamirostra melanosternon*), Black-shouldered Kite (*Elanus axillaris*), Brown Falcon (*Falco berigora*), Brown goshawk (*Accipiter fasciatus*), Collared Sparrowhawk (*Accipiter cirrocephalus*), Spotted Harrier (*Circus assimilis*), Wedge-tailed Eagle (*Aquila audax*), and Whistling kite (*Haliastur sphenurus*) within 50km of the site. Records of these species indicate the presence of largely permanent populations of them on the Knapdale Range. They are frequently observed thermaling and foraging above the Project area, and five of the species have been observed in the potential RSA. These are the: Black Kite, Black-shouldered Kite, Brown Falcon, Wedge-tailed Eagle, and Whistling Kite. Due to the small size of the site and connectivity of the surrounding habitat, works within the site are unlikely to interfere with the recovery of the species.

4.5. Known bats

Finlayson's Cave Bat (*Vespadelus finlaysoni*)

EPBC – Least concern. NCA – Least concern.

Finlayson's Cave Bat (*Vespadelus finlaysoni*) is a small microbat with dark brown-blackish fur on the dorsal side and a lighter shade on the ventral side. Their skin is dark, including the bare parts of the face and the wing membranes. Their face lacks and distinguishing features and resembles that of many species of the genus. They are associated with rocky outcrops and ranges. Colonies occupy and roost in caves, cliffs, or crevices within rocky terrain as well as abandoned mineshafts. They forage for prey near water (Reardon, Milne, Kutt, & Armstrong, 2008). They have been recorded in Bird Utilisation Surveys (BUS) flying less than 15m above the ground (BASE Consulting Group, 2022). Therefore it is unlikely that this species will occur within the RSA.

Gould's Wattled Bat (*Chalinolobus gouldii*)

EPBC – Least concern. NCA – Least concern.

Gould's Wattled Bat (*Chalinolobus gouldii*) is the largest microbat of its genus. The genus *Chalinolobus* is distinguished by fleshy lobes located at the corners of the mouth. The fur on the dorsal side is dark brown, becoming black on the head and shoulders. They are found in a variety of habitats and can roost alone or in colonies of around 30 bats, or occasionally up to 200 bats. In wooded areas they are mostly arboreal and can utilise trees hollows and bird nests. They are insectivorous and moths are the most common prey item (Chruszez & Barclay, 2002). Their flight is direct and rapid, and manoeuvrability is limited (O'Neill & Taylor, 1986). They tend to stay below 20 m and may descend to a height of 1 m above the ground (Dixon, 1995). Therefore it is unlikely that this species will occur within the RSA.

Hoary Wattled Bat (*Chalinolobus nigrogriseus*)

EPBC – Least concern. NCA – Least concern.

The Hoary Wattled Bat (*Chalinolobus nigrogriseus*) is a small sooty coloured microbat with white tipped hairs of varying length, giving it a frosted, 'hoary' appearance. The genus *Chalinolobus* is distinguished by fleshy lobes located at the corners of the mouth. They are insectivores and feed primarily aerially but can also land and crawl after non-flying prey (Australian Museum, 2020). They are found in forests, woodlands, vine thickets, and open grasslands in norther and eastern Australia. They roost in tree hollows and rock fissures (Churchill, 2008). Their flight is direct and rapid, and manoeuvrability is limited (O'Neill & Taylor, 1986). They tend to stay below 20 m and may descend to a height of 1 m above the ground (Dixon, 1995). Therefore it is unlikely that this species will occur within the RSA.

Inland Broad-nosed Bat (*Scotorepens balstoni*)

EPBC – Least concern. NCA – Least concern.

The Inland Broad-nosed Bat (*Scotorepens balstoni*) is a medium-sized microbat with a characteristic square-shaped muzzle when viewed from above. Their fur varies from dark brown to sandy brown, with light grey-brown on the back and pale brown on the belly being most common. They are widely distributed throughout

inland Australia and roost in tree hollows or similar structures in groups of up to 45 bats. They are insectivores and feed aerially (Churchill, 2008). They have been recorded in Bird Utilisation Surveys (BUS) as having the potential to fly anywhere from 40-300m above the ground (BASE Consulting Group, 2022). Therefore it is possible this species will occur within the RSA.

Inland Forest Bat (*Vespadelus baverstocki*)

EPBC – Least concern. NCA – Least concern.

The Inland Forest Bat (*Vespadelus baverstocki*) is a small microbat with greyish-brown or sandy-brown fur on the dorsal side and white fur on the ventral side. Some individuals are darker on the ventral side giving them a uniform greyish-brown colour. They have a pinkish face. They are found in the arid areas of the eastern states of Australia and generally inhabit rocky outcrops or tree hollows in woodlands or shrublands, where they roost in groups of varying size, from only a few individuals up to 60 bats. They are insectivores and feed aerially, with moths making up the majority of their diet (Menkhorst & Knight, 2011) (Australian Museum, 2020). Vespadelus characteristically fly through open woodland areas from about 1.5m to near canopy level (<15m) (Dwyer, 1965). Therefore it is unlikely that this species will occur within the RSA.

Little Broad-nosed Bat (*Scotorepens greyii*)

EPBC – Least concern. NCA – Least concern.

The Little Broad-nosed Bat (*Scotorepens greyii*) is a slender microbat with a characteristic square-shaped muzzle when viewed from above. Fur ranges from brown to greyish-brown on the dorsal side and is paler on the ventral side. Fur has whitish tips giving the bat a slightly hoary appearance. They are found in most areas of mainland Australia, primarily they inhabit dry grasslands, sandy deserts, open forests, and forests along inland rivers. They generally roost in tree hollows and similar structures. They are insectivores that feed and drink aerially, generally foraging over tree tops or over water (Van Dyck & Strahan, 2008) (Churchill, 2008) (Menkhorst & Knight, 2011). They have been recorded in Bird Utilisation Surveys (BUS) as having the potential to fly anywhere from 40-300m above the ground (BASE Consulting Group, 2022). Therefore it is possible this species will occur within the RSA.

Northern Freetail Bat (*Chaerophon jobensis*)

EPBC – Least concern. NCA – Least concern.

The Northern Freetail Bat (*Chaerophon jobensis*) is a large robust bat with greyish red-brown fur on the dorsal side and paler fur on the ventral side. They are distributed through the northern half of Australia, typically foraging in tropical savannahs by night and roosting in tree hollows or caves during the day. They are insectivorous and feed aerially, utilizing their muscular build for fast direct flight suited for open areas (Van Dyck & Strahan, 2008). Its fast and direct flight is appropriate to open habitats and foraging over tree-tops as it lacks the manoeuvrability to hunt in dense vegetation. They have been recorded in Bird Utilisation Surveys (BUS) flying less than 15m above the ground (BASE Consulting Group, 2022). Therefore it is unlikely that this species will occur within the RSA.

Northern Free-tailed Bat (*Ozimops lumsdenae*)

EPBC – Least concern. NCA – Least concern.

The Northern Free-tailed Bat (*Ozimops lumsdenae*) is a larger robust microbat with rich brown fur on the dorsal side and lighter coloured fur on the ventral side. They are distributed across most of northern Australia from the coast up to 700km inland. They are associated with permanent water and watercourses in semi-arid regions, inhabiting eucalypt woodland (Reardon, et al., 2014). They have been recorded in Bird Utilisation Surveys (BUS) flying less than 15m above the ground (BASE Consulting Group, 2022). Therefore it is unlikely that this species will occur within the RSA.

White-striped Freetail Bat (*Austronomus australis*)

EPBC – Least concern. NCA – Least concern.

The White-striped Freetail Bat (*Austronomus australis*) is a large robust microbat with deep chocolate brown fur and well-defined white dorsal stripes where the wings meet the body (Menkhorst & Knight, 2011). They are widespread and common in Australia, inhabiting most habitats from closed forest to open flood plains. They are a highly colonial tree-dweller and use large internal hallows for communal roosting, however some may also have individual roosts in smaller hollows separate from the colony. They are an insectivorous species and feed aerially at high-altitudes (Churchill, 2008). They have been recorded in Bird Utilisation Surveys (BUS) as having the potential to fly anywhere from 40-300m above the ground (BASE Consulting Group, 2022). Therefore it is possible this species will occur within the RSA.

Yellow-bellied Sheathtail Bat (*Saccolaimus flaviventris*)

EPBC – Least concern. NCA – Least concern.

The Yellow-bellied Sheathtail Bat (*Saccolaimus flaviventris*) is a fairly large microbat with distinctive shiny jet black fur on the dorsal side and contrasting cream white on the ventral side (Churchill, 2008) (Rhodes & Hall, 1997). They are widely distributed throughout northern and eastern Australia, (Dickman, Pressey, Lim, & Parnaby, 1993) occupying most wooded habitats, shrublands, deserts, and open woodlands. They are hollow roosting and hence are often found in proximity to old-growth trees (Hall & Richards, 1979). They are mostly solitary, occasionally nesting in small groups of up to 10 individuals. They are insectivores, feeding above the canopy at heights of 20-25m, except in open areas where they fly lower (Churchill, 2008). Therefore it is unlikely that this species will occur within the RSA.

Species	Positively identified calls within the Project area	Species flight height relative to RSA	Risk of Collision with turbine tower or blades
Finlayson's Cave Bat (*Vespadelus finlaysoni*)	41	Below	Unlikely – due to the low abundance of this species within the Project area, flight height below the RSA and habit of foraging above water, it is unlikely members of this species will collide with the turbine blades or tower.
Gould's Wattled Bat (*Chalinolobus gouldii*)	3553	Below	Possible – due to the high abundance of this species within the Project area, combined with their direct and rapid flight with limited manoeuvrability, it is possible members this species will collide with the turbine tower below the RSA.
Hoary Wattled Bat (*Chalinolobus nigrogriseus*)	57	Below	Unlikely - due to the low abundance of this species within the Project area and flight height below the RSA it is unlikely members of this species will collide with any part of the wind turbines.
Inland Broad-nosed Bat (*Scotorepens balstoni*)	22	Within	Possible – despite the low abundance of this species within the Project area, the species potential to fly anywhere from 40-300m makes it possible members of this species will collide with the turbine blades or tower.
Inland Forest Bat (*Vespadelus baverstocki*)	275	Below	Unlikely - due to the low abundance of this species within the Project area and flight height below the RSA it is unlikely members of this species will collide with any part of the wind turbines.
Little Broad-nosed Bat (*Scotorepens greyii*)	622	Within	Possible – due to the relatively high abundance of this species within the Project area, and the species potential to fly anywhere from 40-300m, it is possible members of this species will collide with the turbine blades or tower.
Northern Freetail Bat (*Chaerophon jobensis*)	1214	Below	Possible – due to the high abundance of this species within the Project area, combined with their direct and rapid flight with limited manoeuvrability, it is possible members this species will

			collide with the turbine tower below the RSA.
Northern Free-tailed Bat (*Ozimops lumsdenae*)	40	Below	Unlikely - due to the low abundance of this species within the Project area and flight height below the RSA it is unlikely members of this species will collide with any part of the wind turbines.
White-striped Freetail Bat (*Austronomus australis*)	5	Within	Possible – despite the low abundance of this species within the Project area, the species potential to fly anywhere from 40-300m makes it possible members of this species will collide with the turbine blades or tower.
Yellow-bellied Sheathtail Bat (*Saccolaimus flaviventris*)	777	Below	Unlikely – despite the relatively high abundance of this species within the Project area, the flight height below the RSA makes it unlikely members of this species will collide with any part of the wind turbines.

Due to the absence of conservation significant listings for the above species, the SRI criteria are not applicable. However, in lieu of other relevant impact assessment criteria, they were used.

Table 38: Impact assessment for bats

Is there a chance or possibility that an action will?	Response
Lead to a long-term decrease in the size of an important population of the species; or	**Unlikely:** It is unlikely project works in the site could lead to a long-term decrease in the size of an important population of the above species. There are several records of Finlayson's Cave Bat (*Vespadelus finlaysoni*), Gould's Wattled Bat (*Chalinolobus gouldii*), Hoary Wattled Bat (*Chalinolobus nigrogriseus*), Inland Broad-nosed Bat (*Scotorepens balstoni*), Inland Forest Bat (*Vespadelus baverstocki*), Little Broad-nosed Bat (*Scotorepens greyii*), Northern Freetail Bat (*Chaerophon jobensis*), Northern Free-tailed Bat (*Ozimops lumsdenae*), White-striped Freetail Bat (*Austronomus australis*), and Yellow-bellied Sheathtail Bat (*Saccolaimus flaviventris*) within 50km of the site. Eastern Bent-winged Bats (*Miniopterus orianae oceanensis*) have been detected at an altitude of 100m and it is therefore conceivable that other microbat species can fly at similar altitudes, and hence have the possibility to occur in the RSA. Bats are also particularly susceptible to barotrauma due to their morphology and can be killed as a result of flight close to rotor blades. It is possible there will be an impact on local populations of the above species by works in the site. However, due to the wide distribution and absence of conservation significant listings for the above species, there is unlikely to be an impact on a significant population of the above species by works in the site.
Reduce the area of occupancy of an important population; or	**Unlikely:** It is unlikely project works in the site could reduce the area of occupancy of an important population. There are several records of Finlayson's Cave Bat (*Vespadelus finlaysoni*), Gould's Wattled Bat (*Chalinolobus gouldii*), Hoary Wattled Bat (*Chalinolobus nigrogriseus*), Inland Broad-nosed Bat (*Scotorepens balstoni*), Inland Forest Bat (*Vespadelus baverstocki*), Little Broad-nosed Bat (*Scotorepens greyii*), Northern Freetail Bat (*Chaerophon jobensis*), Northern Free-tailed Bat (*Ozimops lumsdenae*), White-striped Freetail Bat (*Austronomus australis*), and Yellow-bellied Sheathtail Bat (*Saccolaimus flaviventris*) within 50km of the site. Eastern Bent-winged Bats (*Miniopterus orianae oceanensis*) have been detected at an altitude of 100m and it is therefore conceivable that other microbat species can fly at similar altitudes, and hence have the possibility to occur in the RSA. Bats are also particularly susceptible to barotrauma due to their morphology and can be killed as a result of flight close to rotor blades. It is possible there will be an impact on the area of occupancy of local populations of the above species by works in the site. However, due to the wide distribution and absence of conservation significant listings for the above species, there is unlikely to be an impact on a significant population of the above species by works in the site.
Fragment an existing important population into two or more populations; or	**Unlikely:** It is unlikely project works in the site could fragment an existing important population. There are several records of Finlayson's Cave Bat (*Vespadelus finlaysoni*), Gould's Wattled Bat (*Chalinolobus gouldii*), Hoary Wattled Bat (*Chalinolobus nigrogriseus*), Inland Broad-nosed Bat (*Scotorepens balstoni*), Inland Forest Bat (*Vespadelus baverstocki*), Little Broad-nosed Bat (*Scotorepens greyii*), Northern Freetail Bat (*Chaerophon jobensis*), Northern Free-tailed Bat (*Ozimops lumsdenae*), White-striped Freetail Bat (*Austronomus australis*), and Yellow-bellied Sheathtail Bat (*Saccolaimus flaviventris*) within 50km of the site. Eastern Bent-winged Bats (*Miniopterus orianae oceanensis*) have been detected at an altitude of 100m and it is therefore conceivable that other microbat species can fly at similar altitudes, and hence have the possibility to

Is there a chance or possibility that an action will?	Response
	occur in the RSA. Bats are also particularly susceptible to barotrauma due to their morphology and can be killed as a result of flight close to rotor blades. Therefore it is possible for project works to fragment any existing local populations.
Adversely affect habitat critical to the survival of the species; or	**Unlikely:** Project works in the site are unlikely to adversely affect habitat critical to the survival of the species. There are several records of Finlayson's Cave Bat (*Vespadelus finlaysoni*), Gould's Wattled Bat (*Chalinolobus gouldii*), Hoary Wattled Bat (*Chalinolobus nigrogriseus*), Inland Broad-nosed Bat (*Scotorepens balstoni*), Inland Forest Bat (*Vespadelus baverstocki*), Little Broad-nosed Bat (*Scotorepens greyii*), Northern Freetail Bat (*Chaerophon jobensis*), Northern Free-tailed Bat (*Ozimops lumsdenae*), White-striped Freetail Bat (*Austronomus australis*), and Yellow-bellied Sheathtail Bat (*Saccolaimus flaviventris*) within 50km of the site. Eastern Bent-winged Bats (*Miniopterus orianae oceanensis*) have been detected at an altitude of 100m and it is therefore conceivable that other microbat species can fly at similar altitudes, and hence have the possibility to occur in the RSA. Bats are also particularly susceptible to barotrauma due to their morphology and can be killed as a result of flight close to rotor blades. There are four known bat roosts in the Knapdale Range. However, there is no habitat critical to the survival of any of the above species within the proposed Project area. Due to the small size of the site and connectivity of the surrounding habitat, works within the site are unlikely to impact habitat critical to the survival of the species.
Disrupt the breeding cycle of an important population; or	**Unlikely:** It is unlikely project works in the site could disrupt the breeding cycle of an important population of the species. There are several records of Finlayson's Cave Bat (*Vespadelus finlaysoni*), Gould's Wattled Bat (*Chalinolobus gouldii*), Hoary Wattled Bat (*Chalinolobus nigrogriseus*), Inland Broad-nosed Bat (*Scotorepens balstoni*), Inland Forest Bat (*Vespadelus baverstocki*), Little Broad-nosed Bat (*Scotorepens greyii*), Northern Freetail Bat (*Chaerophon jobensis*), Northern Free-tailed Bat (*Ozimops lumsdenae*), White-striped Freetail Bat (*Austronomus australis*), and Yellow-bellied Sheathtail Bat (*Saccolaimus flaviventris*) within 50km of the site. Eastern Bent-winged Bats (*Miniopterus orianae oceanensis*) have been detected at an altitude of 100m and it is therefore conceivable that other microbat species can fly at similar altitudes, and hence have the possibility to occur in the RSA. Bats are also particularly susceptible to barotrauma due to their morphology and can be killed as a result of flight close to rotor blades. There are four known bat roosts in the Knapdale Range and individuals likely travel through the Project area to reach them, therefore it is possible there will be an impact on the breeding cycle local populations of the species. However, due to the wide distribution and absence of conservation significant listings for the above species, there is unlikely to be an impact on a significant population of the above species by works in the site.
Modify, destroy, remove, or isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline; or	**Unlikely:** Project works in the site are unlikely to impact habitat to the extent that the species is likely to decline. There are several records of Finlayson's Cave Bat (*Vespadelus finlaysoni*), Gould's Wattled Bat (*Chalinolobus gouldii*), Hoary Wattled Bat (*Chalinolobus nigrogriseus*), Inland Broad-nosed Bat (*Scotorepens balstoni*), Inland Forest Bat (*Vespadelus baverstocki*), Little Broad-nosed Bat (*Scotorepens greyii*), Northern Freetail Bat (*Chaerophon jobensis*), Northern Free-tailed Bat (*Ozimops lumsdenae*), White-striped Freetail Bat (*Austronomus australis*), and Yellow-bellied Sheathtail Bat (*Saccolaimus flaviventris*) within 50km of the site. Eastern Bent-winged Bats (*Miniopterus orianae oceanensis*) have been detected at an altitude of 100m and it is therefore conceivable that other

Is there a chance or possibility that an action will?	Response
	microbat species can fly at similar altitudes, and hence have the possibility to occur in the RSA. Bats are also particularly susceptible to barotrauma due to their morphology and can be killed as a result of flight close to rotor blades. There is suitable foraging habitat within and above the RSA. There are four known bat roosts in the Knapdale Range. However, there is no habitat critical to the survival of any of the above species within the proposed Project area. Due to the small size of the site and connectivity of the surrounding habitat, works within the site are unlikely to impact habitat critical to the survival of the species.
Result in invasive species that are harmful to a vulnerable species becoming established in the vulnerable species' habitat; or	**Unlikely:** Project works in the site are unlikely to introduce and/or allow a harmful invasive species to become established in the habitat of the species. Feral cats and European Red Foxes are recognised threats to most native fauna, however microbats are generally not vulnerable to them. Several species of invasive flora have been detected on site and have the potential to modify the species' habitat. The project will operate under the *Biosecurity Act* (2014) and follow the General Biosecurity Obligation (GBO) to identify and manage any potential invasive species.
Introduce disease that may cause the species to decline; or	**Unlikely:** Project works are unlikely to introduce novel diseases to the site. There are no recognised diseases threatening any of the above species. The project will operate under the *Biosecurity Act* (2014) and follow the General Biosecurity Obligation (GBO) to identify and manage detrimental diseases or pathogens if present.
Interfere substantially with the recovery of the species.	**Unlikely:** Project works in the site are unlikely to interfere substantially with the recovery of the species. There are several records of Finlayson's Cave Bat (*Vespadelus finlaysoni*), Gould's Wattled Bat (*Chalinolobus gouldii*), Hoary Wattled Bat (*Chalinolobus nigrogriseus*), Inland Broad-nosed Bat (*Scotorepens balstoni*), Inland Forest Bat (*Vespadelus baverstocki*), Little Broad-nosed Bat (*Scotorepens greyii*), Northern Freetail Bat (*Chaerophon jobensis*), Northern Free-tailed Bat (*Ozimops lumsdenae*), White-striped Freetail Bat (*Austronomus australis*), and Yellow-bellied Sheathtail Bat (*Saccolaimus flaviventris*) within 50km of the site. Eastern Bent-winged Bats (*Miniopterus orianae oceanensis*) have been detected at an altitude of 100m and it is therefore conceivable that other microbat species can fly at similar altitudes, and hence have the possibility to occur in the RSA. Bats are also particularly susceptible to barotrauma due to their morphology and can be killed as a result of flight close to rotor blades. Due to the small size of the site and connectivity of the surrounding habitat, works within the site are unlikely to interfere with the recovery of the species.

4.6. Known terrestrial fauna

Purple-necked Rock-wallaby (*Petrogale purpureicollis*)

EPBC – Not listed. NCA - Vulnerable

The PNRW is a comparatively small wallaby species. Their weight ranges from 4.7 to 7.0 kg, their head-body length ranges from 500 – 610 mm, and their tail length ranges from 450 – 600 mm (Menkhorst & Knight, A Field Guide to the Mammals of Australia, 2011). Their body is light brown, with a paler underside and a characteristic purple-mauve colouration over the neck, face, head, and sometimes upper chest and shoulders. They have a dark brown stripe extending from the eyes to between the ears along the midline of the top of the head (Menkhorst & Knight, 2011). The PNRW favours habitat which includes boulder piles, rocky slopes, cliffs and gorges in limestone areas, and sandstone and quartzite outcrops amongst dry Eucalyptus and Acacia woodlands. It also inhabits spinifex grasslands in association with the rocky areas (Rowland, 2012). They are largely nocturnal in summer, crepuscular or partially diurnal in other months. The PNRW shelters during the day among rocks or within boulder piles. In cooler months, they tend to sit in regular sites on rocks to bask in the sun in early morning and sometimes in afternoon. They move off the rocks in late afternoon or evening to feed in surrounding woodland (Mittermeier & Wilson, 2015). They are known to occur in the vicinity of the site due to the presence of nearby records, and hummock grassland and mulga, which are preferable to the species (Menkhorst & Knight, 2011).

The total area of PNRW habitat impacted by the proposed Project disturbance amounts to 23 ha of primary (denning and foraging) habitat and 38 ha of secondary (dispersal) habitat (Figure 7). This amounts to approximately 1.9% of the available habitat on the Knapdale Range.

While the proposed Project area is linear in nature, it is unlikely to cause fragmentation of habitat for the following reasons:

- the majority of the footprint lies centrally on the Knapdale Range meaning the primary habitat has largely been avoided and remains intact along the gullies and slopes that skirt the edges of the range
- while the linear impacts may be as wide as 25 m in sections, they are unlikely to restrict movement of the rock-wallaby across the landscape once construction has been completed as this distance is unlikely to impede movement and traffic will be limited to maintenance activities with speed limits imposed
- edges of the larger tracks will be maintained with a low vegetation cover allowing for greater refuge and reducing the overall width unsheltered roads.
- the PNRW is likely to traverse the area using existing drainage lines and rocky features in the landscape which remain relatively unimpacted.
- drainage lines over which the tracks will be constructed will include the installation of culverts. Culverts may vary in size depending on the size of the drainage feature though, owing to the specifications required to support the weight of large machinery and equipment, will be sufficient in height below to allow for the PNRW and other fauna to traverse beneath the road.

Table 39: SRI assessment for the Purple-necked Rock-wallaby (*Petrogale purpureicollis*)

Is there a chance or possibility that an action will?	Response
Lead to a long-term decrease in the size of an important population of the species; or	**Unlikely:** Project works in the site are unlikely to lead to a long-term decrease in the size of an important population of the species. There are 611 records of this species on the site over 12 years. There are multiple confirmed and multiple speculated dens around the site, including several along the Knapdale Range near the project area. Due to the relatively low ground disturbance associated with wind farms, there is not likely to be an impact on the population by works in the site.
Reduce the area of occupancy of an important population; or	**Unlikely:** Project works in the site are unlikely to reduce the area of occupancy of an important population. There are 611 records of this species on the site over 12 years. There are multiple confirmed and multiple speculated dens around the site, including several along the Knapdale Range near the project area. Due to the relatively low ground disturbance associated with wind farms, there is not likely to be an impact on the population by works in the site.
Fragment an existing important population into two or more populations; or	**Unlikely:** Project works in the site are unlikely to fragment an existing important population. There are 611 records of this species on the site over 12 years. There are multiple confirmed and multiple speculated dens around the site, including several along the Knapdale Range near the project area. The small subpopulations in the denning habitat areas confirmed along the Knapdale Range can be collectively considered as a single population. Temporary disturbance to a subpopulation associated with the clearance and construction phase of the project is unlikely to significantly impact the population as a whole. However, the operation phase of the project may cause ongoing simultaneous disturbance to several subpopulations and hence have an impact on the collective Knapdale Range population. However, due to the relatively low ground disturbance associated with wind farms, the small size of the site, the connectivity of the surrounding habitat, and the small range of rock-wallabies, works within the site are unlikely to fragment any existing populations.
Adversely affect habitat critical to the survival of the species; or	**Unlikely:** Project works in the site are unlikely to adversely affect habitat critical to the survival of the species. There are 611 records of this species on the site over 12 years. There are multiple confirmed and multiple speculated dens around the site, including several along the Knapdale Range near the project area. The purple-necked rock wallaby favours habitat which includes boulder piles, rocky slopes, cliffs and gorges in limestone areas, and sandstone and quartzite outcrops amongst dry Eucalyptus and Acacia woodlands. It also inhabits spinifex grasslands in association with the rocky areas (Rowland, 2012). The ongoing noise, pressure and vibrations produced during the operation phases of the project have the possibility to disturb surrounding habitat, making it less preferable for rock-wallabies. There is a risk of conditioning avoidance and affecting normal distribution patterns of rock-wallabies on site. However, due to the small size of the project area and the large area of local habitat available, works within the site are unlikely to adversely affect habitat critical to the survival of the species.
Disrupt the breeding cycle of an important population; or	**Possible:** It is possible that the disturbance associated with project works in the site could disrupt the breeding cycle of an important population. There are 611 records of this species on the site over 12 years. There are multiple confirmed and multiple speculated dens around the site, including several along the Knapdale Range near the project area. The small subpopulations in the denning habitat areas confirmed along the Knapdale Range can be collectively considered as a single population. Temporary disturbance to a subpopulation associated with the clearance and

Is there a chance or possibility that an action will?	Response
	construction phase of the project is unlikely to significantly impact the population as a whole. However, the operation phase of the project may cause ongoing simultaneous disturbance to several subpopulations and hence have an impact on the collective Knapdale Range population. The ongoing noise and vibrations produced during the operation phases of the project have the possibility to disturb surrounding habitat, including these dens, making it less preferable for rock-wallabies. There is a risk of conditioning avoidance and affecting normal distribution patterns of rock-wallabies on site. Due to the proximity of known dens, it is possible that the disturbance associated with project works in the site could disrupt the breeding cycle of an important population
Modify, destroy, remove, or isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline; or	**Possible:** It is possible that the disturbance associated with project works in the site could impact habitat to the extent that the species is likely to decline. There are 611 records of this species on the site over 12 years. There are multiple confirmed and multiple speculated dens around the site, including several along the Knapdale Range near the project area. The purple-necked rock wallaby favours habitat which includes boulder piles, rocky slopes, cliffs and gorges in limestone areas, and sandstone and quartzite outcrops amongst dry Eucalyptus and Acacia woodlands. It also inhabits spinifex grasslands in association with the rocky areas (Rowland, 2012). The small subpopulations in the denning habitat areas confirmed along the Knapdale Range can be collectively considered as a single population. Temporary disturbance to a subpopulation associated with the clearance and construction phase of the project is unlikely to significantly impact the population as a whole. However, the operation phase of the project may cause ongoing simultaneous disturbance to several subpopulations and hence have an impact on the collective Knapdale Range population. The ongoing noise and vibrations produced during the operation phases of the project have the possibility to disturb surrounding habitat, making it less preferable for rock-wallabies. There is a risk of conditioning avoidance and affecting normal distribution patterns of rock-wallabies on site. Due to the proximity of known utilised habitat, it is possible that the disturbance associated with project works in the site could impact habitat to the extent that the species is likely to decline.
Result in invasive species that are harmful to a vulnerable species becoming established in the vulnerable species' habitat; or	**Unlikely:** Project works in the site are unlikely to introduce and/or allow a harmful invasive species to become established in the habitat of the species. Feral cats and European Red Foxes are recognised threats to several similar species and have been detected on site. Several species of invasive flora have been detected on site and have the potential to modify the species' habitat. The project will operate under the *Biosecurity Act* (2014) and follow the General Biosecurity Obligation (GBO) to identify and manage any potential invasive species. There is not likely to be an introduction and establishment of a harmful invasive species in the habitat of the species.
Introduce disease that may cause the species to decline; or	**Unlikely:** Project works are unlikely to introduce novel diseases to the site. Hydatid disease (*Echinococcus granulosus*) and Toxoplasmosis (*Toxoplasmosis gondii*) are both recognised diseases that have the potential to threaten rock-wallaby populations. The project will operate under the *Biosecurity Act* (2014) and follow the General Biosecurity Obligation (GBO) to identify and manage detrimental diseases or pathogens if present.

Is there a chance or possibility that an action will?	Response
	There is not likely to be an introduction of a novel diseases to the rock-wallaby population on site.
Interfere substantially with the recovery of the species.	**Unlikely:** Project works in the site are unlikely to interfere substantially with the recovery of the species. There are 611 records of this species on the site over 12 years. There are multiple confirmed and multiple speculated dens around the site, including several along the Knapdale Range near the project area. Due to the relatively low ground disturbance associated with wind farms, the small size of the site, and the connectivity of the surrounding habitat, works within the site are unlikely to interfere with the recovery of the species.

Short-beaked Echidna (*Tachyglossus aculeatus)*

EPBC – Not listed. NCA – Special least concern

The Short-beaked Echidna (*Tachyglossus aculeatus*) is one of Australia's five monotreme species. It is highly specialised and feeds exclusively on ants and termites with an elongated, protrusible tongue. It is Australia's most widely distributed mammal, inhabiting almost every terrestrial environment on the continent (Menkhorst & Knight, A Field Guide to the Mammals of Australia, 2011). They rely on fallen logs, tree stumps and understory vegetation for cover.

Threats to echidnas include predation by feral carnivores such as domestic dogs, foxes, and feral cats, as well as habitat loss.

Table 40: SRI assessment for the Short-beaked Echidna (*Tachyglossus aculeatus*)

Is there a chance or possibility that an action will result in?	Response
A long-term decrease in the size of a local population; or	**Unlikely:** Project works in the site are unlikely to cause a long-term decrease in the size of a local population. There are four records within a 50km radius of the site. The species is solitary and has a very wide distribution, therefore it is not likely a local population will be impacted by works within the site.
A reduced extent of occurrence of the species; or	**Unlikely:** Project works in the site are unlikely to reduce the extent of occurrence of the species. Due to the wide distribution and range of habitats occupied, it is not likely the extent of occurrence will be impacted by works in the site.
Fragmentation of an existing population; or	**Unlikely:** Project works in the site are unlikely to fragment an existing population. There are four records within a 50km radius of the site. Due to the small size of the site and connectivity of the surrounding habitat, works within the site are very unlikely to fragment any existing populations.
The formation of genetically distinct populations as a result of habitat isolation; or	**Unlikely:** Project works in the site are unlikely to create habitat isolation. Due to the small size of the site and connectivity of the surrounding habitat, works within the site will not create habitat isolation.

Disruption to ecologically significant locations (breeding, feeding, or nesting sites) of the species	**Unlikely:** Project works in the site are unlikely to disrupt an ecologically significant location for this species. Due to the wide distribution and range of habitats occupied, it is not likely any significant locations will be impacted by works in the site.

Merten's water monitor (*Varanus mertensi*)

EPBC – Not listed. NCA – Endangered

Merten's water monitor (*Varanus mertensi*) is a moderately large semi-aquatic monitor. It has a broad distribution that encompasses coastal and inland waters across far north Australia from the Kimberley to Cape York. This species is rarely seen far from water. It is often seen basking on branches overhanging water or on rocks in the middle of streams.

Threats include toxicity from ingesting cane toads. Mertens water monitors can easily consume a cane toad large enough to result in death of the monitor (Smith & Phillips, 2006).

Table 41: SRI assessment for Merten's water monitor (*Varanus mertensi*)

Is there a chance or possibility that an action will?	Response
Lead to a long-term decrease in the size of an important population of the species; or	**Unlikely:** Project works in the site are unlikely to lead to a long-term decrease in the size of an important population of the species. There are two records of this species along Dugald River within the last 12 years. These records are not within the site but on an adjacent Harmony Gold Mining Lease. Due to the relatively low ground disturbance associated with wind farms, there is not likely to be an impact on the population by works in the site.
Reduce the area of occupancy of an important population; or	**Unlikely:** Project works in the site are unlikely to reduce the area of occupancy of an important population. There are two records of this species on the site over 12 years. Due to the relatively low ground disturbance associated with wind farms, there is not likely to be an impact on the population by works in the site.
Fragment an existing important population into two or more populations; or	**Unlikely:** Project works in the site are unlikely to fragment an existing important population. There are two records of this species along Dugald River within the last 12 years. These records are not within the site but on an adjacent Harmony Gold Mining Lease. Due to the relatively low ground disturbance associated with wind farms, the small size of the site, the connectivity of the surrounding habitat, and the small range of rock-wallabies, works within the site are unlikely to fragment any existing populations.
Adversely affect habitat critical to the survival of the species; or	**Unlikely:** Project works in the site are unlikely to adversely affect habitat critical to the survival of the species. There are two records of this species along Dugald River within the last 12 years. These records are not within the site but on an adjacent Harmony Gold Mining Lease. Dugald River, and North Creek and Silvermine Creek that feed it, represent the only suitable habitat for this species within the site. Due to the distance of the project area from Dugald River, the relatively low ground disturbance associated with wind farms, the small size of the site, and the connectivity of the surrounding habitat, works within the site are unlikely to directly adversely affect habitat critical to the survival of the species.

Is there a chance or possibility that an action will?	Response
Disrupt the breeding cycle of an important population; or	**Unlikely:** Project works in the site are unlikely to disrupt the breeding cycle of an important population of the species. There are two records of this species along Dugald River within the last 12 years. These records are not within the site but on an adjacent Harmony Gold Mining Lease. Due to the relatively low ground disturbance associated with wind farms, the small size of the site, and the connectivity of the surrounding habitat, works within the site are unlikely to disrupt the breeding cycle of an important population of the species.
Modify, destroy, remove, or isolate or decrease the availability or quality of habitat to the extent that the species is likely to decline; or	**Unlikely:** Project works in the site are unlikely to impact habitat to the extent that the species is likely to decline. There are two records of this species along Dugald River within the last 12 years. These records are not within the site but on an adjacent Harmony Gold Mining Lease. Dugald River, and North Creek and Silvermine Creek that feed it, represent the only suitable habitat for this species within the site. Due to the distance of the project area from Dugald River, the relatively low ground disturbance associated with wind farms, the small size of the site, and the connectivity of the surrounding habitat, works within the site are unlikely to directly impact habitat to the extent that the species is likely to decline.
Result in invasive species that are harmful to a vulnerable species becoming established in the vulnerable species' habitat; or	**Unlikely:** Project works in the site are unlikely to introduce and/or allow a harmful invasive species to become established in the habitat of the species. Ingestion of cane toads is a recognised threat to this species. They have been detected on site. Several species of invasive flora have been detected on site and have the potential to modify the species' habitat. The project will operate under the *Biosecurity Act* (2014) and follow the General Biosecurity Obligation (GBO) to identify and manage any potential invasive species. There is not likely to be an introduction and establishment of a harmful invasive species in the habitat of the species.
Introduce disease that may cause the species to decline; or	**Unlikely:** Project works are unlikely to introduce novel diseases to the site. There are no recognised diseases that threaten this species. The project will operate under the *Biosecurity Act* (2014) and follow the General Biosecurity Obligation (GBO) to identify and manage detrimental diseases or pathogens if present. There is not likely to be an introduction of a novel diseases to the rock-wallaby population on site.
Interfere substantially with the recovery of the species.	**Unlikely:** Project works in the site are unlikely to interfere substantially with the recovery of the species. There are two records of this species along Dugald River within the last 12 years. These records are not within the site but on an adjacent Harmony Gold Mining Lease. Due to the relatively low ground disturbance associated with wind farms, the small size of the site, and the connectivity of the surrounding habitat, works within the site are unlikely to interfere with the recovery of the species.

5. Preliminary Impact Management Plans

5.1. Design Phase

Wind farm design adjustments implemented to reduce the impact of the project:

- Positioning the turbines on the Knapdale Range to increase output without increasing the number of turbines, reducing the total RSA;
- Removing lights from the tops of the turbines to avoid attraction of aerial fauna;

5.2. Clearing and Construction Phase (also applicable to decommissioning phase)

Table 42: Preliminary Impact Management Plan - Clearing and Construction Phase

Threat	Impact	Controls/Management			
		Avoid	Minimise	Mitigate	Monitor
Introduction and/or spread of weed species due to vehicle and machinery movements across the landscape.	Modification of native habitats.	Where possible, activities must be planned to avoid movement of vehicles or machinery between properties, corridors, or areas with weed infestations. All equipment that enters site must be washed down on each occasion (including vehicles, earthmovers, generators, etc.)	General vehicle and machinery hygiene procedures implemented to minimise spreading of seeds.	Weed management and control methods will be implemented based on infestation size, location, and species of which it is comprised.	Monitoring performed as per DRM Land and Biodiversity Management Plan and management as per DRM Weed Control Program.
Introduction of pest species or increase of their	Competing with, predating on, or otherwise harming native species.	Not applicable.	Not applicable.	Implement a pest management plan (PMP)	Monitoring and management performed as per DRM Land and

Threat	Impact	Controls/Management			
		Avoid	Minimise	Mitigate	Monitor
populations in the project area.	Facilitating the infection of native species with diseases/parasites such as hydatid disease (*Echinococcus granulosus*) or toxoplasmosis (*Toxoplasmosis gondii*) which can be fatal.			for pest species found in the project area.	Biodiversity Management Plan.
	Indirectly modifying the habitat of native species.				
Contaminants and waste (including litter).	Direct harm to native fauna (e.g. ingestion of waste by a native animal).	All waste generated must be stored, handled, and transported in sealed containers. Project area to be kept free of litter.	Not applicable.	Not applicable.	Monitoring and management performed as per DRM Land and Biodiversity Management Plan.
	Indirect harm to native fauna through degradation of their habitat.	All waste generated must be stored, handled, and transported in sealed containers.	Not applicable.	Green waste produced may be used on site for rehabilitation, sediment, or erosion control.	
Noise, dust, light pollution, and vibrations (particularly during night-time works).	Confusion of birds by light causing increased risk of interactions.	Lighting will be shielded so as not to be seen from casual observers (this refers to people but will provide the same cover from passing birds) unless necessary.	Hours and amount of artificial light will be minimised wherever practical.	Not applicable.	Light meters can be used to monitor light pollution and ensure it stays at or below acceptable levels during works.

Threat	Impact	Controls/Management			
		Avoid	Minimise	Mitigate	Monitor
	Disturbing surrounding habitat making it less preferable for native species or conditioning avoidance and affecting normal distribution patterns	Lights directed away from habitat, or shields used to block light from habitat. Misting or wetting can be used to manage airborne dust particles.	Hours and amount of artificial light and noisy machine operation will be minimised wherever practical to reduce impact on surrounding habitat. Watering down and implementation of sensible driving speeds on the access roads will minimise dust generation and reduce impact on surrounding habitat.		Light meters can be used to monitor light pollution and ensure it stays at or below acceptable levels during works. Air quality, Noise and Vibration monitoring and management performed as per DRM Air Quality, Noise and Vibration Management Plan.
Construction or clearing activities.	Injury/fatality of fauna.	Pre-clearance surveys to be undertaken by qualified fauna spotter/catchers to avoid unintentional tampering of animal breeding places. Clearing will be performed sequentially to direct fauna towards adjacent habitat and away from work sites.	All people driving on site to stay on roads to lower risk of hitting an animal. Vehicle speed limits will are in place to further lower risk.	Fauna spotter/catchers operating under an approved rehabilitation permit to check areas prior to work commencing, and to be present during clearing. Fauna will preferably be allowed to move on their own accord, but if this does not occur and access is required immediately then fauna spotter/catchers operating under an approved rehabilitation permit will relocate them. Injured wildlife can be brought to local wildlife carers: **Western Qld Wildlife Rehabilitation Centres: Cloncurry – 0419 422 900**	Maintaining records of any fauna interactions on site to inform management adjustments.

Threat	Impact	Controls/Management			
		Avoid	Minimise	Mitigate	Monitor
	Destruction of native habitat (specifically important in the case of rocky habitat/sub-habitat due to importance of native fauna species reliant on such habitat).	Where possible, avoid the clearing of areas of rocky habitat due to the importance of native fauna species reliant on such habitat.	Not applicable.	Rehabilitate cleared areas that are no longer required after construction has finished.	Monitor and maintain rehabilitated sites to ensure they are progressing as required (control of weeds, etc.).
	Creating barriers to distribution of native fauna (namely the Purple-necked Rock-wallaby).	Where possible, avoid the creation of barriers within Purple-necked Rock-wallaby habitat.	Fauna ramps implemented along barriers to allow animals to cross.	Not applicable.	Maintaining records of any fauna interactions on site to inform management adjustments.
	Creating barriers damming flow to downstream water holes.	Install culverts in drainage lines to allow continued flow of water.	Not applicable.	Not applicable.	Ground and surface water monitoring as per DRM Groundwater Management Plan.
Active work areas, pits, trenches, and other hazardous disturbed areas.	Injury/fatality of fauna.	Fencing or coverings should be used to restrict access to all faunae.	Fauna ramps implemented in any pits or trenches to allow animals to escape.	Injured wildlife can be brought to local wildlife carers: **Western Qld Wildlife Rehabilitation Centres: Cloncurry – 0419 422 900**	Maintaining records of any fauna injuries/fatalities on site resulting from human activities to inform management adjustments. Open pits and trenches will be checked daily to identify and relocate trapped fauna.

5.3. Operation Phase – Terrestrial fauna

Table 43: Preliminary Impact Management Plan - Operation Phase - Terrestrial Fauna

Threat	Impact	Controls/Management			
		Avoid	Minimise	Mitigate	Monitor
Noise pollution, and vibrations.	Disturbing surrounding habitat making it less preferable for native species or conditioning avoidance and affecting normal distribution patterns.	Not applicable.	Not applicable.	Not applicable.	Air quality, Noise and Vibration monitoring and management performed as per DRM Air Quality, Noise and Vibration Management Plan. Existing DRM Purple-necked rock-wallaby Monitoring Program be extended around the Knapdale Range and the Project area to monitor the impacts of ongoing noise pollution and vibrations on the local population's range and usage of habitat and dens.

5.4. Operation Phase – Aerial fauna

Aerial fauna is managed under the Bird and Bat Management Plan (BBMP) - APPENDIX A.

6. Conclusion and Recommendations

The Project area has been studied extensively since many Suitably Qualified and Experienced personnel represented by multiple organisations over the last 14 years. This is considered to be a robust dataset for the proposed development and more than sufficient to adequately assess the potential impacts of the Project.

6.1. Summary of potential impacts

The Dugald River Mine proposed Windfarm requires additional disturbance area of 75 Ha, less than 2% of the total area of the Knapdale Range.

As category B regulated remnant vegetation is mapped for the whole of the Knapdale Range, the project will require impacts to 75 Ha of category B remnant vegetation.

Most of the proposed disturbance area has a biodiversity status of no concern at present however ERE 1.3.7b 1.3.7b: *Eucalyptus camaldulensis* fringing woodland, usually with *Lophostemon grandiflorus* and *Melaleuca bracteata* and/or *M. dissitiflora* was confirmed present within the proposed footprint. Ground-truthing surveys delineating the category B ESA - ERE 1.3.7b indicate that only 1.04 Ha of the ESA will be impacted as a result of the Project. This RE is least concern under the VM Act and as such is not assessable under the significant residual impact criteria for regulated vegetation and area of impact is only 1.04 ha of sparse vegetation type.

Total approximate area of regional ecosystem intersecting a watercourse within the proposed disturbance area is 3.5 ha (section 3.1.6.1.4). Impacts to regulated vegetation intersecting a watercourse exceed criteria 1 and 3 of the significant residual impact test of table 1 of the guidelines (Department of the Environment, 2013) (See section 4.1.1). While the total area of impact for the project exceeds the criteria, each individual area of disturbance is minimal and unavoidable.

The project will impact 68.7 Ha of regulated vegetation essential habitat for the PNRW. A significant residual impact assessment for disturbance to rock-wallaby habitat determined that significant residual impacts to the PNRW as a result of Project related disturbance will be unlikely based on the disturbance of essential habitat alone (See section 4.1.2).

Specific threats posed by the Project, and their associated impacts, are:

- Wind turbine structures, primarily rotor blades and associated RSA, causing;
    - Collisions between flying fauna and wind turbine tower, rotor, blades or other structures, or barotrauma as a result of flight close to rotor blades, resulting in injury or fatality;
    - Displacement and barrier effects resulting in greater energetic cost to fauna flying through the area;
- Noise, pressure, and vibrations from the operation of the wind turbines;
    - Potential for disturbing surrounding habitat making it less preferable for native species or conditioning avoidance and affecting normal distribution patterns.

The Project was determined to have potential for significant residual impacts to the vulnerably listed (NC Act) Purple-necked rock-wallaby due to the unknown effects of turbine operation on the rock-wallaby directly and

breeding, feeding and dispersal behaviours as a result of operation with particular respect to noise and vibrations. Potential impacts to the PNRW are assessed against the significant residual impact criteria for protected wildlife habitat in section 4 of this report.

The significant residual impact assessments concluded that the project is unlikely to have a significant impact on any additional conservation significant species assessed.

Additional least concern species and populations identified as potentially being impacted during the operation phase of the project were also assessed. While impacts from the various phases of the Project are unlikely to have residual impacts to the following least concern species populations, localised impacts may be possible for the following bird and bat species populations in the Project area:

- Birds
    - Australian Hobby (*Falco longipennis*)
    - Black Kite (*Milvus migrans*)
    - Black-breasted Buzzard (*Hamirostra melanosternon*)
    - Black-faced Woodswallow (*Artamus cinereus*)
    - Black-shouldered Kite (*Elanus axillaris*)
    - Brown Falcon (*Falco berigora*)
    - Brown goshawk (*Accipiter fasciatus*)
    - Collared Sparrowhawk (*Accipiter cirrocephalus*)
    - Fairy Martin (*Petrochelidon ariel*)
    - Little woodswallow (*Artamus minor*)
    - Masked woodswallow (*Artamus personatus*)
    - Nankeen Kestrel (*Falco cenchroides*)
    - Spotted harrier (*Circus assimilis*)
    - Varied Lorikeet (*Psitteuteles versicolor*)
    - Wedge-tailed eagle (*Aquila audax*)
    - Whistling kite (*Haliastur sphenurus*)
    - White-breasted woodswallow (*Artamus leucorhynchus*)
    - White-browed woodswallow (*Artamus superciliosus*)
    - White-necked heron (*Ardea pacifica*)
- Bats
    - Finlayson's Cave Bat (*Vespadelus finlaysoni*)
    - Gould's Wattled Bat (*Chalinolobus gouldii*)
    - Hoary Wattled Bat (*Chalinolobus nigrogriseus*)
    - Inland Broad-nosed Bat (*Scotorepens balstoni*)
    - Inland Forest Bat (*Vespadelus baverstocki*)
    - Little Broad-nosed Bat (*Scotorepens greyii*)
    - Northern Freetail Bat (*Chaerophon jobensis*)
    - Northern Free-tailed Bat (*Ozimops lumsdenae*)
    - White-striped Freetail Bat (*Austronomus australis*)

- Yellow-bellied Sheathtail Bat (*Saccolaimus flaviventris*)

The possibility of a local impact on the above species is due to their flying behaviour and their likelihood to occur in the RSA.

6.2. Recommendations

The following monitoring strategies are recommended to monitor the impacts of the project and inform implementation and adjustment of management strategies:

- Ongoing fauna monitoring and maintaining records of any fauna interactions on site, through vigilance and carrion surveying;
- Maintaining records of aerial fauna movement through the project area;
- Air quality, Noise and Vibration monitoring and management performed as per DRM Air Quality, Noise and Vibration Management Plan, with additional noise level monitoring to be implemented as part of BBUS surveys.
- Bird and Bat Management Plan (BBMP) – A bird and bat management plan outlining the species potentially impacted by the operation of the wind farm and how these species will be managed and monitored during operations is attached as APPENDIX A. This BBMP is subject to ongoing assessment and will be refined following ongoing monitoring of bird and bat activity.

7. References

AGDEH. (2005). *Background Paper to the Wildlife Conservation Plan for Migratory Shorebirds.* Canberra: Australian Government Department of the Environment and Heritage (AGDEH).

ALA. (2023, November). *Atlas of Living Australia Spatial Portal*. Retrieved from Atlas of Living Australia: spatial.ala.org/#

Alcorn, M., Alcorn, R., & Fleming, M. (1994). Wader Movement in Australia. *RAOU Report Series 94*, 1-135.

Alcorn, R. (1988). Australasian Wader Study Group Regular Wader Counts Project. Interim report to June 1987: migratory waders. *Stilt 12*, 7-23.

Atlas of Living Australia. (2023). *Atlas of Living Australia Spatial Portal*. Retrieved from Atlas of Living Australia: https://spatial.ala.org.au/

Atlas of Living Australia. (2023). *Atlas of Living Australia Spatial Portal*. Retrieved from Atlas of Living Australia: https://spatial.ala.org.au/

AustralAsian Resource Consultants Pty Ltd. (2011). *Dugald River Project Terrestrial Flora and Fauna Assessment.*

Australian Museum. (2020, December 04). *Hoary Wattled Bat*. Retrieved from Australian Museum: https://australian.museum/learn/animals/bats/hoary-wattled-bat/

Australian Museum. (2020, December 04). *Inland Forest Bat*. Retrieved from Australian Museum: https://australian.museum/learn/animals/bats/inland-forest-bat/

Bamford, M. (1988). *Kakadu National Park: a Preliminary Survey of Migratory Waders.* Melbourne: Royal Australian Ornithologists Union.

Barnett, P. (1980). Notes from King Island. *Tasmanian Naturalist*, 60:10.

Barter, M. (1992). Distribution, abundance, migration and moult of the Red Knot Calidris canutus rogersi. *Wader Study Group Bulletin Supplement 64*, 64-70.

Barter, M. (2002). *Shorebirds of the Yellow Sea: Importance, Threats and Conservation Status.* Retrieved from Wetlands International: https://www.wetlands.org/publications/shorebirds-of-the-yellow-sea-importance-threats-and-conservation-status/#

Barton, D. (1979). Albatrosses in the Western Tasman Sea. *Emu 79(1)*, 31-35.

BASE Consulting Group. (2022). *Mount James Wind Farm Bird and Bat Management Plan.* North Queensland Renewable Energy Zone Pty Ltd (NQREZ).

Bean, A. (1991). Two new species of red gum (Eucalyptus L'Herit., Myrtaceae) from Queensland. *Austrobaileya 3*, 467-471.

Bean, A. (2009). *Conservation status assessment for Eucalyptus nudicaulis (Myrtaceae).* Nomination under the NC Act.

Benl, G. (1979). Two new taxa of Ptilotus (Amaranthaceae) . *Journal of the Adelaide Botanic Gardens 1(4)*, 201-204.

BirdLife International. (2009). *Apus pacificus.* Retrieved from BirdLife International IUCN Red List of Threatened Species.

BirdLife International. (2009). *Bubulcus ibis.* Retrieved from BirdLife International IUCN Red List of Threatened Species.

BirdLife International. (2023). Species factsheet: Chalcites osculans. UCN Red List for birds.

Birdlife International. (2023). *Species factsheet: Hydropogne caspia*. Retrieved from Birdlife International.

BirdLife International. (n.d.). *East Asia/ Australiasia Flyway.* BirdLife International.

Birds Australia. (2010). *Birds in Backyards-Caspian Tern factshee*. Retrieved from Birds Australia : http://birdsinbackyards.net/species/Sterna-caspia

Blakers, M., Davies, S., & Reilly, P. (1984). *The Atlas of Australian Birds.* Melbourne: Melbourne University Press.

Brett Lane & Associates Pty Ltd. (2005). *Wind Farms and Birds: Interim Standards For Risk Assessment.* Carlton North: Australian Wind Energy Association.

Chatto, R. (2001). *The distribution and status of colonial breeding seabirds in the Northern Territory. Technical Report 70.* Parks & Wildlife Commission of the NT.

Chruszez, B., & Barclay, R. (2002). Chalinolobus gouldii. *Mammalian Species 690*, 1-4.

Churchill, S. (2008). *Australian Bats (2nd Edition).* Sydney: Allen and Unwin.

Cramp, S., & Simmons, K. (1983). *Handbook of the Birds of Europe, the Middle East and North Africa. The Birds of the Western Palearctic. Volume 3, Waders to Gulls.* Oxford: Oxford University Press.

DCCEEW. (2023). *Species Profile and Threats Database*. Retrieved from Department of Climate Change, Energy, the Environment and Water (DCCEEW): http://www.environment.gov.au/cgi-bin/sprat/public/sprat.pl

de Schauensee, R. (1970). *A Guide to the Birds of South America.* Wynnewood: Livingstone Publishing Company.

de Schauensee, R. (1984). *The Birds of China.* Oxford: Oxford University Press.

del Hoyo, J., Elliott, A., & Sargatal, J. (1996). *Handbook of the Birds of the World. Volume 3, Hoatzin to Auks.* Barcelona: Lynx Edicions.

Dennis, T. &. (1996). Distribution and abundance of White-bellied Sea-Eagles in South Australia. *Corella*, 20:93-102.

Departement of Environment and Science. (2020). *How to address environmentally sensitive areas and offset requirements in an application for an environmental authority for resource activities.* Brisbane: Queensland Government.

Department of Climate Change, Energy, the Environment and Water. (2023). *Species Profile and Threats Database*. Retrieved from http://www.environment.gov.au/cgi-bin/sprat/public/sprat.pl

Department of Environment and Heritage Protection. (2014). *Queensland Environmental Offsets Policy: Significant Residual Impact Guideline.* Brisbane: Queensland Government.

Department of Environment and Resource Management. (2009). *Fauna Survey Methodology for Environmental Impact Assessments.* Brisbane: Queensland Government.

Department of Environment and Science. (2020). *Method for mapping Matters of state environmental significance .For the State Planning Policy 2017. Version 6.0.* Brisbane: Queensland Government.

Department of Environment and Science. (2022). *Terrestrial ecology—EIS information guideline, ESR/2020/5309.* Brisbane: Queensland Government.

Department of Natural Resources, Mines and Energy. (2020). General guide to the vegetation - Accepted development vegetation clearing codes. Brisbane: State of Queensland. Retrieved from https://www.resources.qld.gov.au/__data/assets/pdf_file/0006/1447098/general-guide-vegetation-clearing-codes.pdf

Department of Resources. (2023). *Accepted development vegetation clearing code: Clearing for infrastructure - Effective 22 November 2023.* Brisbane: State of Queensland.

Department of Sustainability, Environment, Water, Population and Communities. (2011, July 6). *Threat abatement plan for the biological effects, including lethal toxic ingestion, caused by cane toads*. Retrieved from Department of Sustainability, Environment, Water, Population and Communities: http://www.environment.gov.au/resource/threat-abatement-plan-biological-effects-including-lethal-toxic-ingestion-caused-cane-toads

Department of the Environment. (2013). *Matters of National Environmental Significance: Significant impact guidelines 1.1.* Canberra: Australian Government .

Department of the Environment. (2015, April 29). *Conservation Advice Calidris ferruginea curlew sandpiper.* Retrieved from Department of the Environment: http://www.environment.gov.au/biodiversity/threatened/species/pubs/856-conservation-advice.pdf

Department of the Environment. (2015). *Conservation Advice Numenius madagascariensis eastern curlew.* Canberra: Department of the Environment.

Department of the Environment, Water, Heritage and the Arts. (2008). *Approved Conservation Advice for Elseya lavarackorum (Gulf Snapping Turtle).* Retrieved from http://www.environment.gov.au/biodiversity/threatened/species/pubs/67197-conservation-advice.pdf

Department of the Environment, Water, Heritage and the Arts. (2009). *Draft Significant impact guidelines for 36 migratory shorebirds Draft EPBC Act Policy Statement 3.21.* Canberra, ACT: Commonwealth of Australia.

DEWHA. (2009). *Draft Significant impact guidelines for 36 migratory shorebirds Draft EPBC Act Policy Statement 3.21.* Canberra: Department of the Environment, Water, Heritage and the Arts (DEWHA).

Dickman, C., Pressey, R., Lim, L., & Parnaby, H. (1993). Mammals of particular conservation concern in the Western Division of New South Wales. *Biological Conservation 65*, 219-248.

Dixon, J. (1995). Gould's wattled bat Chalinolobus gouldii (Gray 1841). *Mammals of Australia*, 2: 108-111.

Dwyer, P. (1965). Flight Patterns of some Eastern Australian Bats. *The Victorian Naturalist*, 82:40.

EcoSmart Ecology. (2021). *Property Map of Assessable Vegetation (PMAV): Dugald River Project.* Everton Park: EcoSmart Ecology.

Ecosmart Ecology. (2023). *Dugald River Wind Farm Fauna Survey Results.*

Eyre, T. J., Ferguson, D. J., Smith, G. C., Mathieson, M. T., Venz, M. F., Hogan, L. D., . . . Rowland, J. (2022(2)). *Terrestrial Vertebrate Fauna Survey Assessment Guidelines for Queensland: Field Data Sheets. Version 1.4.* Brisbane: Department of Environment and Science, Queensland Government.

Eyre, T., Ferguson, D., Smith, G., Mathieson, M., Venz, M., Hogan, L., . . . Rowland, J. (2022). *Terrestrial Vertebrate Fauna Survey Assessment Guidelines for Queensland.* Retrieved from : Department of Environment and Science, Queensland Government.

Garnett, S., & Crowley, G. (2000). *The Action Plan for Australian Birds.* Canberra: Environment Australia.

Garnett, S., Szabo, J., & Dutson, G. (2011). *The Action Plan for Australian Birds 2010.* Melbourne: Birds Australia, CSIRO Publishing.

Geering A, A. L. (2007). *Shorebirds of Australia.* Melbourne: CSIRO Publishing.

Gochfeld, M., & Burger, J. (1996). Family Sternidae (Terns). In J. del Hoyo, A. Elliot, & J. Sargatal, *Handbook of the Birds of the World – Volume 3 Hoatzin to Auks* (pp. 624-667). Barcelona: Lynx Edicions.

Good, R., Iskali, G., Lombardi, J., McDonald, T., Dubridge, K., Azeka, M., & Tredennick, A. (2022). Curtailment and acoustic deterrents reduce bat mortality at wind farms. *Wildlife Management*.

Grimmett, R., Inskipp, C., & Inskipp, T. (1999b). *A Guide to the Birds of India, Pakistan, Nepal, Bangladesh, Bhutan, Sri Lanka, and the Maldives.* Princeton: Princeton University Press.

Hall, L., & Richards, G. (1979). *Bats of eastern Australia.* Brisbane: Queensland Museum.

Hayman, P., Marchant, J., & Prater, T. (1986). *Shorebirds. An identification guide to the waders of the world.* London & Sydney: Croom Helm.

Higgins, P., & Davies, S. (1996). *Handbook of Australian, New Zealand and Antarctic Birds. Volume Three - Snipe to Pigeons.* Melbourne: Oxford University Press.

Hill, R., Bamford, M., Rounsevell, D., & Vincent, J. (1988). Little Terns and Fairy Terns in Australia - an RAOU Conservation Statement. *RAOU Report Series. 53*, 1-12.

Horsup, A. (1994). Home Range of the Allied Rock-wallaby, Petrogale assimilis. *Wildlife Research*, 65-84.

Johnson, R. W. (1986). FOUR NEW SPECIES OF IPOMOEA L. (CONVOLVULACEAE) FROM AUSTRALIA. *Austrobaileya, 2(3)*, 217–223.

Kew Royal Botanic Gardens. (2023). Ptilotus maconochiei.

Lane, B. (1987). *Shorebirds in Australia.* Sydney: Reed.

Larkins, D. (1984). Little Tern breeding colony on aritficial site at Port Botany, New South Wales. *Corella. 8*, 1-10.

Marchant, S., & Higgins, P. (1990). *Handbook of Australian, New Zealand and Antarctic Birds. Volume One - Ratites to Ducks.* Melbourne: Oxford University Press.

Marchant, S., & Higgins, P. (1993). *Handbook of Australian, New Zealand and Antarctic Birds. Volume 2 - Raptors to Lapwings.* Melbourne, Victoria: Oxford University Press.

Marchant, S., & Higgins, P. (1993). *Handbook of Australian, New Zealand and Antarctic Birds. Volume 2 - Raptors to Lapwings.* Melbourne: Oxford University Press.

May, R., Nygård, T., Falkdalen, U., Åström, J., Hamre, Ø., & Stokke, B. (2020). Paint it black: Efficacy of increased wind turbine rotor blade visibility to reduce avian fatalities. *Ecology and Evolution*.

McClure, C., Rolek, B., Dunn, L., McCabe, J., Martinson, L., & Katzner, T. (2021). Eagle fatalities are reduced by automated curtailment of wind turbines. *Journal of Applied Ecology*.

Menkhorst, P., & Knight, F. (2011). *A Field Guide to the Mammals of Australia.* Melbourne: Oxford University Press.

Menkhorst, P., & Knight, F. (2011). *A Field Guide to the Mammals of Australia.* Melbourne: Oxford University Press.

Mittermeier, R. A., & Wilson, D. E. (2015). Macropodidae. In *Handbook of the Mammals of the World – Volume 5 Monotremes and Marsupials.*

Morris, A. (1979). The declining status of the Little Tern in New South Wales. *Corella. 3*, 105-110.

Naarding, J. (1984). *Latham's Snipe (Gallinago hardwickii) in Australia and Japan. Wildlife Division Technical Report. 84/1.* Tasmania: National Parks and WIldlife Service.

Nelder, V. J., Wilson, B. A., Dillewaard, H. A., Ryan, T. S., Butler, D. W., McDonald, W. J., . . . Appelman, C. N. (2022). *Methodology for survey and mapping of regional ecosystems and vegetation. Version 6.0 .* Brisbane: Queensland Herbarium, Queensland Department of Environment and Science.

Nelder, V. J., Wilson, B. A., Thompson, E. J., & Dellewaard, H. A. (2005). *Methodology for Survey and Mapping of Regional Ecosystems and Vegetation Communities in Queensland. Version 3.1.* Brisbane: Queensland Herbarium.

NESP Threatened Species Recovery Hub. (2021). Threats to Australia's rock-wallabies (Petrogale spp.) with key directions for effective monitoring. *Project 7.5 Research findings factsheet*.

Northern Territory Government. (2015, September 1). *Whistling Kite*. Retrieved from NT.GOV.AU: https://nt.gov.au/environment/animals/wildlife-in-nt/whistling-kite

NRG Systems. (2020). *NRG White Paper - Developing an Ultrasonic Acoustic Bat Deterrent System for the Wind Industry.*

Olsen, P., Crome, F., & Olsen, J. (1993). *The Birds of Prey and Ground Birds of Australia.* Sydney: Angus and Robertson, and the National Photographic Index of Australian Wildlife.

O'Neill, M., & Taylor, R. (1986). Observations on the f light patterns and foraging behaviour of Tasmanian bats. *Australian Wildlife*, 13:427-432.

Orn. Soc. Japan. (2000). *Check-list of Japanese Birds.* Tokyo: Ornithological Society of Japan (Orn. Soc. Japan).

Pizzey, G., & Knight, F. (2012). *The Field Guide to the Birds of Australia.* Sydney: Harper Collins.

Pizzey, G., & Knight, F. (2012). *The Field Guide to the Birds of Australia.* Sydney: Harper Collins.

Queensland Globe. (2023). Retrieved from https://qldglobe.information.qld.gov.au/

Queensland Herbarium. (2021). *Regional Ecosystem Description Database (REDD) Version 12.1*. Retrieved from https://www.qld.gov.au/environment/plants-animals/plants/ecosystems/descriptions/download

Queensland Herbarium. (2023, May). Regional Ecosystem Description Database (REDD). Version 13. Brisbane: Queensland Government.

Reardon, T., McKenzie, N., Cooper, J., Appleton, B., Carthew, S., & Adams, M. (2014). A molecular and morphological investigation of species boundaries and phylogenetic relationships in Australian free-tailed bats Mormopterus (Chiroptera : Molossidae). *Australian Journal of Zoology 62(2)*.

Reardon, T., Milne, D., Kutt, A., & Armstrong, K. (2008). Finlayson's Cave Bat, Vespadelus finlaysoni. In S. Van Dyck, & R. Strahan, *The mammals of Australia. Third Edition* (pp. 565-566). Sydney: Reed New Holland.

Reside, J., Willoughby, L., & Whilliance, L. (1989). *A Report of the Management of Little Terns (Sterna albifrons) in East Gippsland During the 1988/89 Breeding Season.* Bairnsdale: Dept Conservation, Forests & Lands.

Rhodes, M., & Hall, L. (1997). Observations on Yellow-bellied sheath-tailed bats Saccoliamus flaviventris (Peters, 1867)(Chiroptera: Emballonuridae). *Australian Zoologist 30*, 351-357.

Rogers, D., Hance, I., P. S., Tzaros, C., Griffioen, P., Herring, M., . . . Weston, M. (2005). The breeding bottleneck: breeding habitat and population decline in the Australian Painted Snipe. *Status and Conservation of Seabirds in the East Asian-Australasian Flyway*, 15-23.

Rogers, D., Piersma, T., & Hassell, C. (2006). Roost availability may constrain shorebird distribution: exploring the energetic costs of roosting and disturbance around a tropical bay. *Biological Conservation 133*, 225-235.

Rowland, J. (2012). *Purple-necked rock-wallaby, Petrogale purpureicollis. Targeted species survey guidelines.* Department of Environment and Science. Brisbane: Queensland Herbarium.

Sibson, R. (1948). Charadrius leschenaulti at Miranda. *New Zealand Bird Notes*, 51.

Smith, J., & Phillips, B. (2006). Toxic tucker: the potential impact of cane toads on Australian reptiles. *Pac. Conservation Biology*, 12, 40–49.

Smith, P. (1990b). *The biology and management of the Little Tern (Sterna albifrons) in NSW. Species Management Report 1.* Sydney: NSW National Parks & Wildlife Service.

Snow, D., & Perrins, C. (1998). *The birds of the western Palearctic. Consise Edition.* Oxford: Oxford University Press.

Starks, J., & Lane, B. (1987). The northward migration of waders from Australia, February to April 1985. *Stilt 10*, 20-27.

Stewart, D., Rogers, A., & Rogers, D. (2007). Species description. In A. Geering, L. Agnew, & S. Harding, *Shorebirds of Australia* (pp. 75-196). Melbourne: CSIRO Publishing.

Sullivan, B., Wood, C., Iliff, M., Bonney, R., Fink, D., & Kelling, S. (2009). eBird: a citizen-based bird observation network in the biological sciences. *Biological Conservation*, 2282-2292.

Threatened Species Scientific Committee. (2015). Conservation Advice Malurus coronatus coronatus purple-crowned fairy-wren (western). Canberra.

Threatened Species Scientific Committee. (2016). *Conservation Advice for the Carpentarian Grasswren (Amytornis dorotheae).*

Threatened Species Scientific Committee. (2020, July 9). *Conservation Advice Falco hypoleucos - Grey Falcon.* Retrieved from Department of Agriculture, Water and the Environment : http://www.environment.gov.au/biodiversity/threatened/species/pubs/929-conservation-advice-09072020.pdf

TSSC. (2013, May 15). *Commonwealth Listing Advice on Rostratula australis (Australian Painted Snipe).* Retrieved from Department of Sustainability, Environment, Water, Population and Communities, Threatened Species Scientific Committee (TSSC): http://www.environment.gov.au/biodiversity/threatened/species/pubs/77037-listing-advice.pdf

TSSC. (2015). *Conservation Advice Erythrotriorchis radiatus red goshawk.* Canberra: Threatened Species Scientific Committee.

Urban, E., Fry, C., & Keith, S. e. (1986). *The Birds of Africa. Volume 2. Gamebirds to Pigeons. .* London: Academic Press.

Van Dyck, S., & Strahan, R. (2008). *The mammals of Australia. Third Edition.* Sydney: Reed New Holland.

Ward, S., & Woinarski, J. (2012). Threatened Species of the Northern Territory: Purple-crowned fairy-wren.

White, C., & Bruce, M. (1986). The birds of Wallacea. *B.O.U. Check-list. 7.*

Wiersma, P. (1996). Charadriidae (Plovers) species accounts. In J. del Hoyo, A. Elliot, J. Sargatal, & eds, *Handbook of the Birds of the World. Volume 3. Hoatzin to Auks.* (pp. 411-442). Barcelona: Lynx Edicions.

APPENDIX A: Bird and Bat Management Plan



Bird and Bat Management Plan

DUGALD RIVER WINDFARM

MMG DUGALD RIVER PTY LTD

May 2024

WULGURU TECHNICAL SERVICES

Contact Details	
Company	Wulguru Technical Services Pty Ltd
Project Manager	Glyn Thomas
Email	glyn@wulgurutechservices.com.au
Mail	PO Box 2553 IDALIA QLD 4810
ABN	79 644 301 655

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1. Introduction

The objective of the Bird and Bat Management Plan (BBMP) is to provide a plan for monitoring potential impacts of the windfarm on bird and bat species and to provide a strategy to manage and mitigate significant impacts.

The BBMP uses an adaptive management approach. Monitoring will indicate compliance or non-compliance under approval conditions and management strategies. It also informs where management strategies are effective and where they need to be reviewed and altered. The proposed conditions also align with the conditioning precedent in EA EPML00731213.

1.1. Background

MMG are seeking to develop a windfarm at the Dugald River Mine (DRM) on the Knapdale Range to provide a sustainable energy source for mine related activities.

The DRM is located approximately 70 km northwest of Cloncurry in western Queensland and situated adjacent to the Knapdale Range. Other infrastructure such as the mine camp are located on the range itself along with the valley fill tailings dam which is situated in the northern one-third of the range.

The rocky habitat of the Knapdale Range supports populations of Purple-necked Rock-wallaby (PNRW) (*Petrogale purpuriecolis*) which is considered a vulnerable species under the *Nature Conservation Act 1992* (NCA). Local populations are currently monitored under the MMG DRM PNRW Monitoring Program and reported annually to the Department of Environment, Science and Innovation (DESI) in accordance with the EA.

Nine locations across the Knapdale Range were selected for geotechnical investigations with the intended purpose of installation of wind turbines. Construction of turbine pads, access tracks, powerlines, and laydown areas requires 75 ha of land clearing within the lease footprint. There will be eight turbines. The Rotor-swept Area (RSA, i.e. referring to the height range within which the blades of operating wind turbines move (Brett Lane & Associates Pty Ltd, 2005) was considered at the largest dimensions possible to allow for design adjustments. The Goldwind GW 165-5.2/5.6/6.0MW (or equivalent) with a 130m hub height and 165m rotor blade diameter calculates to an RSA between 47.5m - 212.5m height above ground level, with blade rotation area of 21,382m^2. This assessment has been based on these criteria in consideration of the Precautionary Principle and in accordance with accepted methodology and conditioning style adopted through Planning guidance State Code 23: Wind farm development.

The project will consist of a clearing phase, a construction phase, an operation phase, and a decommissioning phase following mine closure.

2. Pre-construction Bird and Bat Information

2.1. Desktop analysis

A review of available information was undertaken to provide insight on the potential occurrence of bird and bat species surrounding and within the windfarm area.

A comprehensive desktop analysis was undertaken as part of the Ecological Assessment Report (WTS, 2023) to identify potential environmental values, constraints, and potential impacts within the Project area and to enhance understanding of the ecology of the area and its relationship to and connectivity with the surrounding landscape.

2.2. Survey Effort

Two rounds of Bird and Bat Utilisation surveys (BBUS) were undertaken by EcoSmart Ecology in May and September 2023 at eight survey sites, four of which are proposed turbine locations that will become impact sites upon commencement of construction and operation.

A subsequent BBUS was performed by Wulguru Technical Services (WTS) in April 2024. Four additional survey sites were included during this campaign to provide a more comprehensive coverage of the Project area, bringing the total to 12 survey sites.

Prior to commencement of construction and operation, impact and control sites are to be monitored twice yearly, once in the post-wet season and once in the pre-wet season.

2.3. Bird Survey

2.3.1. Bird Survey Methodology

Level one bird surveys are conducted as per the approved method outlined in *Wind Farms and Birds: Interim Standards For Risk Assessment* by Brett Lane & Associates (Brett Lane & Associates Pty Ltd, 2005). Level one surveys are considered to be a minimum requirement to assess the potential impacts of a wind farm on birds during the pre-construction phase.

BBUS were performed to collect quantitative data on bird use of the potential windfarm site. This can be used to estimate potential collision rates and provide a ranked abundance of species use of the site at varying heights. The BBUS involved a “Fixed-point Count” methodology where an observer is stationed at a fixed survey point for 20 minutes. During the 20 minutes, all bird species and number of birds observed were recorded. Observations of birds (and theoretically diurnally flying bats) during the survey periods were broken into BBUS and incidental observations. BBUS observations are those which include individuals observed to be flying above the predominant canopy. These observations do not include individuals that briefly fly out of the canopy layer at a low height. All other observation not conforming to BBUS records, including positively identified bird calls were recorded as incidental observations. The BBUS method provides the following information:

- Species
- Number of individuals
- Estimated distance from observer

- Estimated height above observer
- Bearing to record
- Direction of flight
- Behaviour
- Any additional notes on the observation

2.3.2. Bird Survey Results

Birds recorded during the BBUS surveys were characterised as either occurring within or outside of the RSA. These records are shown below in Table 1. An additional 76 species of bird have been historically recorded from the site. These are recorded as incidental observations and are shown in Appendix A. Bird species commonly entering RSA height can be broken into two main groups, raptors and aerial insectivores. Raptors include all species within the Accipitriformes and Falconiformes Orders, while aerial insectivores include woodswallows, martins and the rainbow bee-eater. One listed Marine species, the rainbow bee-eater was recorded during BBUS surveys. A single listed Migratory species, the glossy ibis, has historically been recorded from the Dugald River Project Area.

2.3.3. Bird Collision Likelihood Risk

Collision Risk Susceptibility of birds previously identified on site, as well as potentially occurring NCA or EPBC listed species was determined through the results of the surveys and the ecology of each species.

To determine collision risk susceptibility, a number of characteristics of bird behaviours were considered including:

- Foraging, dispersal and territorial behaviours;
- Flight manoeuvrability;
- General flight patterns;
- Size of birds; and
- Distribution, and biology.

A review of approvals issued by the State and Federal Governments informed the development of a Collision Risk Assessment. A BBMP from Base Consulting (2022) formed the basis of the assessment. Of the key collision risk characteristics, flight height pattern was given the larger weighting over distribution and biology. Flight manoeuvrability was given the lowest weighting. Table 2 below outlines the criteria evaluated for each species or group of birds assessed.

For the purposes of this report, flight height is presented as below, at or above RSA height:

A = Below RSA (< 47.5 metres above ground)

B = At RSA (40 – 212.5 metres above ground)

C = Above RSA (> 212.5 metres above ground).

Table 1. Collision Risk Assessment Table

Risk Characteristics	Criteria	Score
Flight height Expected frequency a species enters the RSA.	Never – Species not expected to enter RSA	0 – Negligible
	Occasional – Species is typically present outside of RSA but may enter infrequently.	5 – Low
	Regular – Species enters RSA, but majority of records are outside RSA.	10 – Medium
	Predominant – Species within RSA most of the time while in flight.	15 – High
Movements and biology Annual presence of a species within the Project Area.	Rare – Present once or twice per year	0 – Negligible
	Intermittent – Present <1 month of the year	2 – Low
	Seasonal/migration – Present for 1-5 months of the year	5 – Medium
	Resident – Present throughout most of the year (>5 months)	10 – High
Manoeuvrability Size and relative manoeuvrability of the bird species	Small size, highly manoeuvrable	0 – Negligible
	Small size, constrained manoeuvrability or medium size, highly manoeuvrable	2 – Low
	Medium size, constrained manoeuvrability or large size, highly manoeuvrable	4 – Medium
	Large size, constrained manoeuvrability	6 – High

Scores for each of the criteria in the above table were combined to produce an overall value for the Collision Risk Susceptibility in Table 3. Species expected to never fly in the RSA are all considered to have a low Collision Risk Susceptibility regardless of other criteria.

Threatened birds including migratory species identified from the desktop EPBC, PMST, and WildNet searches with the potential to occur within the Project Area were also considered during the risk assessment process.

Table 2. Collision Risk Susceptibility

Collision Risk Scoring	Overall Collision Risk Susceptibility
Risk score 0-10	Low
Risk score 11-20	Moderate
Risk score 21+	High

2.3.4. Bird Collision Consequence Criteria

Using the collision risk susceptibility assessment and the relative abundance of species within the Project area, potential collision consequences were able to be estimated. An evaluation of the potential collision consequences for birds is outlined in Table 4.

Table 3. Collision Consequence

Collision Consequence	Collision Consequence Criteria
No loss of individuals	• Not previously identified on site or, • Low abundance with low collision risk susceptibility
Rare loss of individuals	• Low abundance with moderate collision risk susceptibility or, • Moderate abundance with low collision risk susceptibility
Occasional loss of individuals	• Low abundance with high collision risk susceptibility or, • Moderate abundance with moderate collision risk susceptibility or, • High abundance with low collision risk susceptibility
Repeated loss of individuals	• Moderate abundance with high collision risk susceptibility or, • High abundance with moderate collision risk susceptibility
Significant loss of individuals	• High abundant with high collision risk susceptibility

2.3.5. Bird Collision Risk Assessment

2.3.5.1. General Order Risk Assessment

General risk assessments have been made at the Order or Family (for some passerine birds) level for all species found on site, this assessment can be found in Appendix B. The most at risk Orders of birds known to occur within the project area are the Accipitriformes, the Coraciiformes (in part), the Falconiformes, and the Families *Artamidae* and *Hirundinidae* of the Passeriformes Order. Many of these species of birds have been recorded within the proposed RSA of the Project area.

2.3.5.2. Listed Species Risk Assessment

NCA/EPBC listed species deemed as having a 'possible' likelihood of occurrence in WTS's Ecological Assessment Report have been assessed at a species level in Appendix C (Wulguru Technical Services, 2023). Only two species of bird listed under the NC or EPBC Acts are considered to have the potential for losses of individuals as a consequence or turbine interaction. The glossy ibis (EPBC: Marine, Migratory) is considered to have the potential for rare loss of individuals, while the rainbow bee-eater (EPBC: Marine) is considered to have the potential for repeated loss of individuals as identified in previous tables.

Species recorded within the RSA have been assessed at a species level; data from the onsite BBUS was used to inform the assessment. Birds recorded within the RSA are assessed separately in Table 5 below.

2.3.5.3. RSA species

Analysis of the collision consequences for bird species within the RSA did not identify any species as having the potential for significant loss of individuals via turbine interaction. However, based on these assessments, four species were considered to have the potential for repeated loss of individuals. These are as follows:

- Black-faced woodswallow (*Artamus cinereus*)
- Little woodswallow (*Artamus minor*)
- Masked woodswallow (*Artamus personatus*)
- Rainbow bee-eater (*Merops ornatus*)

All other species recorded within the RSA are considered to have the potential for rare or occasional loss of individuals via turbine interaction.

Table 4. Collision Risk for Species Recorded Within Rotor Swept Area

Species	Description and behaviour	Total Records	Records within RSA	% within RSA	Collision Risk Susceptibility	Collision Consequence
Raptors						
Black kite (*Milvus migrans*)	A dark-coloured kite with a distinct fish-tailed appearance from below. The black kite is common across much of the country, often appearing in high abundance in response to favourable foraging conditions, such as bushfires, locust, and mouse plagues (Pizzey & Knight, 2012). The black kite is abundant around the mine and camp area, a typical trait of this species. It is likely this species will occur along the Knapdales in higher abundance when conditions are suitable. Recorded soaring within the RSA.	2	2	100	High	Occasional loss of individuals
Black-shouldered kite (*Elanus axillaris*)	A small, predominantly white kite with black shoulders. The black-shouldered kite is present across most of mainland Australia and may be irruptive in areas in response to prey availability (Pizzey & Knight, 2012). Observed foraging within the RSA	2	1	50	High	Occasional loss of individuals
Brown falcon (*Falco berigora*)	The brown falcon is a large species of falcon with distinct dark double teardrop markings descending from either side of the eye. This species is fairly common across most of Australia, often irruptive in response to high prey abundance (Pizzey & Knight, 2012). This species is known to fly within the RSA.	5	3	60	High	Occasional loss of individuals
Nankeen kestrel (*Falco cenchroides*)	A small falcon, light brown to rufous from above with distinct black wing tips. The nankeen kestrel is often seen hovering above grasslands searching for prey to dive on (Pizzey & Knight, 2012). It has been observed foraging within the RSA	3	1	33.3	High	Occasional loss of individuals
Wedge-tailed eagle (*Aquila audax*)	Australia's largest bird of prey with an unmistakeable diamond-shaped tail from below. The wedge-tailed eagle is typically varying shades of brown, with older individuals darker than the light brown immatures. Often scavenges on carrion but also a very proficient predator, capable of taking large prey items including macropods (Pizzey & Knight, 2012). Typically seen flying within the RSA, often soaring on thermal air currents of the Knapdale Range.	6	5	83.3	High	Occasional loss of individuals
Whistling kite (*Haliastur sphenurus*)	A medium-sized raptor typically sandy-brown in colouration. The whistling kite has a rounded tail from below, with a distinct pale band on each underwing. A regular species across most of Australia, the whistling kite feeds on carrion as well as captured prey (Pizzey & Knight, 2012). Typically flies within the RSA, observed soaring on thermal currents over the Knapdales.	4	4	100	High	Occasional loss of individuals
Aerial Insectivores						
Black-faced woodswallow (*Artamus cinereus*)	A common and widespread species, the black-faced woodswallow is regularly seen swooping from powerlines and other vantage points (Pizzey & Knight, 2012). It is abundant around the main mine area, as well as on the Knapdale Range. This species forages at or below RSA height.	35	29	82.9	High	Repeated loss of individuals

Species	Description and behaviour	Total Records	Records within RSA	% within RSA	Collision Risk Susceptibility	Collision Consequence
Little woodswallow (*Artamus minor*)	The smallest species of woodswallow. It is chocolate-brown in colour within a blueish bill (Pizzey & Knight, 2012). It is the most abundant aerial insectivore within the Project area for most of much of the year, though may be outnumbered by the masked woodswallow on seasonal migration. Forages at or below RSA height.	133	63	47.4	Moderate	Repeated loss of individuals
Masked woodswallow (*Artamus personatus*)	A distinct woodswallow with a large black mask extending from above the eye to the top of the breast. Considered a part-migratory species, the masked woodswallow typically arrives in northern Australia from its breeding habitat in the south in Autumn (Pizzey & Knight, 2012). These dispersive events often see the species travelling in expansive flocks which may be at a high risk of collision with turbines. Travels and forages at RSA height.	200	200	100	Moderate	Repeated loss of individuals
Rainbow bee-eater (*Merops ornatus*)	An unmistakable, vibrantly coloured bird with a finely curved bill. The rainbow bee-eater is a proficient predator of bees, wasps, flies, and similar insects which it catches on the wing (Pizzey & Knight, 2012). Large groups may forage at RSA height in periods of high insect activity.	11	9	81.8	High	Repeated loss of individuals
Fairy martin (*Petrochelidon ariel*)	A small martin with a distinct ginger cap. The fairy martin undertakes a regular migration to the north from its breeding habitat in southeastern Australia, typically arriving in the north from March to April before leaving in September to October (Pizzey & Knight, 2012). Recorded foraging at RSA height.	31	12	38.7	Moderate	Occasional loss of individuals
Other Birds						
Australasian Darter (*Anhinga novaehollandiae*)	A unique cormorant-like bird with a distinct long, pointed bill and long neck. The Australasian darter is an proficient semi-aquatic predator of fish and invertebrates (Pizzey & Knight, 2012). This species is probably a regular inhabitant of watercourses in the vicinity of the Project area. Flies at RSA height but likely limited to rare passes from dispersing individuals.	2	2	100	Moderate	Rare loss of individuals
Varied Lorikeet (*Psitteuteles versicolor*)	A small, predominantly green lorikeet with a pinkish cap and upper breast. The varied lorikeet is nomadic in response to the flowering patterns of *Eucalyptus* and *Melaleuca* species (Pizzey & Knight, 2012). It is very abundant across the project area but rarely enters the RSA. Most individuals or flocks fly quickly at around or just above canopy height.	52	1	1.9	Low	Occasional loss of individuals
White-faced Heron (*Egretta novaehollandiae*)	A medium-sized, mostly grey heron with a white face and yellow legs. It is likely a regular inhabitant of watercourses within the greater Project area. Flies at RSA height but likely limited to rare passes from dispersing individuals.	1	1	100	Moderate	Rare loss of individuals
White-necked Heron (*Ardea pacifica*)	A moderately large heron with a predominantly white head and neck and a slatey grey body. This species is probably a regular inhabitant of watercourses in the vicinity of the Project area. Flies at RSA height but likely limited to rare passes from dispersing individuals.	2	2	100	Moderate	Rare loss of individuals

Only two species of bird listed under the NC or EPBC Acts are considered to have the potential for losses of individuals as a consequence or turbine interaction. The glossy ibis (EPBC: Marine, Migratory; NCA: SL) is considered to have the potential for rare loss of individuals, while the rainbow bee-eater (EPBC: Marine) is considered to have the potential for repeated loss of individuals as identified in previous tables.

2.4. Bat Survey

2.4.1. Bat Survey Methodology

Bats are monitored at each BBUS site using Anabat Chorus passive high-frequency sound recorders to capture microbats calls. One Anabat Chorus bat detector was installed at each of the 12 survey sites for two nights. These passive detectors were set to record in full spectrum .wav files from one hour before sunset to one hour after sunrise. Bat call analysis to identify microbat species present was undertaken by Greg Ford of Balance Environmental for EcoSmart Ecology's two initial rounds of surveying. Bat call analysis undertaken in 2024 was undertaken by Professor Simon Robson for WTS. Additionally, the BBUS methodology can be used to record bat species should they be identified during surveys.

2.4.2. Bat Survey Results

The following bat species have been recorded during BBUS surveys of the Project Area, either by EcoSmart Ecology or WTS (Table 6). As bat presence is measured entirely by call monitoring, relative abundance of bats species is not able to be accurately estimated. Many factors influence the detectability of bat calls, including flight height, distance from recorder, weather and other variables. Additionally, repeated recordings of singular or small numbers of individuals flying close to the bat detector can significantly skew abundance data. As such, for this report we consider bat call records as a confirmation of presence only and not a determinant of relative bat abundance.

2.4.3. Bat Collision Risk Assessment

Collision Risk Susceptibility of bat species previously identified on site through call detection was determined through the review of available literature, with particular reference to flight heights. The collision risks for bats are explained in Table 7, and an evaluation of bat flight heights and their relative collision risks is outlined in Table 8. As with the bird collision risk table, these are derived from a report from Base Consulting (2022).

Table 5: Collision Risk Susceptibility for Bats Recorded on Site During BBUS Surveys

Risk Characteristic	Criteria	Collision Risk
Flight height Expected frequency a species enters the RSA.	Never – Species not expected to fly at RSA height	Low
	Occasional – Species may fly at RSA height during some scenarios	Moderate
	Frequent – Species regularly flies at RSA heigh	High

Table 6: Collision Risk for Bat Species Identified During BBUS Surveys

Species	RSA utilisation	General Description	Flight speed and Manoeuvrability (slow, medium, highly agile)	General flight height	Collision Risk Susceptibility	Collision Consequence
Finlayson's Cave Bat (*Vespadelus finlaysoni*)	Not expected	This species forms colonies that occupy caves or cavities within rocky terrain and will take residence in abandoned mining operations. This species forages for prey near water (Menkhorst & Knight, 2011).	Rapid flight with high mobility suited to foraging over water	<15m	Low	No loss of individuals
Gould's Wattled Bat (*Chalinolobus gouldii*)	Foraging	*C. gouldii* is insectivorous; in much of its range, moths are the most common food item. Other known prey includes cockroaches, flies, stoneflies, orthopterans, hemipterans, hymenopterans and other lepidopterans, including caterpillars. Grass seeds and twig fragments are occasionally ingested as well (Chruszcz & Barclay, 2002). In wooded areas, they are mostly arboreal, though they have also been found in the stumps and hollow limbs of trees or in bird nests.	Rapid flight with limited manoeuvrability	May fly to RSA height	Moderate	Occasional loss of individuals
Hoary Wattled Bat (*Chalinolobus nigrogriseus*)	Not expected	These bats prefer to roost in the hollows of eucalypt trees, and occasionally rock crevices. They like to fly fast below the canopy layer and therefore live in areas where the undergrowth is naturally sparse. They can commonly be found in a range of habitats, including Forests, woodlands, vine thickets, coastal scrub and open grasslands, across the coastal hinterland regions of Queensland (Churchill, Australian bats, 2008) (Hall, 2009).	Rapid flight with high mobility suited to foraging below the canopy	<15m	Low	No loss of individuals
Inland Broad-nosed Bat (*Scotorepens balstoni*)	Not expected	Foraging is achieved using echolocation whilst in continuous flight, keeping within 15 metres of the ground, with rapid diversions to pursue prey. Foraging mainly occurs between trees, not going above the tree canopy, as well as at	Rapid flight with high mobility suited to foraging below the canopy	<25m	Low	No loss of individuals

Species	RSA utilisation	General Description	Flight speed and Manoeuvrability (slow, medium, highly agile)	General flight height	Collision Risk Susceptibility	Collision Consequence
		the edges of forests venturing into open areas. Foraging locations in the drier distribution areas appear to depend on nearness to water points and roosting sites (Churchill, Australian bats, 2008).				
Inland Forest Bat (*Vespadelus baverstocki*)	Not expected	The flight of the species is fluttery and rapid, sharply turning as it forages over water.	Rapid flight with high mobility suited to foraging over water	<15m	Low	No loss of individuals
Little Broad-nosed Bat (*Scotorepens greyii*)	Foraging	The Little broad-nosed bat is an insectivore which feed and drink while in flight. They forage for prey close to treetops, over water, open grassland and other open habitat. They are characteristically fast fliers which make abrupt darts and turns to catch prey (Churchill, 2009) (Van Dyck & Strahan, 2008) (Menkhorst & Knight, 2011).	Rapid flight with high mobility suited to foraging over water and canopy	May fly to RSA height	Moderate	Occasional loss of individuals
Northern Freetail Bat (*Chaerophon jobensis*)	Foraging	They will fly and forage in groups of two or more individuals. Its foraging style utilizes fast, direct flight suited for open areas or above canopies. It is insectivorous, consuming beetles, bugs, moths, lacewings, grasshoppers, cockroaches, flies and leafhoppers (Kutt, Milne, & Richards, 2008).	Rapid flight with limited manoeuvrability	May fly to RSA height	Moderate	Occasional loss of individuals
Northern Free-tailed Bat (*Ozimops lumsdenae*)	Not expected	*O. lumsdenae* is associated with permanent water, agricultural dams, and watercourses in semi-arid regions, where it resides and forages in eucalypt woodland (Reardon & Armstrong, 2020). Roosts in tree hollows.	Rapid flight with high mobility suited to foraging below the canopy	<15m	Low	No loss of individuals
White-striped Freetail Bat (*Austronomus australis*)	Foraging	This free-tailed bat is a specialized high altitude, fast flying interceptor insectivore. Their diet consists principally of moths, beetles and bugs. This species can be	Rapid flight with high manoeuvrability	Flies at RSA height	High	Occasional loss of individuals

Species	RSA utilisation	General Description	Flight speed and Manoeuvrability (slow, medium, highly agile)	General flight height	Collision Risk Susceptibility	Collision Consequence
		found in most habitats from closed forest to open flood plain, and occurs in urban areas, in regions across temperate and subtropical Australia.				
Yellow-bellied Sheathtail Bat (*Saccolaimus flaviventris*)	Not expected	Yellow-bellied sheath-tailed bats are canopy feeders, meaning that they are capable of fast flight, but inefficient at rapid manoeuvring. They generally feed at heights of 20–25 m, unless feeding in open spaces or at forest edges, where they forage lower (Churchill, Australian bats, 2008) (Rhodes, Hall, & Parish, 1997).	Rapid flight with low manoeuvrability	<25m	Low	Rare loss of individuals
Bristle-faced Free-tailed Bat (*Setirostris eleyri*)		Bristle-faced Free-tailed Bats are locally uncommon across inland Australia, and only known to inhabit riparian zones and floodplains. During the day these bats roost in tree hollows of mature eucalypts, but are noted as squeezing themselves into other tiny crevices. The observations are along drainage lines and open channels, flying with slow fluttering movements below the canopy at a low altitude of 3 to 4 metres (Pennay, 2006).	Rapid flight with high mobility suited to foraging below the canopy	<15m	Low	No loss of individuals
Common Sheathtail Bat (*Taphozous georgeanis*)		Common Sheathtail Bats roost in caves, old mines and cracks in rocks. They often rest on rocks during the night's feeding. They hunt alone, flying slowly in a straight line while following a grid pattern over the feeding ground. They feed over bushes and water catching and eating insects while flying (Australian Museum, 2020).	Slow flight with low manoeuvrability	May fly to RSA height	Moderate	Rare loss of individuals

3. Potential impacts

The potential impacts of the windfarm to birds and bats lie within the construction and operation phases, and have been listed below:

- Loss or degradation of habitat through clearing of turbine pads and tracks.
- Wind turbine structures, primarily rotor blades and associated RSA, causing;
    - Collisions between flying fauna and wind turbine rotor blades or other structures, or barotrauma as a result of flight close to rotor blades, resulting in injury or fatality. The likelihood of a collision is dependent on a range of factors, including:
        - Design characteristics, such as:
            - the type of wind turbine; and
            - the layout of the wind farm;
        - site characteristics, including:
            - the ecosystems on the wind farm site;
            - proximity to bird concentrations;
            - the numbers of birds moving across the wind farm site;
            - the behaviours of birds and bats (e.g. soaring at RSA height); and
            - weather conditions (Brett Lane & Associates Pty Ltd, 2005).
    - Displacement and barrier effects resulting in greater energetic cost to fauna flying through the area;
- Noise pollution, pressure, and vibrations from the operation of the wind turbines;
    - Light confusing/disorientating aerial fauna increasing risk of collision (risk has been nullified by design adjustments – lighting will not be present on the turbines); or
    - Disturbing surrounding habitat making it less preferable for native species or conditioning avoidance and affecting normal distribution patterns.

4. Monitoring and Management

4.1. Ongoing BBUS

BBUS will continue throughout the construction and operation phase with the same methodology, with the potential to increase survey timing from biannually to quarterly as the construction and operation phases begin.

Ongoing BBUS during operation, compared to pre-construction surveys, should also monitor avoidance behaviours defined below:

- Avoidance – involves birds remaining on a wind farm site but flying around, over or under operating wind turbines and it is a commonly observed behaviour at wind farms.
- Diversion – involves birds remaining within the area around a wind farm but avoiding the wind farm site entirely.
- Displacement – involves birds being displaced through disturbance from the area around the wind farm.

4.2. Carrion monitoring

Carrion monitoring involves surveying of the areas immediately under or around the turbines for carcasses of birds and bats.

In the first instance, surveys should cover an area out to a distance equivalent to the height of the wind turbine for dead birds, remains and feather spots. This distance can be altered if carcass locations indicate this.

For each turbine in the windfarm, a 220m radius area will be searched surrounding the turbine once per month, on a random day, until searchers are satisfied they have found what they can/what is present. Information on each carcass found should be recorded as follows:

- date;
- species;
- signs of injury and likelihood of death due to collision;
- signs of scavenging;
- distance and bearing from turbine tower base;
- ground conditions (e.g. height and density of vegetation, presence of stock, etc.);and
- aerosphere conditions (e.g. visibility conditions such as fog, wind, rain, current and previous 24hr weather conditions).

Carrion monitoring should occur for the first 48 months of the windfarms operation phase. If a significant level of bird or bat mortality to a regional species or species population is measured, then the monitoring should continue (Brett Lane & Associates Pty Ltd, 2005).

The number of carcasses found during surveys is an underestimated measure of the true mortality rate, as it is affected by two major biases: the overlooking of carcasses present in the field; and carcass disappearance before being counted due to removal by scavengers or other means (Barrientos, et al., 2018; Wood, 2017).

A scavenging trial should be undertaken at least twice during the first 48 months of operation during different times of the year. The aim of this trial is to determine the typical rate of removal of carcasses by scavengers, and therefore estimate the likelihood a carcass is detected during carrion monitoring and provide more accurate estimates of bird and bat fatality rate from the wind farm.

Outside of the scavenging trial, carcasses should be removed when located to prevent unnecessary attraction of scavengers to the area potentially resulting in higher bird mortality.

Eight carcasses collected during carrion monitoring, or incidentally from the roads, should be frozen and kept for use in the scavenging trial, with an even ratio of small and large birds if available. One carcass should be placed within the carrion monitoring radius at each turbine, along with an appropriately placed camera trap to capture scavenging birds and monitor the condition of the carcass. Carcasses should be checked weekly until there is no flesh left for scavenging. It is important to note the condition (wholeness) of the carcass upon initial collection, the size (small or large bird), and the

time taken for partial (~50%) and complete (~100%) removal or decomposition of the carcass, as well as the species observed scavenging. The removal of carcasses during carrion monitoring will reduce the chance of scavenger swamping, a bias observed in some scavenging trials caused by an abundance of available carcasses reducing the likelihood of scavenging of the monitored ones.

A searcher efficiency trial should be run in the same season as the scavenger trial, up to twice per year, to determine the proportion of bird and bat fatalities that the observer undertaking the searches actually finds. Four to eight additional carcasses collected during carrion monitoring, or incidentally from the roads, should be frozen and kept for use in the searcher trial, with an even ratio of small and large birds if available. Chicken or mice sourced from pet food suppliers may be used as surrogates for bird and bat carcasses if required. Carcasses should be placed within a 50m radius surrounding a random wind turbine by a member of staff not involved in the searcher efficiency trial, ensuring that carcasses are placed in a stratified random manner that reflects a natural carcass resting place, and that they reflect the habitat of the full carrion monitoring area including different vegetation types/densities, crevices, gullies, and flat areas. An approximate 50/50 split should be used of carcasses in cover and in the open, with an even ration of small and large birds in each if available. The searcher efficiency trial search should be performed to the same thoroughness as the carrion monitoring, that is until searchers are satisfied they have found what they can/what is present.

Correction factors for scavenging and observer efficiency should be developed from these trials and applied to the monitored number of dead birds in order to derive an estimate of collision rate (Brett Lane & Associates Pty Ltd, 2005).

If carcasses are identified repeatedly for a period of 3 months a strategy will be developed to manage the risk of collision and monitoring design will be updated to confirm the level of impact.
It is assumed that a fauna collision with the turbine will be fatal. However, injured wildlife will be referred to local wildlife carers:
Western Qld Wildlife Rehabilitation Centres: Cloncurry – 0419 422 900

4.3. Management

Table 7: General Management Strategies

Threat	Impact	Controls/Management				
		Avoid	Minimise	Mitigate	Monitor	Timing
Introduction and/or spread of weed species due to vehicle and machinery movements across the landscape.	Modification of native habitats.	Where possible, activities must be planned to avoid movement of vehicles or machinery between properties, corridors, or areas with weed infestations. All equipment that enters site must be washed down on each occasion (including vehicles, earthmovers, generators, etc.)	General vehicle and machinery hygiene procedures implemented to minimise spreading of seeds.	Weed management and control methods will be implemented based on infestation size, location, and species of which it is comprised.	Monitoring performed as per DRM Land and Biodiversity Management Plan and management as per DRM Weed Control Program.	During construction and operation
Introduction of pest species or increase of their populations in the project area.	Competing with, predating on, or otherwise harming native species.	Not applicable.	Not applicable.	Implement a pest management plan (PMP) for pest species found in the project area.	Monitoring and management performed as per DRM Land and Biodiversity Management Plan.	During construction and operation
	Facilitating the infection of native species with diseases/parasites					
	Indirectly modifying the habitat of native species.					
	Indirect harm to native fauna through degradation of their habitat.	All waste generated must be stored, handled, and transported in sealed containers.	Not applicable.	Green waste produced may be used on site for rehabilitation, sediment, or erosion control.		
Noise, dust, light pollution, and vibrations (particularly	Confusion of birds by light causing increased risk of interactions.	Works will not occur at night.	Hours and amount of artificial light will be minimised wherever practical.	Not applicable.	Light meters can be used to monitor light pollution and ensure it stays at or below acceptable levels during works.	During construction and operation

during night-time works).	Disturbing surrounding habitat making it less preferable for native species or conditioning avoidance and affecting normal distribution patterns	Works will not occur at night. Misting or wetting can be used to manage airborne dust particles.	Hours and amount of artificial light and noisy machine operation will be minimised wherever practical to reduce impact on surrounding habitat. Watering down and implementation of sensible driving speeds on the access roads will minimise dust generation and reduce impact on surrounding habitat.		Light meters can be used to monitor light pollution and ensure it stays at or below acceptable levels during works. Air quality, Noise and Vibration monitoring and management performed as per DRM Air Quality, Noise and Vibration Management Plan.	
Construction or clearing activities.	Injury/fatality of fauna.	Pre-clearance surveys to be undertaken by qualified fauna spotter/catchers to avoid unintentional tampering of animal breeding places. Clearing will be performed sequentially to direct fauna towards adjacent habitat and away from work sites.	All people driving on site to stay on roads to lower risk of hitting an animal, and follow vehicle speed limits to further lower risk. Speed limit along turbine access roads will be 20km/h or less.	Fauna spotter/catchers operating under an approved rehabilitation permit to check areas prior to work commencing, and to be present during clearing. Fauna will preferably be allowed to move on their own accord, but if this does not occur and access is required immediately then fauna spotter/catchers operating under an approved rehabilitation permit will relocate them. Injured wildlife can be brought to local wildlife carers: **Western Qld Wildlife Rehabilitation Centres: Cloncurry – 0419 422 900**	Maintaining records of any fauna interactions on site as per existing WAF Permits to inform management adjustments.	During design and construction

	Destruction of native habitat	Where possible, avoid the clearing of areas of habitat	Not applicable.	Rehabilitate cleared areas that are no longer required after construction has finished.	Monitor and maintain rehabilitated sites to ensure they are progressing as required (control of weeds, etc.).	
Wind turbine structures, primarily rotor blades and associated RSA.	Collisions between flying fauna and wind turbine rotors or other structures, or barotrauma as a result of flight close to rotors, resulting in injury or fatality.	Not applicable.	Maintain slashed grass transitioning into low shrub cover surrounding turbine pad to minimise bird and bat foraging and to facilitate carcass counts/removal. Project design including turbine selection and siting to minimise on ground disturbance footprint and total RSA, and increase RSA low boundary to reduce impact on aerial fauna.	Follow impact triggers and associated adaptive management strategies.	Follow impact triggers and associated adaptive management strategies.	During design and construction

5. Impact triggers and Adaptive Management

The impact triggers below are in accordance with the interim standards for risk assessment for wind farms and birds (Brett Lane & Associates Pty Ltd, 2005).

An impact trigger for threatened species occurs where a carcass (or recognisable part) of a threatened bird or bat species (listed under the NCA or EPBC Act) is found under or in close proximity to a turbine during any carcass search or incidentally during commissioning or operation.

For non-threatened birds and bat species, an impact trigger is where two or more of the same species, in two successive searches at the same turbine is recorded (i.e. a total of four or more carcasses of the same species in two successive searches at the same turbine) (Brett Lane & Associates Pty Ltd, 2005).

Under Condition D34 of the EA Permit (EPML00731213), this information will be made available to the administering authority upon request, and within forty eight (48) hours of the discovery of any fauna mortalities. Details of mortalities will include but not be limited to:

- animal species of the discovery of any fauna mortality;
- number of animals;
- location; and
- likely cause of death.

If the event is considered a potentially regular occurrence (based on assessment of survey data), or likely to lead to an impact to the population (at the appropriate scale i.e. Local, Regional, State, National); species specific monitoring may be required to determine potential causes and mitigation measures.

Table 8: Impacts and Mitigation Measures

Potential cause of impact	Monitoring to determine cause of impact	Mitigation Measure in response to impact trigger	Likelihood of impact after implementation of mitigation
Foraging source identified that attracts 'at risk' species to impact areas (e.g. flowering eucalypts, carrion associated with road kills, or spawning of insects).	Conduct additional targeted BBUS to assist in determining activity during these events. Conduct additional carrion monitoring in response to these events to determine if events are linked to impacts.	Trial acoustic or visual deterrents at turbine/s responsible for impact trigger.	Low
			Low
Bushfire, low pressure systems and storm fronts creating favourable conditions for aerial foragers.			Low
Low visibility due to wind/rain/fog.			Low

Potential options for acoustic deterrents include:

- The NRG ultrasonic acoustic Bat Deterrent System – which showed a 50% reduction in bat fatalities between turbines with 5 modules and turbines with none over a two year study in Texas (NRG Systems, 2020); and
- The Scarecrow 180™ - a well-researched bio-acoustic bird dispersal system. When coupled with a Scarecrow 360™ 'slave' unit it creates a system that provides 360º of dispersal.

6. References

Ashmole, N. P. (2022, August 29). *pelecaniform*. Retrieved from Encyclopedia Britannica: https://www.britannica.com/animal/pelecaniform

Atlas of Living Australia. (n.d.). Retrieved from http://www.ala.org.au

Austin, O. L., Clench, M. H., & Gill, F. (2024, April 11). *passeriform*. Retrieved from Encyclopedia Britannica: https://www.britannica.com/animal/passeriform

Australian Museum. (2020, 12 03). *Common Sheathtail Bat*. Retrieved from Australian Museum: https://australian.museum/learn/animals/bats/common-sheathtail-bat/

Barrientos, R., Martins, R. C., Ascensão, F., D'Amico, M., Moreira, F., & Borda-de-Água, L. (2018). A review of searcher efficiency and carcass persistence in infrastructure-driven mortality assessment studies. *Biological Conservation 222*, 146-153.

BASE Consulting. (2022). *Mount James Wind Farm Bird and Bat Management Plan.* Porcupine: BASE Consulting.

Birdlife Australia. (2022). *Rainbow Bee-eater*. Retrieved from Birdlife Australia: https://birdlife.org.au/bird-profile/rainbow-bee-eater

Birdlife Australia. (2024). Retrieved from Birdlife Australia: Birdlife.org.au/bird-profile

BirdLife International. (2023). *Species factsheet: Hydroprogne caspia. IUCN Red List for birds*. Retrieved February 24, 2023

Bollich, E. (n.d.). *Struthioniformes*. Retrieved from Animal Diversity Web: https://animaldiversity.org/accounts/Struthioniformes/

Bouglouan, N. (n.d.). *otididae*. Retrieved from Oiseaux Birds: https://www.oiseaux-birds.com/page-family-otididae.html

Brett Lane & Associates Pty Ltd. (2005). *Wind Farms and Birds: Interim Standards For Risk Assessment.* Carlton North: Australian Wind Energy Association.

Chruszcz, B., & Barclay, M. (2002). *Mammalian Species Chalinolobus gouldii - Archived 2007-07-13 at the Wayback Machine.* The American Society of Mammalogists.

Churchill, S. (2008). *Australian bats.* Crows Nest: Allen & Unwin.

Churchill, S. (2009). *Australian bats, 2nd ed.* Crows Nest: Allen & Unwin.

Clunie, P. (1994). *Flora & Fauna Guarantee Action Statment No 60 - White-bellied Sea-eagle.* Retrieved from DSE Vic: http://www.dse.vic.gov.au/web%2Froot%2Fdomino%2Fcm_da%2Fnrenpa.nsf/frameset/NRE+Plants+and+Animals?OpenDocument

del Hoyo, J., Elliot, A., & Sargatal, J. (1992). *Handbook of the Birds of the World: Ostrich to Ducks.* Barcelona: Lynx Edicions.

del Hoyo, J., Elliott, A., & Sargatal, J. (1994). *Handbook of the Birds of the World. Volume 2: New World Vultures to Guineafowl.* Barcelona: Lynx Edicions.

Department of Environment and Science. (2022). *Terrestrial ecology—EIS information guideline, ESR/2020/5309.* Brisbane: Queensland Government.

Ferguson-Lees, J., & Christie, D. (2001). *Raptors of the World.* London: Christopher Helm.

Fogarty, M., & Hetrick, W. (1973). Summer Foods of Cattle Egrets in North Central Florida. *The Auk*, 90(2):268-280.

Friedmann, H. (2024, January 24). *cuculiform*. Retrieved from Encyclopedia Britannica: https://www.britannica.com/animal/cuculiform

Gill, F., & Brown, L. H. (2016, August 26). *falconiform*. Retrieved from Encyclopedia Britannica: https://www.britannica.com/animal/falconiform

Gill, F., & Woolfenden, G. E. (2024, April 10). *psittaciform*. Retrieved from Encyclopedia Britannica: https://www.britannica.com/animal/psittaciform

Gowland, P. (1988). *RAOU Microfiche.* Moonee Pond: RAOU.

Hall, L. (2009). *Bats, A Wild Australia Guide*. Steve Parish Publishing.

Haverschmidt, F. (2023, July 9). *galliform*. Retrieved from Encyclopedia Britannica: https://www.britannica.com/animal/galliform

Higgins, P., & Davies, S. (1996). *Handbook of Australian, New Zealand and Antarctic Birds. Volume Three - Snipe to Pigeons.* Melbourne: Oxford University Press.

Kutt, A. S., Milne, D. J., & Richards, G. C. (2008). Northern Freetail-bat Chaerephon jobensis. In S. Van Dyck, & R. Strahan, *The Mammals of Australia* (pp. 485-486). Reed New Holland.

Lane, B. (1987). *Shorebirds in Australia.* Sydney: Reed.

Maddock, M. (1990). Cattle Egrets: South to Tasmania and New Zealand for the winter. *Notornis*, 37(1):1-2.

Marchant, S., & Higgins, P. (1990). *Handbook of Australian, New Zealand and Antarctic Birds. Volume One - Ratites to Ducks.* Melbourne: Oxford University Press.

Marchant, S., & Higgins, P. (1993). *Handbook of Australian, New Zealand and Antarctic Birds. Volume 2 - Raptors to Lapwings.* Melbourne: Oxford University Press.

Marshall, J. T., & Gill, F. (2024, April 12). *owl*. Retrieved from Encyclopedia Britannica: https://www.britannica.com/animal/owl

May, R., Nygård, T., Falkdalen, U., Åström, J., Hamre, Ø., & Stokke, B. (2020). Paint it black: Efficacy of increased wind turbine rotor blade visibility to reduce avian fatalities. *Ecology and Evolution*.

McClure, C., Rolek, B., Dunn, L., McCabe, J., Martinson, L., & Katzner, T. (2021). Eagle fatalities are reduced by automated curtailment of wind turbines. *Journal of Applied Ecology*.

Menkhorst, P., & Knight, F. (2011). *A Field Guide to the Mammals of Australia.* Melbourne: Oxford University Press.

Murton, R. K. (2023, November 17). *columbiform*. Retrieved from Encyclopedia Britannica: https://www.britannica.com/animal/columbiform

Ocean Animals. (2023). *Suliformes*. Retrieved from Ocean Animals: https://oceananimals.org/seabirds/suliformes/#section-19211d0-2

Pennay, M. (2006). *Ecological Study of the Endangered Bristle-nosed Bat (Mormopterus species 6) and Survey of Microchiropteran Bats in Gundabooka National Park.* Upper Darling Region: NSW National Parks & Wildlife Service.

Pizzey, G., & Knight, F. (2012). *The Field Guide to the Birds of Australia.* Sydney: Harper Collins.

Pringle, J. (1987). The Shorebirds of Australia. In J. Pringle, *National Photographic Index of Australian Wildlife.* Sydney: Angus and Robertson.

Rand, A. L. (2023, September 14). *coraciiform*. Retrieved from Encyclopedia Britannica: https://www.britannica.com/animal/coraciiform

Reader's Digest. (1997). *Complete Book of Australian Birds (second edition).* Sydney: Reader's Digest Australia Pty Ltd.

Reardon, T., & Armstrong, K. (2020). Mormopterus lumsdenae. *IUCN Red List of Threatened Species*.

Rhodes, M., Hall, L., & Parish, S. (1997). Observations on Yellow-bellied sheath-tailed bats Saccoliamus flaviventris (Peters, 1867)(Chiroptera: Emballonuridae). *Australian Zoologist*, 30:351-357.

Rose, A. (2001). Supplementary records of the food of some terrestrial non-passerines in New South Wales. *Australian Bird Watcher*, 19:60-68.

Schwartz, P. A. (2008, July 9). *Caprimulgiform*. Retrieved from Britannica: https://www.britannica.com/animal/caprimulgiform

Seedikkoya, K., Azeez, P., & Shukkur, E. (2007). Cattle egret as a biocontrol agent. *Zoo's Print Journal*, 22(10):2864-2866.

Siegfried, W. (1971). The food of the Cattle Egret. *Journal of Applied Ecology*, 8(2):447-468.

Simpson, K., & Day, N. (1999). *Field guide to the birds of Australia, 6th Edition.* Penguin Books.

Storer, R. W. (2023, November 14). *grebe*. Retrieved from Encyclopedia Britannica: https://www.britannica.com/animal/grebe

Telfair II, R. (2006). Cattle Egret (Bubulcus ibis). *The Birds of North America Online*.

TSSC. (2015, October 31). *Conservation Advice Malurus coronatus coronatus purple-crowned fairy-wren (western).* Retrieved from Threatened Species Scientific Committee (TSSC): http://www.environment.gov.au/biodiversity/threatened/species/pubs/64442-conservation-advice-31102015.pdf

Van Dyck, S., & Strahan, R. (2008). *The Mammals of Australia.* New Holland Publishers.

Vestjens, W. (1977). *Technical Memorandum Division of Wildlife Research.* CSIRO.

Ward, S., & Woinarski, J. (2012, December). *PURPLE-CROWNED FAIRY-WREN (Western subspecies) Malurus coronatus coronatus.* Retrieved from Threatened Species of the Northern Territory: chrome-extension://efaidnbmnnnibpcajpcglclefindmkaj/https://nt.gov.au/__data/assets/pdf_file/0003/206364/purple-crowned-fairy-wren.pdf

Wood, M. (2017). *Macarthur Wind Farm Bat and Avifauna Mortality Monitoring.*

Wulguru Technical Services. (2023). *MMG - Dugald River Windfarm Ecological Assessment Report.*

Appendix A – incidental species records

Common Name (*Scientific Name*)	Order	Status*	
		NCA	EPBC
Collared Sparrowhawk (*Accipiter cirrocephalus*)	Accipitriformes	LC	NL
Spotted Harrier (*Circus assimilis*)	Accipitriformes	LC	NL
Black Swan (*Cygnus atratus*)	Anseriformes	LC	NL
Australian Owlet-nightjar (*Aegotheles cristatus*)	Caprimulgiformes	LC	NL
Spotted Nightjar (*Eurostopodus argus*)	Caprimulgiformes	LC	NL
Tawny Frogmouth (*Podargus strigoides*)	Caprimulgiformes	LC	NL
Black-fronted Dotterel (*Elseyornis melanops*)	Charadriiformes	LC	NL
Pied Stilt (*Himantopus leucocephalus*)	Charadriiformes	LC	NL
Little Button-quail (*Turnix velox*)	Charadriiformes	LC	NL
Peaceful Dove (*Geopelia placida*)	Columbiformes	LC	NL
Spinifex Pigeon (*Geophaps plumifera*)	Columbiformes	LC	NL
Crested Pigeon (*Ocyphaps lophotes*)	Columbiformes	LC	NL
Common Bronzewing (*Phaps chalcoptera*)	Columbiformes	LC	NL
Red-backed Kingfisher (*Todiramphus pyrrhopygius*)	Coraciiformes	LC	NL
Pallid Cuckoo (*Heteroscenes pallidus*)	Cuculiformes	LC	NL
Pheasant Coucal (*Centropus phasianinus*)	Cuculiformes	LC	NL
Horsefield's Bronze Cuckoo (*Chalcites basalis*)	Cuculiformes	LC	NL
Common Koel (*Eudynamys orientalis*)	Cuculiformes	LC	NL
Australian Hobby (*Falco longipennis*)	Falconiformes	LC	NL
Black Falcon (*Falco subniger*)	Falconiformes	LC	NL
Brown Quail (*Synoicus ypsilophorus*)	Galliformes	LC	NL
Australian Bustard (*Ardeotis australis*)	Otidiformes	LC	NL
Spiny-cheeked Honeyeater (*Acanthagenys rufogularis*)	Passeriformes	LC	NL
Yellow-rumped Thornbill (*Acanthiza chrysorrhoa*)	Passeriformes	LC	NL
Kalkadoon Grasswren (*Amytornis ballarae*)	Passeriformes	LC	NL
Dusky Woodswallow (*Artamus cyanopterus*)	Passeriformes	LC	NL
White-browed Woodswallow (*Artamus superciliosus*)	Passeriformes	LC	NL
Pied Honeyeater (*Certhionyx variegatus*)	Passeriformes	LC	NL
Spotted Bowerbird (*Chlamydera maculata*)	Passeriformes	LC	NL
Great bowerbird (*Chlamydera nuchalis*)	Passeriformes	LC	NL
Banded Honeyeater (*Cissomela pectoralis*)	Passeriformes	LC	NL
Black-tailed Treecreeper (*Climacteris melanurus*)	Passeriformes	LC	NL
Grey Shrike-thrush (*Colluricincla harmonica*)	Passeriformes	LC	NL
Little Shrike-thrush (*Colluricincla megarhyncha*)	Passeriformes	LC	NL
White-bellied Cuckoo-shrike (*Coracina papuensis*)	Passeriformes	LC	NL
Grey Butcherbird (*Cracticus torquatus*)	Passeriformes	LC	NL
Varied Sittella (*Daphoenositta chrysoptera*)	Passeriformes	LC	NL
Crimson Chat (*Epthianura tricolor*)	Passeriformes	LC	NL
Singing Honeyeater (*Gavicalis virescens*)	Passeriformes	LC	NL
Western Gerygone (*Gerygone fusca*)	Passeriformes	LC	NL

Magpie Lark (*Grallina cyanoleuca*)	Passeriformes	LC	NL
Australian Magpie (*Gymnorhina tibicen*)	Passeriformes	LC	NL
Pictorella Mannikin (*Heteromunia pectoralis*)	Passeriformes	LC	NL
White-winged Triller (*Lalage tricolor*)	Passeriformes	LC	NL
White-plumed Honeyeater (*Lichenostomus penicillatus*)	Passeriformes	LC	NL
Brown Honeyeater (*Lichmera indistincta*)	Passeriformes	LC	NL
Purple-backed Fairy-wren (*Malurus assimilis*)	Passeriformes	LC	NL
Red-backed Fairy-wren (*Malurus melanocephalus*)	Passeriformes	LC	NL
Yellow-throated Miner (*Manorina flavigula*)	Passeriformes	LC	NL
Rufous Songlark (*Megalurus mathewsi*)	Passeriformes	LC	NL
Northern Inland Hooded Robin (*Melanodryas cucullata picata*)	Passeriformes	LC	NL
Brown-headed Honeyeater (*Melithreptus brevirostris*)	Passeriformes	LC	NL
Black-chinned Honeyeater (*Melithreptus gularis*)	Passeriformes	LC	NL
Jacky Winter (*Microeca fascinans*)	Passeriformes	LC	NL
Paperbark Flycatcher (*Myiagra nana*)	Passeriformes	LC	NL
Crested Bellbird (*Oreoica gutturalis*)	Passeriformes	LC	NL
Olive-backed Oriole (*Oriolus sagittatus*)	Passeriformes	LC	NL
Rufous Whistler (*Pachycephala rufiventris*)	Passeriformes	LC	NL
Red-browed Pardalote (*Pardalotus rubricatus*)	Passeriformes	LC	NL
Striated Pardalote (*Pardalotus striatus*)	Passeriformes	LC	NL
Red-capped Robin (*Petroica goodenovii*)	Passeriformes	LC	NL
Long-tailed Finch (*Poephila acuticauda*)	Passeriformes	LC	NL
Grey-crowned Babbler (*Pomatostomus temporalis*)	Passeriformes	LC	NL
Spinifexbird (*Poodytes carteri*)	Passeriformes	LC	NL
Yellow-tinted Honeyeater (*Ptilotula flavescens*)	Passeriformes	LC	NL
Grey Fantail (*Rhipidura fuliginosa*)	Passeriformes	LC	NL
Weebill (*Smicrornis brevirostris*)	Passeriformes	LC	NL
Double-barred Finch (*Taeniopygia bichenovii*)	Passeriformes	LC	NL
Glossy Ibis (*Plegadis falcinellus*)	Pelicaniformes	SL	M
Australasian Grebe (*Tachybaptus novaehollandiae*)	Podicepediformes	LC	NL
Red-winged Parrot (*Aprosmictus erythropterus*)	Psittaciformes	LC	NL
Cloncurry Ringneck (*Barnardius zonarius macgilvrayi*)	Psittaciformes	LC	NL
Sulphur-crested Cockatoo (*Cacatua galerita*)	Psittaciformes	LC	NL
Southern Boobook (*Ninox boobook*)	Strigiformes	LC	NL
Eastern Barn Owl (*Tyto alba*)	Strigiformes	LC	NL
Emu (*Dromaius novaehollandiae*)	Struthioniformes	LC	NL

* NCA = *Nature Conservation Act 1992*; EPBC = *Environment Protection and Biodiversity Conservation Act 1999*; CR = Critically Endangered; EN = Endangered; VU = Vulnerable; NT = Near Threatened; SLC = Special Least Concern; LC = Least Concern; M = Migratory; Ma = Marine

Appendix B - General Collision Risk Assessment For Bird Orders/Families

Order	RSA Utilisation	General description	Flight speed and Manoeuvrability (slow, medium, highly agile)	General Flight height	Size (small/ medium/ large)	Total Records within Project area	Collision Risk Susceptibility	Collision Consequence
Accipitriformes	Foraging and dispersing	Accipitriformes is an order of birds that includes most of the diurnal birds of prey, including hawks, eagles, vultures, and kites, but not falcons (Atlas of Living Australia, n.d.).	Fast flight with medium manoeuvrability	Within RSA	Medium to large	16	High	Occasional loss of individuals
Anseriformes	Dispersal	Anseriformes is an order of birds also known as waterfowl that comprises about 180 living species of birds in three families. Most modern species in the order are highly adapted for an aquatic existence at the water surface. (Atlas of Living Australia, n.d.)	Slow with low manoeuvrability	Typically below RSA height, other than migration.	Large		Low	No loss of individuals
Caprimulgiformes	Dispersal	Caprimulgiformes are soft-plumaged birds, the major groups of which are called nightjars, nighthawks, potoos, frogmouths, and owlet-frogmouths. Most are twilight- or night-flying birds (Schwartz, 2008).	Medium speed with medium manoeuvrability	Typically below RSA height, other than dispersal.	Medium		Low	No loss of individuals
Charadriiformes	Dispersal	Charadriiformes is a diverse order of small to medium-large birds. Most charadriiform birds live near water and eat invertebrates or other small animals; however, some are pelagic (seabirds), others frequent deserts, and a few are found in dense forest. Members of this group can also collectively be referred to as shorebirds (Atlas of Living Australia, n.d.).	Slow to medium speed with low manoeuvrability	Foraging activities occur under RSA height, but dispersal flight height is within the RSA	Small to medium		Low	No loss of individuals

Order	RSA Utilisation	General description	Flight speed and Manoeuvrability (slow, medium, highly agile)	General Flight height	Size (small/ medium/ large)	Total Records within Project area	Collision Risk Susceptibility	Collision Consequence
Columbiformes	Not likely	Columbiformes is an order of birds containing the pigeons and doves in one family, and the extinct dodo and solitaire in another. The pigeon family (Columbidae) contains about 316 species (Murton, 2023).	Medium speed with medium manoeuvrability	Typically below RSA height	Small to medium	43	Low	Rare loss of individuals
Coraciiformes	Dispersal and foraging for some species	Coraciiformes is an order of usually colourful birds including kingfishers and bee-eaters. The members of this order are linked by their “slamming” behaviour in which they thrash their prey into surfaces (Rand, 2023).	Medium speed with high manoeuvrability	Dispersal flight height is within the RSA. Foraging may occur in the RSA for some species	Small to medium	11	Moderate to high	Rare to repeated loss of individuals
Cuculiformes	Dispersal	Cuculiformes is an order of birds containing the cuckoos and the hoatzin. Most cuckoos are solitary, often furtive birds that are inconspicuous even when relatively common, and they do not form flocks (Friedmann, 2024).	Medium speed with medium manoeuvrability	May fly within height of RSA	Small to medium		Low	No loss of individuals
Falconiformes	Foraging and dispersal	Falconiformes is an order of birds containing falcons; diurnal raptors but not included in the order Accipitriformes with the others. Although rarely abundant, falcons are widespread and live in diverse habitats (Gill & Brown, falconiform, 2016).	Fast flight with high manoeuvrability	Within RSA	Medium	8	High	Occasional loss of individuals
Galliformes	Not likely	Galliformes is an order of fowl-like birds containing 290 species including turkeys, chickens, quail, pheasant, and peacock (Haverschmidt, 2023).	Fast flight but rarely sustained for long distances. Low manoeuvrability	Typically below RSA height	Small to large		Low	No loss of individuals

Order	RSA Utilisation	General description	Flight speed and Manoeuvrability (slow, medium, highly agile)	General Flight height	Size (small/ medium/ large)	Total Records within Project area	Collision Risk Susceptibility	Collision Consequence
Otidiformes	Not likely	Otidiformes is an order of large birds containing bustards, floricans, and korhaans. They are highly terrestrial, often seen walking slowly or staying motionless among the vegetation. They don't fly very often but can sustain strong flight when they do (Bouglouan, n.d.).	Fast flight with low manoeuvrability	Typically below RSA height	Large		Moderate	Rare loss of individuals
Passeriformes *Artamidae*	Foraging and dispersal	The *Artamidae* family of the Order Passeriformes includes the woodswallows, butcherbirds and the Australian magpie. Most are predatory, feeding on a vast array of prey items, from insects to reptiles and other birds.	Variable. Some species fast and agile.	Some species frequently within RSA	Small to medium	292	Moderate to High	Occasional to repeated loss of individuals
Passeriformes *Hirundinidae*	Foraging and dispersal	The *Hirundinidae* family of the Order Passeriformes includes swallows and martins. These passerine birds are specifically adapted for aerial feeding on insects.	Fast flight with high manoeuvrability.	Within the RSA	Small	31	Moderate	Repeated loss of individuals
Passeriformes *Other families*	Foraging and dispersal	Passeriformes is the largest order of birds and the dominant avian group comprised of approximately 5700 species. Passeriformes are true perching birds characterised by their four toes, three directed forward and one backward. The majority are insectivorous, some being aerial feeders and others gleaning insects from surfaces (Austin, Clench, & Gill, 2024).	Variable. Some species fast and agile.	May fly within height of RSA	Small to medium	174	Low to Moderate	Occasional loss of individuals

Order	RSA Utilisation	General description	Flight speed and Manoeuvrability (slow, medium, highly agile)	General Flight height	Size (small/ medium/ large)	Total Records within Project area	Collision Risk Susceptibility	Collision Consequence
Pelecaniformes	Dispersal	Pelecaniformes is an order of large aquatic birds with webbing or partial webbing between all four toes, including pelicans, egrets, ibises, and spoonbills. The various groups of Pelecaniformes are specialized for different feeding methods, however they all feed at bodies of water (Ashmole, 2022).	Medium speed with low manoeuvrability	May fly within height of RSA	Large	5	Moderate	Rare loss of individuals
Podicipediformes	Dispersal	Podicipediformes is an order comprised of a single family of foot-propelled diving birds called Grebes. Grebes feed and breed on still or slow-moving bodies of water (Storer, 2023).	Medium speed with low manoeuvrability	May fly within height of RSA	Medium		Moderate	Rare loss of individuals
Psittaciformes	Dispersal	Psittaciformes is an order of more than 360 species of generally bright coloured, noisy birds. Typically, parrots are gregarious and noisy, often forming small groups, sometimes huge flocks, flying rapidly high overhead and screeching. Parrots feed almost entirely on plant materials. The smaller species tend to utilize grass seeds, berries, fruits, and the juices of blossoms; the larger forms obtain fruits and nuts from trees and bulbs, tubers, and roots from the ground (Gill & Woolfenden, 2024).	Medium speed with medium manoeuvrability	May fly within height of RSA	Medium	98	Moderate	Rare loss of individuals

Order	RSA Utilisation	General description	Flight speed and Manoeuvrability (slow, medium, highly agile)	General Flight height	Size (small/ medium/ large)	Total Records within Project area	Collision Risk Susceptibility	Collision Consequence
Strigiformes	Foraging and dispersing	Strigiformes is an order of primarily nocturnal raptors known as owls. Owls often attain higher population densities than hawks, the distribution and density of most species seem to be limited by the availability of suitable nesting sites, rather than by the number of potential prey animals. Owls that hunt over grassland hunt by sustained flight, dropping into the grass to catch rodents. Many woodland owls secure prey by dropping from perches at the edges of forest openings. The nocturnal routine of most owls involves peaks of activity at dusk and dawn (Marshall & Gill, 2024).	Fast flight with high manoeuvrability	May fly within height of RSA	Medium to large		Moderate	Rare loss of individuals
Struthioniformes	Not likely	Struthioniformes is an order of large flightless birds of which there are approximately 15 species. In Australia this refers to Emus and Cassowaries. They are omnivorous, and often good runners due to their long muscular legs (Bollich, n.d.).	Flightless	Flightless	Large		Low	No loss of individuals
Suliformes	Dispersal	Suliformes is a relatively new order of birds that includes cormorants, anhingas, frigatebirds, and boobies. These birds are adapted for life in the water and are generally large, with long wings and webbed feet. Suliformes are social animals and can often be found in large groups (Ocean Animals, 2023).	Medium speed with medium manoeuvrability	May fly within height of RSA	Large	2	Moderate	Rare loss of individuals

Appendix C - Collision Risk for NC and EPBC Act Listed Species

Common name (*Scientific name*)	Status*		Likelihood of occurrence	RSA Utilisation	Flight Habits	General Flight height	Size (small/ medium/ large)	Behaviour, habitat and feeding	Records on site	Collision Risk Susceptibility	Collision Consequence
	NCA	EPBC									
Cattle Egret (*Bubulcus ibis*)	LC	Ma	Possible	Dispersing	Capable of flying large distances. Is not considered highly mobile in the air	Would fly within the RSA.	Medium	The cattle egret has undergone one of the most rapid and wide-reaching natural expansions of any bird species (Telfair II, 2006). Cattle egret populations can be both sedentary and migratory (Maddock, 1990). If migrating, migration takes place from the south during spring. The cattle egret feeds on a wide range of prey, particularly insects, especially grasshoppers, crickets, flies (adults and maggots), and moths, (Seedikkoya, Azeez, & Shukkur, 2007)	Nil	Moderate	No loss
Sharp-tailed Sandpiper (*Calidris acuminata*)	SL	M, Ma, V	Possible	Dispersing	Capable of flying great distance during migration.	Likely to fly within RSA height during migration	Medium	The Sharp-tailed sandpiper prefers the grassy edges of shallow inland freshwater wetlands. It is also found around sewage farms, flooded fields, mudflats, mangroves, rocky shores and beaches. Its breeding habitat in Siberia is the peat hummock and lichen tundra of the high Arctic The Sharp-tailed sandpiper feeds on aquatic insects and their larvae, as well as worms, molluscs, crustaceans and sometimes, seeds. It is often found in large flocks, often with other waders, foraging in shallow waters (Pringle, 1987) (Simpson & Day, 1999).	Nil	Low	No loss

Common name (*Scientific name*)	Status*		Likelihood of occurrence	RSA Utilisation	Flight Habits	General Flight height	Size (small/ medium/ large)	Behaviour, habitat and feeding	Records on site	Collision Risk Susceptibility	Collision Consequence
	NCA	EPBC									
Black-eared Cuckoo (*Chalcites osculans*)	LC	Ma	Possible	Dispersing	Mobile agile flyer	May fly within height of RSA, but not normally at this height	Small	The Black-eared cuckoo is a parasitic breeder, that is, it lays its eggs in the nests of other birds. By preference, the Black-eared cuckoo chooses the domed or enclosed nests of species such as the Speckled Warbler, or the Redthroat (Birdlife Australia, 2024) It is migratory, moving into the sub-coastal areas of south-east and south-west Australia for the summer. The Black-eared Cuckoo perches on a shrub or tree, and drops from its perch to forage for insects on the ground. Would generally forage within canopy height (Birdlife Australia, 2024).	Nil	Low	No loss of individuals
Latham's Snipe (*Gallinago hardwickii*)	SL	M, Ma, V	Possible	Dispersing	Capable of flying great distance during migration. Moderate mobility	May fly to RSA during migration	Medium	Latham's Snipe is a migratory wader, travelling to Australia during the warmer months, typically arriving in Australia in September. Birds may fly directly between Japan and Australia, stopping at a few staging areas. They leave their breeding areas from August to November, arriving in Australia mainly in September. They leave the south-east by the end of February, moving northwards along the coast. Most have left Queensland by mid-April (Pringle, 1987) (Higgins & Davies, 1996). Latham's snipes are omnivorous, eating seeds and plant material, worms, spiders and insects, some molluscs, isopods and centipedes (Higgins & Davies, 1996) (Lane, 1987).	Nil	Low	No loss of individuals

Common name (*Scientific name*)	Status*		Likelihood of occurrence	RSA Utilisation	Flight Habits	General Flight height	Size (small/ medium/ large)	Behaviour, habitat and feeding	Records on site	Collision Risk Susceptibility	Collision Consequence
	NCA	EPBC									
White-bellied Sea-Eagle (*Haliaeetus leucogaster*)	LC	Ma	Possible	Dispersing	Capable of flying great distance. Moderate mobility	Likely to fly within RSA height	Large	Inhabits a variety of habitats including coasts, islands, estuaries, inlets, large rivers, inland lakes, reservoirs. Widespread along all Australian coasts, travels inland along large rivers or to large water sources. (Pizzey & Knight, 2012). The White-bellied Sea-Eagle feeds opportunistically on a variety of fish, birds, reptiles, mammals and crustaceans, and on carrion and offal (Rose, 2001). The White-bellied Sea-Eagle hunts its prey from a perch, or whilst in flight (by circling slowly, or by sailing along 10–20 m above the shore). When a prey item is located, the sea-eagle usually launches into a dive or shallow glide to snatch its prey, usually in one foot, from the ground or water surface (Clunie, 1994) (del Hoyo, Elliott, & Sargatal, Handbook of the Birds of the World. Volume 2: New World Vultures to Guineafowl, 1994) (Ferguson-Lees & Christie, 2001) (Marchant & Higgins, 1993).	Nil	High	No loss of individuals
Caspian tern (*Hydroprogne caspia*)	SL	M, Ma	Possible	Dispersing	Capable of flying great distance during migration. Moderate mobility	May fly to RSA during migration	Medium	A large, part-migratory to migratory species of tern with a cosmopolitan distribution. In Australia, this species is primarily coastal, though travels inland to visit large bodies of water (Pizzey & Knight, 2012). The Caspian Tern's diet consists predominantly of fish (5–25 cm in length) as well as the eggs and young of other birds, carrion, aquatic invertebrates (e.g. crayfish), flying insects and earthworms (Birdlife International 2010a). They	Nil	Low	No loss of individuals

Common name (*Scientific name*)	Status*		Likelihood of occurrence	RSA Utilisation	Flight Habits	General Flight height	Size (small/ medium/ large)	Behaviour, habitat and feeding	Records on site	Collision Risk Susceptibility	Collision Consequence
	NCA	EPBC									
								forage diurnally, mostly early to mid-morning, patrolling in slow lazy flight, 3–15 m above the water. The species may forage up to 60 km from their nesting site (BirdLife International, 2023) (Higgins & Davies, 1996).			
Purple-crowned Fairy-wren (*Malurus coronatus*)	V		Possible	Foraging	Highly agile	Unlikely to fly within the RSA	Small	The species occurs from the Kimberly region to the gulf of Carpentaria drainage of western Queensland and north-eastern Northern Territory (TSSC, 2015). The species is restricted to a narrow band around well-vegetated river channels. They prefer thick riparian vegetation, typically of cane grass and/or pandanus, but also dense patchy shrubs up to 3 m (Ward & Woinarski, 2012). Purple-crowned fairy-wrens are territorial and sedentary, feeding in loose groups in the undergrowth or on the ground. The species is mainly insectivorous, consuming a range of small invertebrates such as beetles, ants, bugs, wasps, grasshoppers, moths, larvae, spiders, and worms and small quantities of seeds. They forage for their prey amongst foliage and in the leaf litter on the ground that may have accumulated as debris during floods.	Nil	Low	No loss of individuals

Common name (*Scientific name*)	Status*		Likelihood of occurrence	RSA Utilisation	Flight Habits	General Flight height	Size (small/ medium/ large)	Behaviour, habitat and feeding	Records on site	Collision Risk Susceptibility	Collision Consequence
	NCA	EPBC									
Rainbow Bee-eater (*Merops ornatus*)	LC	M	Known	Dispersing / Foraging	Highly mobile and agile in flight. Able to forage for insects on the wing. On migration, the Rainbow bee-eater may also fly over the top of non-preferred habitats such as rainforest or treeless plains	Would fly within the RSA.	Small	The Rainbow Bee-eater is most often found in open forests, woodlands and shrublands, and cleared areas, usually near water. It will be found on farmland with remnant vegetation and in orchards and vineyards. It will use disturbed sites such as quarries, cuttings and mines to build its nesting tunnels (Birdlife Australia, 2022). The species is mainly insectivorous. Birds consume a range of small invertebrates captured in flight, including wasps, bees, dragonflies and similar.	11 (BBUS)	High	Repeated loss of individuals
Glossy ibis (*Plegadis falcinellus*)	SL	Ma, M	Known	Dispersing	Capable of flying large distances. Is not considered highly mobile in the air	Would fly within the RSA.	Medium	Prefers well-vegetated wetlands, floodplains, irrigated pastures, sewage ponds, mangroves, mudflats though may occur in dry grasslands further inland, particularly during good rainfall years. The migratory and nomadic species breeds in southern Australia between October to December and in north Australia between February to April (Pizzey & Knight, 2012). Glossy Ibis feed mainly on aquatic invertebrates/insects such as freshwater snails, mussels, crabs and crayfish. The species will also, however, eat fish, frogs and tadpoles, dryland invertebrates (such as beetles and grasshoppers), lizards, small snakes and nestling birds (del Hoyo, Elliot, & Sargatal, 1992) (Gowland, 1988) (Marchant & Higgins, 1990) (Vestjens, 1977).	One (prelim. surveys)	Moderate	Rare loss of individuals

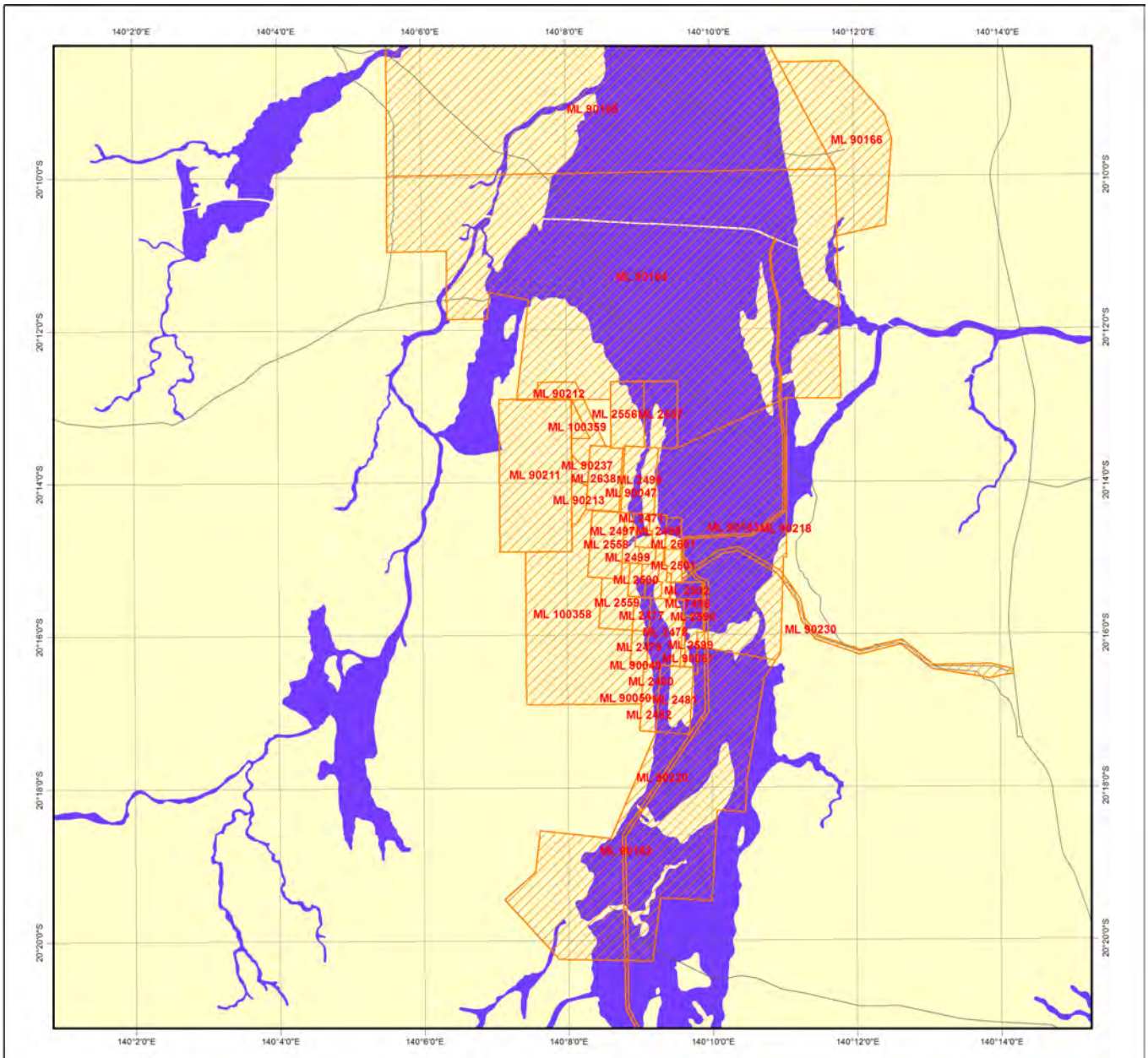
Common name (*Scientific name*)	Status*		Likelihood of occurrence	RSA Utilisation	Flight Habits	General Flight height	Size (small/ medium/ large)	Behaviour, habitat and feeding	Records on site	Collision Risk Susceptibility	Collision Consequence
	NCA	EPBC									
Australian Painted Snipe (*Rostratula australis*)	E	E, Ma	Possible	Dispersing	Capable of flying great distances. Moderate mobility	No reference to flight height.	Medium	The Australian painted snipe occurs in shallow freshwater (occasionally brackish) waters, both ephemeral and permanent, such as lakes, swamps, claypans, inundated or waterlogged grassland, dams, rice crops, sewage farms and bore drains, generally with a good cover of grasses, rushes and reeds, low scrub, *Muehlenbeckia* spp. (lignum), open timber or samphire (Reader's Digest, 1997) (Marchant & Higgins, 1993). This species feeds on insects, freshwater snails and worms from dusk to early morning, mostly in shallow water.	Nil	Low	No loss of individuals
Common Greenshank (*Tringa nebularia*)	SL	Ma, M, E	Possible	Dispersing	Capable of flying great distances. Highly agile.	Would fly within the RSA.	Medium	Inhabits mudflats, estuaries, saltmarshes, lake and pond margins, wetlands. Generally found in coastal environments, but present inland where habitat is suitable. Widespread summer migrant, with some overwintering. (Pizzey & Knight, 2012). The Common Greenshank is carnivorous. In Australia is has been recorded eating molluscs, crustaceans, insects, and occasionally fish and frogs. Elsewhere, it has also been recorded eating annelids, lizards, and rodents. The species feeds during both day and nighttime. It is active and agile, finding prey by sight or, occasionally, by touch (Higgins & Davies, 1996).	Nil	Low	No loss of individuals

APPENDIX B: Environmentally Sensitive Areas

Tenure type: Mining Leases

Map requested: 21/11/2023 17:04:35

Centred on point position: Longitude: 140.13467 Latitude: -20.24531



ENVIRONMENTALLY SENSITIVE AREAS - Mining Activities

- Mining Leases
- CATEGORY A
- National Parks
- Conservation Parks
- Forest Reserves
- Special Wildlife Reserve
- Wet Tropics World Heritage Area
- Great Barrier Reef Marine Park Area
- Marine Parks other than General Use Zones
- CATEGORY B
- Queensland Heritage Register Places
- Ramsar Sites
- Cultural Heritage Registered Areas and DLA's other than Stanbroke
- Special Forestry Areas
- Seaward Side of Highest Astronomical Tide
- Fish Habitat Areas
- Coordinated Conservation Areas
- Endangered Regional Ecosystems - regrowth and remnant (Biodiversity Status)
- General Use Zones of Marine Parks
- Marine Plants
- CATEGORY C
- Nature Refuges
- Resources Reserve
- State Forests
- Timber Reserves
- River Improvement Areas
- Stanbroke DLA
- Coastal Management District
- Dams and Weirs
- OTHERS
- Towns
- Roads
- Repealed Wild River Nominated Waterways
- Repealed Wild River Preservation Areas
- Repealed Wild River High Preservation Areas
- Mahogany Glider Habitat
- Directory of Important Wetlands
- Queensland

LOCALITY DIAGRAM

N

0 1,300 2,600 3,900 5,200 6,500 m

This product is projected into GDA 1994 MGA Zone 54

Information presented on this product is distributed by the Queensland Government as an information source only. While every care is taken to ensure the accuracy of this data, The State of Queensland makes no statements, representations or warranties about the accuracy, reliability, completeness or suitability of any information contained in this product.

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NOTE TO USER: Themes presented in this map are indicative only. Field survey may be required to verify the 'true' spatial extent and value. Not all environmentally sensitive areas are presented in this map. A user should refer to the particular circumstances relevant to their situation to assess the 'completeness' of themes provided.

The user should note that some boundaries and indicated values are ambient and may change over time (e.g. regional ecosystem boundaries and conservation status, watercourse mapping etc).

The user should be aware that due to multiple overlapping themes/ layers present, some themes/layers may be obscured by others. Ordering in the Legend does not accurately reflect the order by which themes/layers are displayed.

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Queensland Government

APPENDIX C: WildNet Threatened Species List

Search Cri Species List for a Specified Point

Species:	All
Type:	All
Queenslar	All
Records:	All
Date:	All
Latitude:	-20.2453
Longitude	140.1346
Distance:	50
Email:	delw@wulgurutechservices.com.au
Date subm	Tuesday 21 Nov 2023 16:42:13
Date extra	Tuesday 21 Nov 2023 16:50:02

The number of records retrieved = 840

Disclaimer

Information presented on this product is distributed by the Queensland Government as an information source only. While every care is taken to ensure the accuracy of this data, the State of Queensland makes no statements, representations or warranties about the accuracy, reliability, completeness or suitability of any information contained in this product.

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The information provided should be appropriately acknowledged as being derived from WildNet database when it is used. As the WildNet Program is still in a process of collating and vetting data, it is possible the information given is not complete. Go to the WildNet database webpage (https://www.qld.gov.au/environment/plants-animals/species-information/wildnet) to find out more about WildNet and where to access other WildNet information products approved for publication. Feedback about WildNet species lists should be emailed to wildlife.online@des.qld.gov.au.

Description of the CODES

I - Y indicates that the taxon is introduced to Queensland and has naturalised.

Q - Indicates the Queensland conservation status of each taxon under the Nature Conservation Act 1992.
The codes are Extinct (EX), Extinct in the Wild (PE), Critically Endangered (CR), Endangered (E), Vulnerable (V), Near Threatened (NT), Special Least Concern (SL) and Least Concern (C).

A - Indicates the Australian conservation status of each taxon under the Environment Protection and Biodiversity Conservation Act 1999.
The values of EPBC are Extinct (EX), Extinct in the Wild (XW), Critically Endangered (CE), Endangered (E), Vulnerable (V) and Conservation Dependent (CD).

Records - The first number indicates the total number of records of the taxon (wildlife records and species listings for selected areas).
This number is output as 99999 if it equals or exceeds this value. A second number located after a / indicates the number of specimen records for the taxon.
This number is output as 999 if it equals or exceeds this value.

Kingdom	Class	Family	Scientific Name	Common Name	Q	A	Sighting R	Specimen Records
animals	birds	Falconidae	Falco hypoleucos	grey falcon	V	V	1	0
animals	birds	Laridae	Hydroprogne caspia	Caspian tern	SL		3	0
animals	birds	Maluridae	Amytornis dorotheae	Carpentarian grasswren	E	E	1	0
animals	birds	Maluridae	Malurus coronatus	purple-crowned fairy-wren	V		2	2
animals	birds	Meliphagi	Grantiella picta	painted honeyeater	V	V	1	0
animals	birds	Scolopacic	Calidris acuminata	sharp-tailed sandpiper	SL		1	0
animals	birds	Threskiorr	Plegadis falcinellus	glossy ibis	SL		3	0
animals	mammals	Macropod	Petrogale purpureicollis	purple-necked rock-wallaby	V		80	0
animals	mammals	Tachyglos	Tachyglossus aculeatus	short-beaked echidna	SL		6	0
animals	reptiles	Varanidae	Varanus mertensi	Mertens' water monitor	E		6	0
plants	land plant	Amaranth	Ptilotus maconochiei		NT		1	1
plants	land plant	Arecaceae	Livistona rigida		SL		6	4
plants	land plant	Convolvul	Ipomoea antonschmidii		NT		6	6
plants	land plant	Hydrochar	Najas tenuifolia	water nymph	SL		1	1
plants	land plant	Potamoge	Potamogeton crispus	curly pondweed	SL		1	1
plants	land plant	Santalace	Santalum lanceolatum		SL		4	0
plants	land plant	Sterculiac	Brachychiton collinus		SL		3	0

APPENDIX D: EPBC Act Protected Matter Report

EPBC Act Protected Matters Report

This report provides general guidance on matters of national environmental significance and other matters protected by the EPBC Act in the area you have selected. Please see the caveat for interpretation of information provided here.

Report created: 11-Sep-2023

Summary
Details
- Matters of NES
- Other Matters Protected by the EPBC Act
- Extra Information

Caveat
Acknowledgements

Summary

Matters of National Environment Significance

This part of the report summarises the matters of national environmental significance that may occur in, or may relate to, the area you nominated. Further information is available in the detail part of the report, which can be accessed by scrolling or following the links below. If you are proposing to undertake an activity that may have a significant impact on one or more matters of national environmental significance then you should consider the Administrative Guidelines on Significance.

World Heritage Properties:	None
National Heritage Places:	None
Wetlands of International Importance (Ramsar	None
Great Barrier Reef Marine Park:	None
Commonwealth Marine Area:	None
Listed Threatened Ecological Communities:	None
Listed Threatened Species:	16
Listed Migratory Species:	14

Other Matters Protected by the EPBC Act

This part of the report summarises other matters protected under the Act that may relate to the area you nominated. Approval may be required for a proposed activity that significantly affects the environment on Commonwealth land, when the action is outside the Commonwealth land, or the environment anywhere when the action is taken on Commonwealth land. Approval may also be required for the Commonwealth or Commonwealth agencies proposing to take an action that is likely to have a significant impact on the environment anywhere.

The EPBC Act protects the environment on Commonwealth land, the environment from the actions taken on Commonwealth land, and the environment from actions taken by Commonwealth agencies. As heritage values of a place are part of the 'environment', these aspects of the EPBC Act protect the Commonwealth Heritage values of a Commonwealth Heritage place. Information on the new heritage laws can be found at https://www.dcceew.gov.au/parks-heritage/heritage

A permit may be required for activities in or on a Commonwealth area that may affect a member of a listed threatened species or ecological community, a member of a listed migratory species, whales and other cetaceans, or a member of a listed marine species.

Commonwealth Lands:	None
Commonwealth Heritage Places:	None
Listed Marine Species:	19
Whales and Other Cetaceans:	None
Critical Habitats:	None
Commonwealth Reserves Terrestrial:	None
Australian Marine Parks:	None
Habitat Critical to the Survival of Marine Turtles:	None

Extra Information

This part of the report provides information that may also be relevant to the area you have

State and Territory Reserves:	None
Regional Forest Agreements:	None
Nationally Important Wetlands:	1
EPBC Act Referrals:	3
Key Ecological Features (Marine):	None
Biologically Important Areas:	None
Bioregional Assessments:	None
Geological and Bioregional Assessments:	None

Details

Matters of National Environmental Significance

Listed Threatened Species			[Resource Information]
Status of Conservation Dependent and Extinct are not MNES under the EPBC Act. Number is the current name ID.			
Scientific Name	Threatened Category	Presence Text	Buffer Status
BIRD			
Amytornis dorotheae Carpentarian Grasswren [558]	Endangered	Species or species habitat known to occur within area	In feature area
Calidris ferruginea Curlew Sandpiper [856]	Critically Endangered	Species or species habitat may occur within area	In feature area
Erythrotriorchis radiatus Red Goshawk [942]	Endangered	Species or species habitat known to occur within area	In feature area
Erythrura gouldiae Gouldian Finch [413]	Endangered	Species or species habitat may occur within area	In feature area
Falco hypoleucos Grey Falcon [929]	Vulnerable	Species or species habitat known to occur within area	In feature area
Grantiella picta Painted Honeyeater [470]	Vulnerable	Species or species habitat known to occur within area	In feature area
Numenius madagascariensis Eastern Curlew, Far Eastern Curlew [847]	Critically Endangered	Species or species habitat may occur within area	In feature area
Pezoporus occidentalis Night Parrot [59350]	Endangered	Species or species habitat likely to occur within area	In feature area

Scientific Name	Threatened Category	Presence Text	Buffer Status
Rostratula australis			
Australian Painted Snipe [77037]	Endangered	Species or species habitat may occur within area	In feature area
MAMMAL			
Macroderma gigas			
Ghost Bat [174]	Vulnerable	Species or species habitat likely to occur within area	In feature area
Macrotis lagotis			
Greater Bilby [282]	Vulnerable	Species or species habitat may occur within area	In feature area
Sminthopsis douglasi			
Julia Creek Dunnart [305]	Vulnerable	Species or species habitat may occur within area	In feature area
PLANT			
Eucalyptus nudicaulis			
Mt Isa Mallee [55399]	Endangered	Species or species habitat may occur within area	In buffer area only
REPTILE			
Acanthophis hawkei			
Plains Death Adder [83821]	Vulnerable	Species or species habitat known to occur within area	In feature area
Elseya lavarackorum			
Gulf Snapping Turtle [67197]	Endangered	Species or species habitat may occur within area	In feature area
SHARK			
Pristis pristis			
Freshwater Sawfish, Largetooth Sawfish, River Sawfish, Leichhardt's Sawfish, Northern Sawfish [60756]	Vulnerable	Species or species habitat may occur within area	In feature area

Listed Migratory Species			[Resource Information]
Scientific Name	Threatened Category	Presence Text	Buffer Status
Migratory Marine Birds			
Apus pacificus			
Fork-tailed Swift [678]		Species or species habitat likely to occur within area	In feature area
Migratory Marine Species			

Scientific Name	Threatened Category	Presence Text	Buffer Status
[Pristis pristis](#) Freshwater Sawfish, Largetooth Sawfish, River Sawfish, Leichhardt's Sawfish, Northern Sawfish [60756]	Vulnerable	Species or species habitat may occur within area	In feature area
Migratory Terrestrial Species			
[Hirundo rustica](#) Barn Swallow [662]		Species or species habitat may occur within area	In feature area
[Motacilla cinerea](#) Grey Wagtail [642]		Species or species habitat may occur within area	In feature area
[Motacilla flava](#) Yellow Wagtail [644]		Species or species habitat likely to occur within area	In feature area
Migratory Wetlands Species			
[Actitis hypoleucos](#) Common Sandpiper [59309]		Species or species habitat may occur within area	In feature area
[Calidris acuminata](#) Sharp-tailed Sandpiper [874]		Species or species habitat likely to occur within area	In feature area
[Calidris ferruginea](#) Curlew Sandpiper [856]	Critically Endangered	Species or species habitat may occur within area	In feature area
[Calidris melanotos](#) Pectoral Sandpiper [858]		Species or species habitat may occur within area	In feature area
[Charadrius veredus](#) Oriental Plover, Oriental Dotterel [882]		Species or species habitat may occur within area	In feature area
[Gallinago hardwickii](#) Latham's Snipe, Japanese Snipe [863]		Species or species habitat may occur within area	In buffer area only
[Glareola maldivarum](#) Oriental Pratincole [840]		Species or species habitat may occur within area	In feature area

Scientific Name	Threatened Category	Presence Text	Buffer Status
Numenius madagascariensis			
Eastern Curlew, Far Eastern Curlew [847]	Critically Endangered	Species or species habitat may occur within area	In feature area
Tringa nebularia			
Common Greenshank, Greenshank [832]		Species or species habitat may occur within area	In buffer area only

Other Matters Protected by the EPBC Act

Listed Marine Species			[Resource Information]
Scientific Name	Threatened Category	Presence Text	Buffer Status
Bird			
Actitis hypoleucos			
Common Sandpiper [59309]		Species or species habitat may occur within area	In feature area
Apus pacificus			
Fork-tailed Swift [678]		Species or species habitat likely to occur within area overfly marine area	In feature area
Bubulcus ibis as Ardea ibis			
Cattle Egret [66521]		Species or species habitat may occur within area overfly marine area	In feature area
Calidris acuminata			
Sharp-tailed Sandpiper [874]		Species or species habitat likely to occur within area	In feature area
Calidris ferruginea			
Curlew Sandpiper [856]	Critically Endangered	Species or species habitat may occur within area overfly marine area	In feature area
Calidris melanotos			
Pectoral Sandpiper [858]		Species or species habitat may occur within area overfly marine area	In feature area

Scientific Name	Threatened Category	Presence Text	Buffer Status
[Chalcites osculans as Chrysococcyx osculans](#) Black-eared Cuckoo [83425]		Species or species habitat known to occur within area overfly marine area	In feature area
[Charadrius veredus](#) Oriental Plover, Oriental Dotterel [882]		Species or species habitat may occur within area overfly marine area	In feature area
[Gallinago hardwickii](#) Latham's Snipe, Japanese Snipe [863]		Species or species habitat may occur within area overfly marine area	In buffer area only
[Glareola maldivarum](#) Oriental Pratincole [840]		Species or species habitat may occur within area overfly marine area	In feature area
[Haliaeetus leucogaster](#) White-bellied Sea-Eagle [943]		Species or species habitat known to occur within area	In feature area
[Hirundo rustica](#) Barn Swallow [662]		Species or species habitat may occur within area overfly marine area	In feature area
[Merops ornatus](#) Rainbow Bee-eater [670]		Species or species habitat may occur within area overfly marine area	In feature area
[Motacilla cinerea](#) Grey Wagtail [642]		Species or species habitat may occur within area overfly marine area	In feature area
[Motacilla flava](#) Yellow Wagtail [644]		Species or species habitat likely to occur within area overfly marine area	In feature area
[Numenius madagascariensis](#) Eastern Curlew, Far Eastern Curlew [847]	Critically Endangered	Species or species habitat may occur within area	In feature area

Scientific Name	Threatened Category	Presence Text	Buffer Status
Rostratula australis as Rostratula benghalensis (sensu lato)			
Australian Painted Snipe [77037]	Endangered	Species or species habitat may occur within area overfly marine area	In feature area
Tringa nebularia			
Common Greenshank, Greenshank [832]		Species or species habitat may occur within area overfly marine area	In buffer area only
Reptile			
Crocodylus johnstoni			
Freshwater Crocodile, Johnston's Crocodile, Johnstone's Crocodile [1773]		Species or species habitat may occur within area	In feature area

Extra Information

Nationally Important Wetlands		[Resource Information]
Wetland Name	State	Buffer Status
Lake Julius	QLD	In buffer area only

EPBC Act Referrals				[Resource Information]
Title of referral	Reference	Referral Outcome	Assessment Status	Buffer Status
Controlled action				
CopperString Project	2010/5581	Controlled Action	Completed	In feature area
Not controlled action				
Improving rabbit biocontrol: releasing another strain of RHDV, sthrn two thirds of Australia	2015/7522	Not Controlled Action	Completed	In buffer area only
Not controlled action (particular manner)				
Dugald River Zinc and Lead Mine extension, Qld	2015/7573	Not Controlled Action (Particular Manner)	Post-Approval	In feature area

Caveat

1 PURPOSE

This report is designed to assist in identifying the location of matters of national environmental significance (MNES) and other matters protected by the Environment Protection and Biodiversity Conservation Act 1999 (Cth) (EPBC Act) which may be relevant in determining obligations and requirements under the EPBC Act.

The report contains the mapped locations of:

- World and National Heritage properties;
- Wetlands of International and National Importance;
- Commonwealth and State/Territory reserves;
- distribution of listed threatened, migratory and marine species;
- listed threatened ecological communities; and
- other information that may be useful as an indicator of potential habitat value.

2 DISCLAIMER

This report is not intended to be exhaustive and should only be relied upon as a general guide as mapped data is not available for all species or ecological communities listed under the EPBC Act (see below). Persons seeking to use the information contained in this report to inform the referral of a proposed action under the EPBC Act should consider the limitations noted below and whether additional information is required to determine the existence and location of MNES and other protected matters.

Where data are available to inform the mapping of protected species, the presence type (e.g. known, likely or may occur) that can be determined from the data is indicated in general terms. It is the responsibility of any person using or relying on the information in this report to ensure that it is suitable for the circumstances of any proposed use. The Commonwealth cannot accept responsibility for the consequences of any use of the report or any part thereof. To the maximum extent allowed under governing law, the Commonwealth will not be liable for any loss or damage that may be occasioned directly or indirectly through the use of, or reliance

3 DATA SOURCES

Threatened ecological communities

For threatened ecological communities where the distribution is well known, maps are generated based on information contained in recovery plans, State vegetation maps and remote sensing imagery and other sources. Where threatened ecological community distributions are less well known, existing vegetation maps and point location data are used to produce indicative distribution maps.

Threatened, migratory and marine species

Threatened, migratory and marine species distributions have been discerned through a variety of methods. Where distributions are well known and if time permits, distributions are inferred from either thematic spatial data (i.e. vegetation, soils, geology, elevation, aspect, terrain, etc.) together with point locations and described habitat; or modelled (MAXENT or BIOCLIM habitat modelling) using

Where little information is available for a species or large number of maps are required in a short time-frame, maps are derived either from 0.04 or 0.02 decimal degree cells; by an automated process using polygon capture techniques (static two kilometre grid cells, alpha-hull and convex hull); or captured manually or by using topographic features (national park boundaries, islands, etc.).

In the early stages of the distribution mapping process (1999-early 2000s) distributions were defined by degree blocks, 100K or 250K map sheets to rapidly create distribution maps. More detailed distribution mapping methods are used to update these distributions

4 LIMITATIONS

The following species and ecological communities have not been mapped and do not appear in this report:

- threatened species listed as extinct or considered vagrants;
- some recently listed species and ecological communities;
- some listed migratory and listed marine species, which are not listed as threatened species; and
- migratory species that are very widespread, vagrant, or only occur in Australia in small numbers.

The following groups have been mapped, but may not cover the complete distribution of the species:

- listed migratory and/or listed marine seabirds, which are not listed as threatened, have only been mapped for recorded
- seals which have only been mapped for breeding sites near the Australian continent

The breeding sites may be important for the protection of the Commonwealth Marine environment.

Refer to the metadata for the feature group (using the Resource Information link) for the currency of the information.

Acknowledgements

This database has been compiled from a range of data sources. The department acknowledges the following custodians who have contributed valuable data and advice:

-Office of Environment and Heritage, New South Wales
-Department of Environment and Primary Industries, Victoria
-Department of Primary Industries, Parks, Water and Environment, Tasmania
-Department of Environment, Water and Natural Resources, South Australia
-Department of Land and Resource Management, Northern Territory
-Department of Environmental and Heritage Protection, Queensland
-Department of Parks and Wildlife, Western Australia
-Environment and Planning Directorate, ACT
-Birdlife Australia
-Australian Bird and Bat Banding Scheme
-Australian National Wildlife Collection
-Natural history museums of Australia
-Museum Victoria
-Australian Museum
-South Australian Museum
-Queensland Museum
-Online Zoological Collections of Australian Museums
-Queensland Herbarium
-National Herbarium of NSW
-Royal Botanic Gardens and National Herbarium of Victoria
-Tasmanian Herbarium
-State Herbarium of South Australia
-Northern Territory Herbarium
-Western Australian Herbarium
-Australian National Herbarium, Canberra
-University of New England
-Ocean Biogeographic Information System
-Australian Government, Department of Defence
Forestry Corporation, NSW
-Geoscience Australia
-CSIRO
-Australian Tropical Herbarium, Cairns
-eBird Australia
-Australian Government – Australian Antarctic Data Centre
-Museum and Art Gallery of the Northern Territory
-Australian Government National Environmental Science Program
-Australian Institute of Marine Science
-Reef Life Survey Australia
-American Museum of Natural History
-Queen Victoria Museum and Art Gallery, Inveresk, Tasmania
-Tasmanian Museum and Art Gallery, Hobart, Tasmania
-Other groups and individuals

The Department is extremely grateful to the many organisations and individuals who provided expert advice and information on numerous draft distributions.

Please feel free to provide feedback via the Contact us page.

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Department of Climate Change, Energy, the Environment and Water
GPO Box 3090
Canberra ACT 2601 Australia
+61 2 6274 1111

APPENDIX E: Pre-survey detailed likelihood of occurrence tables

Conservation significant species

Common Name (Scientific Name)	Status		Source[3]	Likelihood of Occurrence
	NCA[1]	EPBC[2]		
Plants (n = 3)				
Eucalyptus nudicaulis	E	E	PMST	**Unlikely** – No records exist within a 50 km buffer from the project area on Atlas of Living Australia (ALA). The 50km buffer falls outside of the extent of occurrence identified within the conservation advice for the species.
Ipomoea antonschmidii	NT	NL	WO	**Unlikely** – The initial population is ~40 km to the east of the project area. A newer population has been found ~100 km northwest of the project area. All records have been found in relatively low elevations, proximal to waterbodies or ephemeral streams, the Project area does not provide suitable conditions for this species.
Ptilotus maconochiei	NT	NL	WO	**Unlikely** - One record exists approximately 40km west of the AOI. The majority of records are centred around Mount Isa.
Birds (n = 27)				
Australian Painted Snipe (*Rostratula australis*)	E	E, Ma	PMST	**Possible** - one record has been recorded approximately 40 km southwest of the site. Waterholes on site are ephemeral and are fed by streams flowing from the ridgeline. All of the waterholes are small and surrounded by rocks, unsuitable habitat for the species.
Barn Swallow (*Hirundo rustica*)	SL	M, Ma	PMST	**Unlikely** - No records exist within a 50 km radius of the site. The habitat within the site is unsuitable and would not support the needs of the species.
Black-eared Cuckoo (*Chalcites osculans*)	LC	Ma	PMST	**Possible** - the species has been recorded withing 50 km of the site twice, however this species is widespread and commonly found through most of Australia.
Carpentarian Grasswren (*Amytornis dorotheae*)	E	E	PMST, WO	**Unlikely -** While one record is located approximately 40km northwest of the site,12 years of fauna survey effort have not produced records of the species in the Knapdale Range. Previous fauna reports have deemed the habitat unsuitable.
Caspian tern (*Hydroprogne caspia*)	SL	M, Ma	WO	**Possible** - within a 50km radius of the site, the Caspian tern has 15 records. The site has no large bodies of water that are suitable for the species, however, the species may use the site temporarily while in transit between waterholes.
Cattle Egret (*Bubulcus ibis*)	LC	Ma	PMST	**Possible** - Three records exist within a 50km radius of the site. However, the lack of permanent water, and unsuitable ephemeral water sources likely mean that the site would not support a population.
Common Greenshank (*Tringa nebularia*)	SL	M, Ma	PMST	**Possible** - four records exist within a 50km radius of the site. The habitat on site is largely unsuitable due to the lack of permanent water sources, however the species may be a temporary resident.

Common Sandpiper (*Actitis hypoleucos*)	SL	M, Ma	PMST	**Unlikely** - no records exist within a 50km radius of the site bases of ALA records. As the site has no permanent water sources, it is unlikely that the species would utilize the site as habitat.
Curlew Sandpiper (*Calidris ferruginea*)	CR	CE, M, Ma	PMST	**Unlikely** - Two records exist within a 50km radius of the site, they are located approximately 40km southwest of the site. A very small percentage of the site would be considered suitable habitat, furthermore due to the seasonal and ephemeral nature of the waterholes, it is unlikely that it would be used as habitat for the species.
Eastern Curlew (*Numenius madagascariensis*)	E	CE, M, Ma	PMST	**Unlikely** - Within the ALA database, no records exist within 50 km of the site. The species does not often travel inland, and most inland records are proximal to large water sources, which the site does not possess.
Fork-tailed Swift (*Apus pacificus*)	SL	M, Ma	PMST	**Unlikely** - There are no records within 50 km of the site on ALA and as such it is unlikely the species utilizes the airspace above the site.
Glossy ibis (*Plegadis falcinellus*)	SL	M, Ma	WO	**Possible** - 14 records exist within a 50 km radius of the site.
Gouldian Finch (*Erythrura gouldiae*)	E	E	PMST	**Unlikely** - no records exist within a 50 km radius of the site. The site does not contain suitable habitat as there are no permanent water sources on site.
Grey Falcon (*Falco hypoleucos*)	V	V	PMST, WO	**Unlikely -** due to the lack of sparsely treed areas preferred by the grey falcon, and the low density of the species, it is considered unlikely to occur in the project area.
Grey Wagtail (*Motacilla cinerea*)	SL	M, Ma	PMST	**Unlikely -** no records exist within a 50 km radius of the site. The nearest record is over 600km away, on the coast.
Latham's Snipe (*Gallinago hardwickii*)	SL	M, Ma	PMST	**Possible -** Two records are located within a 50km radius from the site, they are located approximately 40km southwest of site. The site may contain potential habitat.
Night Parrot (*Pezoporus occidentalis*)	E	E	PMST	**Unlikely -** no records exist within a 50 km radius of the site. The nearest record is over 250km south of the site.
Oriental Plover (*Charadrius veredus*)	SL	M, Ma	PMST	**Unlikely -** no records exist within a 50 km radius of the site.
Oriental Pratincole (*Glareola maldivarum*)	SL	M, Ma	PMST	**Unlikely -** based on information from ALA, no records exist within a 50 km radius of the site.
Painted Honeyeater (*Grantiella picta*)	V	V	PMST, WO	**Unlikely** - Despite the species being recorded three times within a 50km radius of the site, there are no mistletoe species present on site which this speces is highly associated with.
Pectoral Sandpiper (*Calidris melanotos*)	SL	M, Ma	PMST	**Unlikely -** no records exist in the ALA database within a 50 km radius of the site. Habitat on site is likely not optimal as there are no permanent water sources on site.
Purple-crowned Fairy-wren (*Malurus coronatus*)	V	NL	WO	**Possible** - One record exists within a 50km radius of the site. Vegetation along the Dugald river and smaller order streams that run through the site may provide potential habitat for the species.
Rainbow Bee-eater (*Merops ornatus*)	LC	M	PMST	**Likely** – Within a 50 km buffer from the Project area 86 records exist. Rainbow bee-eaters are widesprea

Red Goshawk (*Erythrotriorchis radiatus*)	E	E	PMST	**Unlikely** - No records exist within a 50km radius of the site using the ALA database. Habitat on site may be suitable, but it is unlikely that the species utilizes it.
Sharp-tailed Sandpiper (*Calidris acuminata*)	SL	M, Ma	WO	**Possible -** Within a 50km radius of the site, three records exist within the ALA database. The site has several small, ephemeral waterholes that the species could potentially utilize.
White-bellied Sea-Eagle (*Haliaeetus leucogaster*)	LC	Ma	PMST	**Possible -** The species has been recorded on 14 occurrences within a 50km radius of the site, according to the ALA database. The Dugald River may provide suitable habitat for the species.
Yellow Wagtail (*Motacilla flava*)	SL	M, Ma	PMST	**Unlikely -** No records exist within a 50km radius of the site using the ALA database. The nearest record is over 300km north, in the Gulf of Carpentaria
Mammals (n = 5)				
Ghost Bat (*Macroderma gigas*)	E	V	PMST	**Unlikely -** No records exist within a 50km radius of the site. The habitat on site may be suitable if roosting structures are available.
Greater Bilby (*Macrotis lagotis*)	E	V	PMST	**Unlikely** - No records exist within a 50km radius of the site. The nearest record in the ALA database is approximately 250 km southwest of the site.
Julia Creek Dunnart (*Sminthopsis douglasi*)	E	V	PMST	**Unlikely -** No records exist within a 50km radius of the site. Most records for this species are centred around Julia Creek, with occasional outliers
Purple-necked rock-wallaby (*Petrogale purpureicollis*)	V	NL	WO	**Likely** – 23 records exist within a 50 km radius of the Project area. Seven of the records fall within the ML.
Short-beaked echidna (*Tachyglossus aculeatus*)	SL	NL	WO	**Likely** - Four records exist within a 50km radius of the site based on the ALA database. This species is widely distributed and likely utilizes habitat
Reptiles (n = 4)				
Freshwater Crocodile	LC	Ma	PMST	**Unlikely -** While the species has two records within a 50km radius of the site, the habitat on the site is unsuitable. The creek lines on the site are ephemeral, and they gain elevation rapidly.
Gulf Snapping Turtle (Elseya lavarackorum)	V	E	PMST	**Unlikely -** No records exist within a 50km radius of the site. The nearest population is over 225km northwest of the site.
Mertens' water monitor (*Varanus mertensi*)	E	NL	WO	**Possible** – 6 records exist within 50 km of the Project area. Several recordings are located along the Dugald River.
Plains Death Adder (*Acanthophis hawkei*)	V	V	PMST	**Unlikely** - No records exist within a 50 km radius of the site. The site is likely unsuitable habitat as this species favours habitat that is flat, while the site is geographically complex.
Cartilaginous fish (n = 1)				
Freshwater sawfish (*Pristis pristis*)	LC	V, M	PMST	**Unlikely** - The nearest record on ALA is located over 250km north of site, near the Gulf of Carpentaria. There is no suitable habitat for this species on site as there is no permanent water source.

[1]NCA Status – Nature Conservation Act (1992) Status. LC – Least Concern, SL – Special Least Concern, NT – Near Threatened, V – Vulnerable, E – Endangered, CR – Critically Endangered.

[2]EPBC Status – Environment Protection and Biodiversity Conservation Act (1999) Status. V – Vulnerable, E – Endangered, CE – Critically Endangered, NL – Not Listed, M – Migratory, Ma - Marine.

[3]50 km search radius around central coordinate for records in: PMST – EPBC Act Protected Matters Report; WO – Wildlife Online Database, ALA – Atlas of Living Australia. 2 km search radius around central coordinate for: MPH – Modelled Potential Habitat layer in Qspatial.

EPBC Migratory Species

Common Name (Scientific Name)	Status		Source[3]	Likelihood of Occurrence
	NCA[1]	EPBC[2]		
Asian Dowitcher (*Limnodromus semipalmatus*)	SL	M, Ma	EAA Flyway	**Unlikely -** no records exist within a 50 km radius of the Project area. The species is a regular visitor to the north-west between Port Hedland and Broome. Elsewhere they are sporadic and rare.
Bar-tailed Godwit (*Limosa lapponica*)	SL	M, Ma	EAA Flyway	**Possible** – The species is rarely found inland; however, some inland records suggest there is some passage overland and there are records at Lake Moondarra, approximately 70km southwest of the Project area.
Black-tailed Godwit (*Limosa limosa*)	SL	M, Ma	EAA Flyway	**Possible** - Birds travelling south from northern Australia often pass through the Mt Isa region and there are several records of birds congregating at Lake Moondarra, approximately 70km southwest of the Project area, as well as records at Rifle Creek Dam.
Broad-billed Sandpiper (*Limicola falcinellus*)	SL	M, Ma	EAA Flyway	**Unlikely -** There are no records in the vicinity of the Project area. The species is rarely recorded inland.
Caspian tern (*Hydroprogne caspia*)	SL	M, Ma	ALA, WO, EAA Flyway	**Possible -** Within a 50km radius of the Project area, the Caspian tern has 15 records. This species is primarily coastal, though travels inland to visit large bodies of water.
Common greenshank/ greenshank (*Tringa nebularia*)	SL	M, Ma	ALA, PMST, EAA Flyway	**Possible** - four records exist within a 50km radius of the Project area. The species is present inland where habitat is suitable.
Common Redshank (*Tringa totanus*)	SL	M, Ma	EAA Flyway	**Unlikely - N**o records exist within a 50 km radius of the Project area.
Common Sandpiper (*Actitis hypoleucos*)	SL	M, Ma	EAA Flyway	**Unlikely** - No records within a 50 km radius of the Project area.
Common Tern (*Sterna hirundo*)	SL	M, Ma	EAA Flyway	**Unlikely -** No records exist within a 50 km radius of the Project area.
Curlew sandpiper (*Calidris ferruginea*)	CR	CE, M, Ma	ALA, PMST, EAA Flyway	**Possible** – Two records exist within a 50km radius of the Project area; they are located approximately 40km southwest of the Project area.
Double-banded Plover (*Charadrius bicinctus*)	SL	M, Ma	EAA Flyway	**Unlikely** - no records exist within a 50 km radius of the Project area.
Eastern Curlew (*Numenius madagascariensis*)	E	CE, M, Ma	PMST, EAA Flyway	**Possible -** Within the ALA database, no records exist within 50 km of the Project area. Eastern curlews are rarely recorded inland. They have a continuous distribution from Barrow Island and Dampier Archipelago, Western Australia, through the Kimberley and along the Northern Territory, Queensland, and NSW coasts and the islands of Torres Strait.

Fork-tailed swift (*Apus pacificus*)	SL	M, Ma	PMST	**Unlikely -** no records or modelled flight paths exist within a 50 km radius of the Project area.
Glossy ibis (*Plegadis falcinellus*)	SL	M, Ma	ALA, WO	**Possible** - 14 records exist within a 50 km radius of the Project area.
Great Knot (*Calidris tenuirostris*)	CE	CE, M, Ma	EAA Flyway	**Possible –** No records located near the Project area**.** Recorded primarily around coastal wetlands with sparse scattered inland records, usually on inland lakes. May fly through the Project area to access suitable habitat.
Greater Sand Plover (*Charadrius leschenaultii*)	LC	V, M, Ma	EAA Flyway	**Possible -** There is a record in the vicinity of the Project area at Lake Moondarra, approximately 70km southwest of the Project area.
Grey Plover (*Pluvialis squatarola*)	SL	M, Ma	EAA Flyway	**Possible -** There is a record in the vicinity of the Project area at Lake Moondarra, approximately 70km southwest of the Project area.
Grey-tailed Tattler (*Tringa brevipes*)	SL	M, Ma	EAA Flyway	**Possible -** Australia, the species is found in most coastal regions, primarily along the northern coast. There are rare inland records, including Burdekin Weir, Charters Towers and Mount Isa.
Gull-billed Tern (*Gelochelidon nilotica*)	SL	M, Ma	EAA Flyway	**Unlikely** - no records exist within a 50 km radius of the Project area.
Latham's snipe (*Gallinago hardwickii*)	SL	M, Ma	PMST	**Possible** - Two records are located within a 50km radius from the Project area, they are located approximately 40km southwest of Project area.
Lesser Sand Plover (*Charadrius mongolus*)	E	E, M, Ma	ALA, EAA Flyway	**Possible -** records around Mt Isa City, indicate there is a possibility for this species to occur within the Project area.
Little curlew (*Numenius minutus*)	SL	M, Ma	EAA Flyway	**Unlikely -** no records exist within a 50 km radius of the Project area.
Little Ringed Plover (*Charadrius dubius*)	SL	M, Ma	EAA Flyway	**Unlikely** - no records exist within a 50 km radius of the Project area.
Little Tern (*Sterna albifrons*)	SL	M, Ma	EAA Flyway	**Unlikely -** no records exist within a 50 km radius of the Project area.
Long-toed Stint (*Calidris subminuta*)	SL	M, Ma	EAA Flyway	**Unlikely -** no records exist within a 50 km radius of the Project area.
Marsh sandpiper (*Tringa stagnatilis*)	SL	M, Ma	ALA, EAA Flyway	**Possible** - records at Late Moondarra, Corella Dam, Chinaman Dam, and around Mt Isa City, indicate there is a possibility for this species to occur within the Project area.
Oriental Plover (*Charadrius veredus*)	SL	M, Ma	PMST	**Unlikely -** no records exist within a 50 km radius of the Project area.
Oriental Pratincole (*Glareola maldivarum*)	SL	M, Ma	EAA Flyway	**Unlikely -** no records exist within a 50 km radius of the Project area.
Pacific Golden Plover (*Pluvialis fulva*)	SL	M, Ma	EAA Flyway	**Possible -** records at Late Moondarra and around Mt Isa City, indicate there is a possibility for this species to occur within the Project area.
Pectoral Sandpiper	SL	Ma	EAA Flyway	**Unlikely -** no records exist within a 50 km radius of the Project area.
Red Knot (*Calidris canutus*)	E	E, M, Ma	EAA Flyway	**Possible -** There is evidence of some overland movement, however there are no records in the vicinity of the Project area.
Red-necked Phalarope (*Phalaropus lobatus*)	SL	M, Ma	EAA Flyway	**Unlikely -** no records exist within a 50 km radius of the Project area.

Red-necked Stint (*Calidris ruficollis*)	SL	M, Ma	ALA, EAA Flyway	**Possible -** records at Late Moondarra, Chinaman Dam, and around Mt Isa City and Cloncurry, indicate there is a possibility for this species to occur within the Project area.
Ruddy Turnstone (*Arenaria interpres*)	SL	M, Ma	EAA Flyway	**Possible -** records at Lake Moondarra, indicate there is a possibility for this species to occur within the Project area.
Ruff (*Philomachus pugnax*)	SL	M, Ma	EAA Flyway	**Unlikely -** no records exist within a 50 km radius of the Project area.
Sanderling (*Calidris alba*)	SL	M, Ma	EAA Flyway	**Possible –** Records exist of birds utilizing inland lakes or river pools as a temporary refuge.
Sharp-tailed sandpiper (*Calidris acuminata*)	SL	M, Ma	ALA, WO, EAA Flyway	**Possible -** Within a 50km radius of the Project area, three records exist within the ALA database.
Short-tailed Shearwater (*Ardenna tenuirostris*)	SL	M, Ma	EAA Flyway	**Unlikely -** no records exist within a 50 km radius of the Project area.
Swinhoe's Snipe (*Gallinago megala*)	SL	M, Ma	EAA Flyway	**Unlikely -** no records exist within a 50 km radius of the Project area.
Terek Sandpiper (*Xenus cinereus*)	SL	M, Ma	EAA Flyway	**Possible -** records at Lake Moondarra, indicate there is a possibility for this species to occur within the Project area.
Wandering Albatross (*Diomedea exulans*)	V	V, M, Ma	EAA Flyway	**Unlikely -** no records exist within a 50 km radius of the Project area.
Whimbrel (*Numenius phaeopus*)	SL	M, Ma	EAA Flyway	**Possible –** Inland records suggest there is some overland movement.
White-winged Black Tern (*Chlidonias leucopterus*)	SL	M, Ma	EAA Flyway	**Unlikely -** no records exist within a 50 km radius of the Project area.
Wood Sandpiper (*Tringa glareola*)	SL	M, Ma	EAA Flyway	**Unlikely -** no records exist within a 50 km radius of the Project area.

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[2]EPBC Status – Environment Protection and Biodiversity Conservation Act (1999) Status. V – Vulnerable, E – Endangered, CE – Critically Endangered, NL – Not Listed, M – Migratory, Ma - Marine.

[3]50 km search radius around central coordinate for records in: PMST – EPBC Act Protected Matters Report; WO – Wildlife Online Database, ALA – Atlas of Living Australia, EAA Flyway – East Australasian Flyway. 2 km search radius around central coordinate for: MPH – Modelled Potential Habitat layer in Qspatial.

APPENDIX F: Post-survey detailed likelihood of occurrence tables

Conservation significant species

Common Name (Scientific Name)	Status		Source[3]	Description and Ecology	Likelihood of Occurrence
	NCA[1]	EPBC[2]			
Plants (n = 3)					
Eucalyptus nudicaulis	E	E	PMST	Eucalyptus nudicaulis is known from a restricted distribution to the west of Cloncurry. It grows in skeletal granite soils amongst open woodland of E. leucophloia and Corymbia capricornia on exposed quartzite, rocky gullies, and steep hillsides between 400-520 m above sea level (Bean 1991). It is typically associated with a dense understorey of Triodia spp. (Bean, Two new species of red gum (Eucalyptus L'Herit., Myrtaceae) from Queensland, 1991) and occurs in Queensland Region Ecosystem 1.11.2 – Eucalyptus leicophloia low open woodland (Bean, Conservation status assessment for Eucalyptus nudicaulis (Myrtaceae), 2009) (Queensland Herbarium, 2021). Associated species include Acacia sp., Corymbia aspersa, E. normantonensis and Plectrachne pugens (Queensland Herbarium 2020).	**Unlikely** – No records exist within a 50 km buffer from the project area on Atlas of Living Australia (ALA). The 50km buffer falls outside of the extent of occurrence identified within the conservation advice for the species.
Ipomoea antonschmidii	NT	NL	WO	This species is currently known from a restricted area southwest of Lake Julius Dam, north-northeast of Mt. Isa. It grows on shallow, red, stoney soils in *Eucalyptus leucophloia* woodland (Johnson, 1986). Records within the past 20 years have been centered around gunpowder creek, north of Mt. Isa (Atlas of Living Australia, 2023).	**Unlikely** – The initial population is ~40 km to the east of the project area. A newer population has been found ~100 km northwest of the project area. All records have been found in relatively low elevations, proximal to waterbodies or ephemeral streams, the Project area does not provide suitable conditions for this species.

Ptilotus maconochiei	NT	NL	WO	The native range of this species is W. & Central Queensland. It is a subshrub or shrub and grows primarily in the desert or dry shrubland biome (Kew Royal Botanic Gardens, 2023). The original collections of the species were found between 550 and 570 m in elevation around Mount Isa (Benl, 1979).	**Unlikely** – One record exists approximately 40km west of the AOI. The majority of records are centred around Mount Isa.
Birds (n = 27)					
Australian Painted Snipe (*Rostratula australis*)	E	E, Ma	PMST	Heavily vegetated margins of wetlands, dams, marshy areas, swamps etc.; wet pasture, irrigated areas, lignum, tea-tree shrubs. (Pizzey and Knight, 2012).	**Possible** – one record has been recorded approximately 40 km southwest of the site. Waterholes on site are ephemeral and are fed by streams flowing from the ridgeline. All of the waterholes are small and surrounded by rocks, unsuitable habitat for the species.
Barn Swallow (*Hirundo rustica*)	SL	M, Ma	PMST	A migratory swallow, abundant and widespread in the northern hemisphere. In Queensland, records of this species are largely restricted to coastal areas, particularly between Townsville and Daintree. Favoured habitat includes open areas over agricultural land and towns (Pizzey and Knight, 2012).	**Unlikely** – No records exist within a 50 km radius of the site. The habitat within the site is unsuitable and would not support the needs of the species.
Black-eared Cuckoo (*Chalcites osculans*)	LC	Ma	PMST	Inhabits drier woodlands, scrublands, mallee, mulga, saltmarsh, and riverside thickets (Pizzey and Knight 2012).	**Possible** – the species has been recorded withing 50 km of the site twice, however this species is widespread and commonly found through most of Australia.
Carpentarian Grasswren (*Amytornis dorotheae*)	E	E	PMST, WO	Generally confined to long-unburnt mature Triodia spp. hummock grassland or very open low woodland with Triodia understorey, avoiding recently (3 to 4 years previously) burnt areas, forages for seeds and insects around sandstone outcropping, on the ground, in rock crevices, leaf litter under Triodia hummocks and shrubs. Breeding season is November to March (Threatened Species Scientific Committee, 2016).	**Unlikely** – While one record is located approximately 40km northwest of the site, habitat assessments confirm a lack of hummocking spinifex grasses with which the species is typically associated.12 years of fauna survey effort have not produced records of the species in the Knapdale Range.

Caspian tern (*Hydroprogne caspia*)	SL	M, Ma	WO	A large part-migratory to migratory species of tern with a cosmopolitan distribution. In Australia, this species is primarily coastal, though travels inland to visit large bodies of water (Pizzey and Knight, 2012).	**Possible** – within a 50km radius of the site, the Caspian tern has 15 records. The site has no large bodies of water that are suitable for the species, however, the species may use the site temporarily while in transit between waterholes.
Cattle Egret (*Bubulcus ibis*)	LC	Ma	PMST	Typically inhabit stock paddocks, agricultural land, garbage tips, wetlands, tidal areas, drains. Widespread coastally summer migrant from Kimberly, WA to coastal regions of eastern Australia (Pizzey and Knight, 2012).	**Possible** – Three records exist within a 50km radius of the site. However, the lack of permanent water, and unsuitable ephemeral water sources within the project area itself mean that the site would not support a population.
Common Greenshank (*Tringa nebularia*)	SL	M, Ma	PMST	Inhabits mudflats, estuaries, saltmarshes, lake and pond margins, wetlands. Generally found in coastal environments, but present inland where habitat is suitable. Widespread summer migrant, with some overwintering. (Pizzey and Knight 2012).	**Possible** – four records exist within a 50km radius of the site. The habitat on site is largely unsuitable due to the lack of permanent water sources, however the species may be a temporary resident.
Common Sandpiper (*Actitis hypoleucos*)	SL	M, Ma	PMST	Typically occur in sandy, pebbly, or muddy edges of streams or rivers, either coastal or inland. Also found near dams, tidal flats, mud flats, mangroves, beaches, riverside lawns, drains, and street gutters. Strong association with water. Widespread but uncommon summer migrant. (Pizzey and Knight 2012).	**Unlikely** – no records exist within a 50km radius of the site bases of ALA records. As the site has no permanent water sources, it is unlikely that the species would utilize the site as habitat.
Curlew Sandpiper (*Calidris ferruginea*)	CR	CE, M, Ma	PMST	Usually inhabits intertidal mudflats, such as lagoons, bays, estuaries, inlets etc. Recorded less often inland around permanent and ephemeral water sources such as dams, ponds, lakes, waterholes. Inland records are sparse. (Pizzey and Knight, 2012) (DAWE, 2022d).	**Unlikely** – Two records exist within a 50km radius of the site, they are located approximately 40km southwest of the site. A very small percentage of the site would be considered suitable habitat, furthermore due to the seasonal and ephemeral nature of the waterholes, it is unlikely that it would be used as habitat for the species.

Eastern Curlew (*Numenius madagascariensis*)	E	CE, M, Ma	PMST	Within Australia, the eastern curlew has a primarily coastal distribution. The species is found in all states, particularly the north, east, and south-east regions including Tasmania. Eastern curlews are rarely recorded inland. They have a continuous distribution from Barrow Island and Dampier Archipelago, Western Australia, through the Kimberley and along the Northern Territory, Queensland, and NSW coasts and the islands of Torres Strait. They are patchily distributed elsewhere (Department of the Environment, 2015).	**Unlikely** – Within the ALA database, no records exist within 50 km of the site. The species does not often travel inland, and most inland records are proximal to large water sources, which the site does not possess.
Fork-tailed Swift (*Apus pacificus*)	SL	M, Ma	PMST	Widespread across Australia. Scattered records from throughout the Gulf of Carpentaria and Cape York. Almost exclusively aerial, have been recorded in most habitats across Australia (Pizzey and Knight 2012).	**Unlikely** – There are no records within 50 km of the site on ALA and as such it is unlikely the species utilizes the airspace above the site.
Glossy ibis (*Plegadis falcinellus*)	SL	M, Ma	WO	Prefers well-vegetated wetlands, floodplains, irrigated pastures, sewage ponds, mangroves, mudflats, and the like. Occasionally occurs in dry grasslands. The migratory and nomadic species breeds in southern Australia between October to December and in north Australia between February to April. Range may extend far inland after good rains. (Pizzey and Knight, 2012).	**Known** – 14 records exist within a 50 km radius of the site. Most of the occurrences are proximal to water sources, due to the lack of permanent water sources on site, the species may be less likely to frequent the site.
Gouldian Finch (*Erythrura gouldiae*)	E	E	PMST	A rarely encountered species in the region due to ongoing population declines. Favours Eucalyptus woodlands with a significant layer of tall native grasses. As with other finch species, the Gouldian finch has a high association with water sources, particularly in the dry season (Pizzey and Knight, 2012).	**Unlikely** – no records exist within a 50 km radius of the site. The site does not contain suitable habitat as there are no permanent water sources on site.
Grey Falcon (*Falco hypoleucos*)	V	V	PMST, WO	The grey falcon exists in a variety of habitats, from inland plains and deserts to well-timbered watercourses. It is considered rare and probably exists in low densities throughout most of its range (Pizzey and Knight, 2012).	**Unlikely** – due to the lack of sparsely treed areas preferred by the grey falcon, and the low density of the species, it is considered unlikely to occur in the project area.

Grey Wagtail (*Motacilla cinerea*)	SL	M, Ma	PMST	Distribution suggests this species favours coastal regions with higher rainfall. Typically found near running water in sandy or rocky streams in escarpments and rainforests, sometimes in disused quarries. Also found near sewage ponds, agricultural/cropping areas, and airfields (Pizzey and Knight, 2012).	**Unlikely** - no records exist within a 50 km radius of the site. The nearest record is over 600km away, on the coast.
Latham's Snipe (*Gallinago hardwickii*)	SL	M, Ma	PMST	Typically inhabits soft wet ground, including shallow waters with vegetation and wet parts of paddocks, seepage, irrigation, and similar habitats. Mostly found in coastal regions of eastern Australia but exhibits strong inland movements in certain areas (Pizzey and Knight, 2012).	**Possible** – Two records are located within a 50km radius from the site, they are located approximately 40km southwest of site. The site may contain potential habitat.
Night Parrot (*Pezoporus occidentalis*)	E	E	PMST	Not well known, most associated with spinifex grasslands and chenopod shrublands (Pizzey & Knight, 2012).	**Unlikely** - no records exist within a 50 km radius of the site. The nearest record is over 250km south of the site.
Oriental Plover (*Charadrius veredus*)	SL	M, Ma	PMST	Inland swamps or wetlands, may venture far from water into open plains or bare country (Pizzey & Knight, 2012).	**Unlikely** - no records exist within a 50 km radius of the site.
Oriental Pratincole (*Glareola maldivarum*)	SL	M, Ma	PMST	This species generally migrates to Australia from Nov-Feb, and inhabits plains, shallow edges of wetlands, mudflats, beaches. Nomadic, follows rainfall, appearing in large companies before moving on (Pizzey and Knight 2012).	**Unlikely** – based on information from ALA, no records exist within a 50 km radius of the site.
Painted Honeyeater (*Grantiella picta*)	V	V	PMST, WO	Elusive species with high association with mistletoe, particularly in woodlands with larger numbers of mature eucalypt trees (Pizzey and Knight, 2012). Migration movements are influenced by rainfall and fruiting of mistletoes.	**Unlikely** – Despite the species being recorded three times within a 50km radius of the site, there are no mistletoe species present on site which this speces is highly associated with.
Pectoral Sandpiper (*Calidris melanotos*)	SL	M, Ma	PMST	Typically inhabit shallow fresh water, often with grasses or other herbage. Associated with swamp margins, flooded agricultural land, tidal areas, saltmarshes. Regular but uncommon summer migrant. (Pizzey and Knight 2012). Distribution appears to favour	**Unlikely** - no records exist in the ALA database within a 50 km radius of the site. Habitat on site is likely not optimal as there are no permanent water sources on site.

				coast, with scattered inland records where suitable habitat is present.	
Purple-crowned Fairy-wren (*Malurus coronatus*)	V	NL	WO	The species occurs from the Kimberly region to the gulf of Carpentaria drainage of western Queensland and north-eastern Northern Territory (Threatened Species Scientific Committee, 2015). The species is restricted to a narrow band around well-vegetated river channels. They prefer thick riparian vegetation, typically of cane grass and/or pandanus, but also dense patchy shrubs up to 3 m (Ward & Woinarski, 2012). It is probable the record near the Project area was the eastern subspecies (*Malurus coronatus macgillivrayi*), which occurs along most rivers draining into south-western and southern Gulf of Carpentaria from Roper River in Northern Territory to Leichhardt and Flinders Rivers in Queensland. A natural biogeographic barrier of approximately 300 km of unsuitable habitat separates this subspecies from the western subspecies (*Malurus coronatus coronatus*).	**Possible** – One record exists within a 50km radius of the site. Vegetation along the Dugald river and smaller order streams that run through the site may provide potential habitat for the species.
Rainbow Bee-eater (*Merops ornatus*)	LC	M	PMST	The rainbow bee-eater is abundant throughout most of Australia. It is a breeding migrant in the SE and SW of the country and a breeding resident in north. Throughout inland areas it is generally regarded as a passage migrant (Pizzey and Knight, 2012). It occurs in an extensive array of habitats across the continent.	**Known** – This species has been recorded 21 times on site in the past 12 years.
Red Goshawk (*Erythrotriorchis radiatus*)	E	E	PMST	Rarely encountered species. Habitat is open forests, woodlands, and rainforest fringes, particularly near rivers and wetlands. Range from Kimberly, WA to Sydney, NSW in coastal and subcoastal regions (Pizzey and Knight, 2012).	**Unlikely** – No records exist within a 50km radius of the site using the ALA database. Habitat on site may be suitable, but it is unlikely that the species utilizes it.
Sharp-tailed Sandpiper (*Calidris acuminata*)	SL	M, Ma	WO	Species typically inhabits tidal mudflats, saltmarshes, mangroves, wetlands, floodwater, irrigated agricultural land, ponds. Strong association with water. Widespread	**Possible** – Within a 50km radius of the site, three records exist within the ALA database. The site has several

				summer migrant to coastal and inland Australia (Pizzey and Knight, 2012).	small, ephemeral waterholes that the species could potentially utilize.
White-bellied Sea-Eagle (*Haliaeetus leucogaster*)	LC	Ma	PMST	Inhabits a variety of habitats including coasts, islands, estuaries, inlets, large rivers, inland lakes, reservoirs. Widespread along all Australian coasts, travels inland along large rivers or to large water sources. (Pizzey and Knight, 2012).	**Possible** – The species has been recorded on 14 occurrences within a 50km radius of the site, according to the ALA database. The Dugald River may provide suitable habitat for the species.
Yellow Wagtail (*Motacilla flava*)	SL	M, Ma	PMST	Distribution of records suggests this species favours coastal regions with higher rainfall. Little information available on preferred habitat in Australia.	**Unlikely** - No records exist within a 50km radius of the site using the ALA database. The nearest record is over 300km north, in the Gulf of Carpentaria.
Mammals (n = 5)					
Ghost Bat (*Macroderma gigas*)	E	V	PMST	Patchy and uncommon in most areas with populations limited by the availability of caves, disused mine shafts or similar structures for roosting habitat (Menkhorst and Knight, 2011).	**Unlikely** – No records exist within a 50km radius of the site. The habitat on site may be suitable if roosting structures are available.
Greater Bilby (*Macrotis lagotis*)	E	V	PMST	Open tussock grasslands, Mulga shrublands, hummock grassland. Once widespread through arid and semi-arid areas of the country, now reduced to isolated populations. In QLD, this species is restricted almost exclusively to Astrebla Downs National Park, east of Bedourie (Menkhorst & Knight, 2011).	**Unlikely** - No records exist within a 50km radius of the site. The nearest record in the ALA database is approximately 250 km southwest of the site.
Julia Creek Dunnart (*Sminthopsis douglasi*)	E	V	PMST	Known from open grasslands on deeply cracked soils of the Mitchell Grass Downs bioregion. Infrequently encountered and poorly known species, likely utilising deep soil cracks for shelter (Menkhorst & Knight, 2011).	**Unlikely** - No records exist within a 50km radius of the site. Most records for this species are centred around Julia Creek, with occasional outliers.
Purple-necked rock-wallaby (*Petrogale purpureicollis*)	V	NL	WO	As the name suggests, this species is a rock specialist and generally inhabits rocky outcrops and boulder piles in spinifex grasslands and mulga (Menkhorst & Knight, 2011).	**Known** – Over 12 years of targeted surveys, this species has been recorded on 611 instances on site.
Short-beaked echidna (*Tachyglossus aculeatus*)	SL	NL	WO	This species is Australia's most widely distributed mammal, inhabiting almost every terrestrial habitat on the continent (Menkhorst	**Known** – Four records exist within a 50km radius of the site based on the

				and Knight, 2011). Exists in lower densities in north.	ALA database. This species is widely distributed and likely utilizes habitat
Reptiles (n = 4)					
Freshwater Crocodile	LC	Ma	PMST	In Queensland, this species is a common inhabitant of rivers and creeks flowing into the Gulf of Carpentaria. It may venture far upstream inland rivers, though requires permanent access to water.	**Unlikely** – While the species has two records within a 50km radius of the site, the habitat on the site is unsuitable. The creek lines on the site are ephemeral, and they gain elevation rapidly.
Gulf Snapping Turtle (Elseya lavarackorum)	V	E	PMST	This species is restricted to rivers draining into the Gulf of Carpentaria. It occurs within the Northern Territory and the Southern Gulf (Queensland) Natural Resource Management Regions (Department of the Environment, Water, Heritage and the Arts, 2008).	**Unlikely** - No records exist within a 50km radius of the site. The nearest population is over 225km northwest of the site.
Mertens' water monitor (*Varanus mertensi*)	E	NL	WO	It has a broad distribution that encompasses coastal and inland waters across far north Australia from the Kimberley to Cape York. This species is rarely seen far from water. It is often seen basking on branches overhanging water or on rocks in the middle of streams.	**Known** – This species has been recorded on site twice in 12 years of fauna surveys.
Plains Death Adder (*Acanthophis hawkei*)	V	V	PMST	Not well described. Primarily known from flat, treeless plains of Barkly Tableland where it is associated with Mitchell grasses and deep cracking soils. Taxonomic uncertainty and extreme morphological similarity make correct species identification difficult. (Wilson & Swan, 2021)	**Unlikely** – No records exist within a 50 km radius of the site. The site is likely unsuitable habitat as this species favours habitat that is flat, while the site is geographically complex.
Cartilaginous fish (n = 5)					
Freshwater sawfish (*Pristis pristis*)	LC	V, M	PMST	This species inhabits marine, estuarine, and freshwater habitats. In Queensland, it is known to travel significant distances upstream through large rivers (Department of the Environment, 2014).	**Unlikely** – The nearest record on ALA is located over 250km north of site, near the Gulf of Carpentaria. There is no suitable habitat for this species on site as there is no permanent water source.

[1]NCA Status – Nature Conservation Act (1992) Status. LC – Least Concern, SL – Special Least Concern, NT – Near Threatened, V – Vulnerable, E – Endangered, CR – Critically Endangered.

[2]EPBC Status – Environment Protection and Biodiversity Conservation Act (1999) Status. V – Vulnerable, E – Endangered, CE – Critically Endangered, NL – Not Listed, M – Migratory, Ma - Marine.

[3]50 km search radius around central coordinate for records in: PMST – EPBC Act Protected Matters Report; WO – Wildlife Online Database, ALA – Atlas of Living Australia

EPBC Migratory Species

Common Name (Scientific Name)	Status		Source[3]	Description and Ecology	Likelihood of Occurrence
	NCA[1]	EPBC[2]			
Asian Dowitcher (*Limnodromus semipalmatus*)	SL	M, Ma	Flightpath modelling	A large migratory wader that breeds in isolated colonies in central and eastern Siberia, Mongolia, and north-east China. The species is a regular visitor to the north-west between Port Hedland and Broome. Elsewhere they are sporadic and rare. They occur in sheltered coastal environments, such as embayments, coastal lagoons, estuaries, and tidal creeks (Higgins & Davies, 1996).	**Unlikely** - no records or modelled flight paths exist within a 50 km radius of the Project area.
Bar-tailed Godwit (*Limosa lapponica*)	SL	M, Ma	Flightpath modelling	A large, primarily coastal migratory wader rarely found inland. However, some inland records suggest there is some passage overland and there are records at Lake Moondarra, approximately 70km southwest of the Project area (ALA, 2023).	**Possible** – The presence of modelled flight paths in the vicinity of the Project area, and records at Lake Moondarra, indicate there is a possibility for this species to occur within the Project area.
Black-tailed Godwit (*Limosa limosa*)	SL	M, Ma	Flightpath modelling	A large, migratory wader that inhabits both coastal and inland wetlands. Birds travelling south from northern Australia often pass through the Mt Isa region and there are several records of birds congregating at Lake Moondarra, approximately 70km southwest of the Project area, as well as records at Rifle Creek Dam (ALA, 2023).	**Possible** – The presence of modelled flight paths in the vicinity of the Project area, and records at Lake Moondarra and Rifle Creek Dam, indicate there is a possibility for this species to occur within the Project area.
Broad-billed Sandpiper (*Limicola falcinellus*)	SL	M, Ma	Flightpath modelling	A small, primarily coastal migratory wader rarely recorded inland. There are no records in the vicinity of the Project area (ALA, 2023).	**Possible** – The presence of modelled flight paths in the vicinity of the Project area indicates there is a possibility for this species to occur transiently within the Project area, despite the lack of nearby records.

Common Name (Scientific Name)	Status		Source[3]	Description and Ecology	Likelihood of Occurrence
	NCA[1]	EPBC[2]			
Caspian tern (*Hydroprogne caspia*)	SL	M, Ma	ALA, WO	A large part-migratory to migratory species of tern with a cosmopolitan distribution. In Australia, this species is primarily coastal, though travels inland to visit large bodies of water (Pizzey and Knight, 2012).	**Possible** – within a 50km radius of the Project area, the Caspian tern has 15 records. The Project area has no large bodies of water that are suitable for the species, however, the species may use the Project area temporarily while in transit between waterholes.
Common greenshank/ greenshank (*Tringa nebularia*)	SL	M, Ma	ALA, PMST, Flightpath modelling	Inhabits mudflats, estuaries, saltmarshes, lake and pond margins, wetlands. Generally found in coastal environments, but present inland where habitat is suitable. Widespread summer migrant, with some overwintering. (Pizzey and Knight, 2012).	**Possible** – four records exist within a 50km radius of the Project area. The habitat on Project area is largely unsuitable due to the lack of permanent water sources, however the species may be a temporary resident.
Common Redshank (*Tringa totanus*)	SL	M, Ma	Flightpath modelling	A stout migratory wader that breeds in Iceland, the British Isles, and Scandinavia and spends the non-breeding season in Asia, primarily China, Australasia, Australia, and some Pacific islands (Higgins & Davies, 1996). In Australia, the Common Redshank has been recorded at scattered locations. In Queensland, the species is known to occur in the Cairns district.	**Unlikely** - no records or modelled flight paths exist within a 50 km radius of the Project area.
Common Sandpiper (*Actitis hypoleucos*)	SL	M, Ma	Flightpath modelling	A small sandpiper that is found along all coastlines of Australia and in many areas inland, it is widespread in small numbers. When in Australia, populations are concentrated in northern and west Australia (Higgins and Davies, 1996). They typically occur in sandy, pebbly, or muddy edges of streams or rivers, either coastal or inland (Pizzey & Knight, The Field Guide to the Birds of Australia, 2012).	**Unlikely** - no records or modelled flight paths exist within a 50 km radius of the Project area.

Common Name (Scientific Name)	Status		Source[3]	Description and Ecology	Likelihood of Occurrence
	NCA[1]	EPBC[2]			
Common Tern (*Sterna hirundo*)	SL	M, Ma	Flightpath modelling	A medium-sized slender sea-tern that breeds in North America and Eurasia. They are a non-breeding migrant to Australia, where they are widespread and common on the eastern coast south to eastern Victoria, and common on parts of the northern coast, mainly east of Darwin. In Australia, they are recorded in all marine zones, but are commonly observed in near-coastal waters, both on ocean beaches, platforms, and headlands and in sheltered waters (Higgins & Davies, 1996).	**Unlikely** - no records or modelled flight paths exist within a 50 km radius of the Project area.
Curlew sandpiper (*Calidris ferruginea*)	CR	CE, M, Ma	ALA, PMST, Flightpath modelling	Usually inhabits intertidal mudflats, such as lagoons, bays, estuaries, inlets etc. Recorded less often inland around permanent and ephemeral water sources such as dams, ponds, lakes, waterholes. Inland records are sparse. (Pizzey and Knight, 2012) (DAWE, 2022d).	**Possible** – Two records exist within a 50km radius of the Project area; they are located approximately 40km southwest of the Project area. A very small percentage of the Project area would be considered suitable habitat, furthermore due to the seasonal and ephemeral nature of the waterholes, it is unlikely that it would be used as habitat for the species.
Double-banded Plover (*Charadrius bicinctus*)	SL	M, Ma	Flightpath modelling	A medium-sized dotterel that is generally found in pairs during the breeding season but are gregarious in the non-breeding season. The Double-banded Plover breeds only in New Zealand, where it is widespread. During the non-breeding season, it is common in eastern and southern Australia, mainly between the Tropic of Capricorn and western Eyre Peninsula, with occasional records in northern Queensland and Western Australia (Marchant & Higgins, 1993). They are found on littoral, estuarine and fresh or saline terrestrial wetlands and also saltmarsh, grasslands, and pasture.	**Unlikely** - no records or modelled flight paths exist within a 50 km radius of the Project area.

Common Name (Scientific Name)	Status		Source[3]	Description and Ecology	Likelihood of Occurrence
	NCA[1]	EPBC[2]			
Eastern Curlew (*Numenius madagascariensis*)	E	CE, M, Ma	PMST, Flightpath modelling	Within Australia, the eastern curlew has a primarily coastal distribution. The species is found in all states, particularly the north, east, and south-east regions including Tasmania. Eastern curlews are rarely recorded inland. They have a continuous distribution from Barrow Island and Dampier Archipelago, Western Australia, through the Kimberley and along the Northern Territory, Queensland, and NSW coasts and the islands of Torres Strait. They are patchily distributed elsewhere (Department of the Environment, 2015).	**Possible** – Within the ALA database, no records exist within 50 km of the Project area. The species does not often travel inland, and most inland records are proximal to large water sources, which the Project area does not possess. However, due to the presence of modelled flight paths in the vicinity of the Project area indicates there is a possibility for this species to occur transiently within the Project area, despite the lack of nearby records.
Fork-tailed swift (*Apus pacificus*)	SL	M, Ma	PMST	Widespread across Australia. Scattered records from throughout the Gulf of Carpentaria and Cape York. Almost exclusively aerial, have been recorded in most habitats across Australia (Pizzey and Knight, 2012).	**Unlikely** - no records or modelled flight paths exist within a 50 km radius of the Project area.
Glossy ibis (*Plegadis falcinellus*)	SL	M, Ma	ALA, WO	Prefers well-vegetated wetlands, floodplains, irrigated pastures, sewage ponds, mangroves, mudflats, and the like. Occasionally occurs in dry grasslands. The migratory and nomadic species breeds in southern Australia between October to December and in north Australia between February to April. Range may extend far inland after good rains. (Pizzey and Knight, 2012).	**Known** – 14 records exist within a 50 km radius of the Project area. Most of the occurrences are proximal to water sources, due to the lack of permanent water sources on Project area, the species may be less likely to frequent the Project area.
Great Knot (*Calidris tenuirostris*)	CE	CE, M, Ma	Flightpath modelling	The largest of its genus. A migratory bird that breeds in Siberia and spends the non-breeding season in Australia. Recorded primarily around coastal wetlands with sparse scattered inland records, usually on inland lakes (Garnett, Szabo, & Dutson, The Action Plan for Australian Birds 2010, 2011).	**Possible** – The presence of modelled flight paths in the vicinity of the Project area indicates there is a possibility for this species to occur transiently within the Project area, despite the lack of nearby records.

Common Name (Scientific Name)	Status		Source[3]	Description and Ecology	Likelihood of Occurrence
	NCA[1]	EPBC[2]			
Greater Sand Plover (*Charadrius leschenaultii*)	LC	V, M, Ma	Flightpath modelling	A medium-sized migratory plover that breeds in Asia and migrates to Australia and some western-pacific islands for the non-breeding season. They are primarily coastal, arriving in northern Australia and dispersing around the country. The scarcity of inland records suggests that movements to southern and eastern areas in Australia occur around the coastline rather than across the continent (Bamford, 1988) (Blakers, Davies, & Reilly, 1984) (Lane, 1987) (Sibson, 1948) (Stewart, Rogers, & Rogers, 2007). However, there is a single record in the vicinity of the Project area at Lake Moondarra, approximately 70km southwest of the Project area (ALA, 2023).	**Possible** – The presence of modelled flight paths in the vicinity of the Project area indicates there is a possibility for this species to occur transiently within the Project area, despite the lack of nearby records.
Grey Plover (*Pluvialis squatarola*)	SL	M, Ma	Flightpath modelling	A medium-sized migratory plover that breeds in the far northern hemisphere and spends the non-breeding season on the coasts of America, southern Europe, Africa, southern Asia, and Australia (Cramp & Simmons, 1983) (de Schauensee, 1970) (de Schauensee, The Birds of China, 1984) (Grimmett, Inskipp, & Inskipp, 1999b) (Orn. Soc. Japan, 2000) (Urban, Fry, & Keith, 1986) (Wiersma, 1996). In Australia, Grey Plovers occur almost entirely in coastal areas, however there are records of overland movement. There is a single record in the vicinity of the Project area at Lake Moondarra, approximately 70km southwest of the Project area (ALA, 2023).	**Possible** – The presence of modelled flight paths in the vicinity of the Project area indicates there is a possibility for this species to occur transiently within the Project area, despite the lack of nearby records.

Common Name (Scientific Name)	Status		Source[3]	Description and Ecology	Likelihood of Occurrence
	NCA[1]	EPBC[2]			
Grey-tailed Tattler (*Tringa brevipes*)	SL	M, Ma	Flightpath modelling	A medium-sized migratory wader that breeds in the northern hemisphere, specifically north Siberia, and migrates south to Australia for the boreal winter. In Australia, the species is found in most coastal regions, primarily along the northern coast. There are rare inland records, including Burdekin Weir, Charters Towers and Mount Isa. There are no records in the vicinity of the Project area (ALA, 2023).	**Possible** – The presence of modelled flight paths in the vicinity of the Project area indicates there is a possibility for this species to occur transiently within the Project area, despite the lack of nearby records.
Gull-billed Tern (*Gelochelidon nilotica*)	SL	M, Ma	Flightpath modelling	A medium-sized, stocky tern. Preferred habitat includes beaches, mudflats, fresh and brackish wetlands including far inland, grasslands, crops, ploughed fields and airfields (Pizzey & Knight, The Field Guide to the Birds of Australia, 2012). Breeding occurs in September–May usually in small colonies on islands.	**Unlikely** - no records or modelled flight paths exist within a 50 km radius of the Project area.
Latham's snipe (*Gallinago hardwickii*)	SL	M, Ma	PMST	Typically inhabits soft wet ground, including shallow waters with vegetation and wet parts of paddocks, seepage, irrigation, and similar habitats. Mostly found in coastal regions of eastern Australia but exhibits strong inland movements in certain areas (Pizzey and Knight, 2012).	**Possible** – Two records are located within a 50km radius from the Project area, they are located approximately 40km southwest of Project area. The Project area may contain potential habitat.
Lesser Sand Plover (*Charadrius mongolus*)	E	E, M, Ma	ALA, Flightpath modelling	Two Lesser Sand Plover subspecies migrate to Australia for the boreal winter. In Australia, this species is present in coastal regions in all states but are most common in northern and eastern Australia. They are rarely recorded inland; however, they have been recorded at margins of lakes and soaks and swamps associated with artesian bores (Marchant & Higgins, 1993). Within the vicinity of the Project area, there are three records around Mt Isa City (ALA, 2023).	**Possible** – The presence of modelled flight paths in the vicinity of the Project area, and records around Mt Isa City, indicate there is a possibility for this species to occur within the Project area.

Common Name (Scientific Name)	Status		Source[3]	Description and Ecology	Likelihood of Occurrence
	NCA[1]	EPBC[2]			
Little curlew (*Numenius minutus*)	SL	M, Ma		A small migratory curlew that breeds in Siberia, and generally spends the non-breeding season in northern Australia from Port Hedland, WA to the Queensland coast. They are widespread in coastal regions with some inland records. In the vicinity of the Project area, they are known to congregate at Lake Moondarra, approximately 70km southwest of the Project area, and there are records scattered in and around Mt Isa City (ALA, 2023).	**Unlikely** - no records or modelled flight paths exist within a 50 km radius of the Project area.
Little Ringed Plover (*Charadrius dubius*)	SL	M, Ma		A small delicately built plover that breeds on stony substrates around lakes, gravel pits, and along rivers. Migrants occur in wide variety of fresh and brackish wetland habitats, but rarely out on open tidal areas (Sullivan, et al., 2009).	**Unlikely** - no records or modelled flight paths exist within a 50 km radius of the Project area.
Little Tern (*Sterna albifrons*)	SL	M, Ma	Flightpath modelling	A small, slender tern that breeds overseas and in Australia. In Australia there are three distinct populations of Little Tern: two breeding populations in northern and eastern Australia and one non-breeding population that migrates from breeding grounds in Asia to avoid the winter. They are associated with sheltered coastal environments. There are no records of this species in the vicinity of the Project area (ALA, 2023).	**Possible** – The presence of modelled flight paths in the vicinity of the Project area indicates there is a possibility for this species to occur transiently within the Project area, despite the lack of nearby records.
Long-toed Stint (*Calidris subminuta*)	SL	M, Ma		A very small migratory sandpiper that is believed to breed in Siberia and is a regular summer visitor to Australia, but uncommon in the east. In Australia, the Long-toed Stint occurs in a variety of terrestrial wetlands. They prefer shallow freshwater or brackish wetlands including lakes, swamps, river floodplains, streams, lagoons and sewage ponds. They have been recorded at Mount Isa (Higgins & Davies, 1996).	**Unlikely** - no records or modelled flight paths exist within a 50 km radius of the Project area.

Common Name (Scientific Name)	Status		Source[3]	Description and Ecology	Likelihood of Occurrence
	NCA[1]	EPBC[2]			
Marsh sandpiper (*Tringa stagnatilis*)	SL	M, Ma	ALA, Flightpath modelling	A medium-sized migratory sandpiper often found singly or in small to large flocks. They are a non-breeding visitor to Australia, where they are found on coastal and inland wetlands around the country. In the vicinity of the Project area, they are known to congregate at Lake Moondarra, approximately 70km southwest of the Project area, and there are abundant records in and around Mt Isa City, as well as at Corella Dam and Chinaman Dam (ALA, 2023).	**Possible** – The presence of modelled flight paths in the vicinity of the Project area, and records at Late Moondarra, Corella Dam, Chinaman Dam, and around Mt Isa City, indicate there is a possibility for this species to occur within the Project area.
Oriental Plover (*Charadrius veredus*)	SL	M, Ma	PMST	Inland swamps or wetlands, may venture far from water into open plains or bare country (Pizzey & Knight, 2012).	**Unlikely** - no records exist within a 50 km radius of the Project area.
Oriental Pratincole (*Glareola maldivarum*)	SL	M, Ma		A tern-like shorebird with long, pointed wings and a forked tail (Department of Climate Change, Energy, the Environment and Water., 2023). This species generally migrates to Australia from Nov-Feb, and inhabits plains, shallow edges of wetlands, mudflats, beaches. Nomadic, follows rainfall, appearing in large companies before moving on.	**Unlikely** - no records or modelled flight paths exist within a 50 km radius of the Project area.
Pacific Golden Plover (*Pluvialis fulva*)	SL	M, Ma	Flightpath modelling	A medium-sized migratory plover often found in flocks of 20-50 birds (Marchant & Higgins, 1993). They breed in northern Siberia and Alaska, and spend the non-breeding season in Asia, Australia, and Polynesia (Grimmett, Inskipp, & Inskipp, 1999b) (de Schauensee, 1984). They are common in coastal regions in all states, though there are also inland records in all states often along major river systems. In the vicinity of the Project area, there are several records at Lake Moondarra, approximately 70km southwest of the Project area, and in and around Mt Isa City (ALA, 2023).	**Possible** – The presence of modelled flight paths in the vicinity of the Project area, and records at Late Moondarra and around Mt Isa City, indicate there is a possibility for this species to occur within the Project area.

Common Name (Scientific Name)	Status		Source[3]	Description and Ecology	Likelihood of Occurrence
	NCA[1]	EPBC[2]			
Pectoral Sandpiper	SL	Ma		A small to medium sized sandpiper characterised by a flat back and a plump body that tapers to a drawn-out rear end (Higgins & Davies, 1996). Typically, they inhabit shallow fresh water, often with grasses or other herbage. Associated with swamp margins, flooded agricultural land, tidal areas, saltmarshes. Regular but uncommon summer migrant. (Pizzey & Knight, The Field Guide to the Birds of Australia, 2012). In Queensland, most records occur around Cairns with scattered records elsewhere including a few inland records around Mt Isa.	**Unlikely** - no records or modelled flight paths exist within a 50 km radius of the Project area.
Red Knot (*Calidris canutus*)	E	E, M, Ma	Flightpath modelling	A robust small to medium-sized migratory wader that breeds in the Arctic and migrates to non-breeding areas that extend to south America, Africa, and Australasia (del Hoyo, Elliott, & Sargatal, 1996). They are primarily coastal and mainly inhabit intertidal mudflats, sandflats, and sandy beaches of sheltered coasts. There is evidence of some overland movement, however there are no records in the vicinity of the Project area (ALA, 2023).	**Possible** – The presence of modelled flight paths in the vicinity of the Project area indicates there is a possibility for this species to occur transiently within the Project area, despite the lack of nearby records.
Red-necked Phalarope (*Phalaropus lobatus*)	SL	M, Ma		A distinctive marine wader that is the smallest of its family. One of the only waders occurring regularly at sea. They mainly winter at sea around the tropics but are occasionally seen on coastal and inland wetlands (Higgins & Davies, 1996). In Queensland the species has been found at Lake Moondarra, Mount Isa, Hood's Lagoon and Helidon.	**Unlikely** - no records or modelled flight paths exist within a 50 km radius of the Project area.

Common Name (Scientific Name)	Status		Source[3]	Description and Ecology	Likelihood of Occurrence
	NCA[1]	EPBC[2]			
Red-necked Stint (*Calidris ruficollis*)	SL	M, Ma	ALA, Flightpath modelling	The smallest shorebird in Australia. They breed in Siberia and Alaska and migrate to Australasia, primarily Australia, for the Boreal winter (Higgins & Davies, 1996). In Australia, they are found mainly on the coast in sheltered inlets, bays, lagoons, and estuaries with intertidal mudflats, and can also occur on near coastal or inland ephemeral or permanent shallow wetlands. They often move overland and there are several records within the vicinity of the Project area at Lake Moondarra, approximately 70km southwest of the Project area, in and around Mt Isa City, at Chinaman Dam, and in Cloncurry (ALA, 2023).	**Possible** – The presence of modelled flight paths in the vicinity of the Project area, and records at Late Moondarra, Chinaman Dam, and around Mt Isa City and Cloncurry, indicate there is a possibility for this species to occur within the Project area.
Ruddy Turnstone (*Arenaria interpres*)	SL	M, Ma	Flightpath modelling	A stocky medium-sized wader that breeds in coastal Europe, Asia, and North America. Their non-breeding distribution is almost cosmopolitan, they are common throughout Australasia and are widespread in Australia (Higgins & Davies, 1996). In Australia, they are found in most coastal regions with exposed rock coast lines or coral reefs, with occasional records of inland populations in habitats such as riverbeds, and on inland lakes and adjacent farmland (Higgins & Davies, 1996). In the vicinity of the Project area, there are several records at Lake Moondarra, approximately 70km southwest of the Project area (ALA, 2023).	**Possible** – The presence of modelled flight paths in the vicinity of the Project area, and records at Lake Moondarra, indicate there is a possibility for this species to occur within the Project area.

Common Name (Scientific Name)	Status		Source[3]	Description and Ecology	Likelihood of Occurrence
	NCA[1]	EPBC[2]			
Ruff (*Philomachus pugnax*)	SL	M, Ma		A medium-sized wader that breeds in Europe from north Russia to north-west Kazakhstan. They are a rare but regular visitor to Australia, being recorded in all States and Territories. In Australia the Ruff is found on generally fresh, brackish of saline wetlands with exposed mudflats at the edges. It is found in terrestrial wetlands including lakes, swamps, pools, lagoons, tidal rivers, swampy fields and flood lands.	**Unlikely** - no records or modelled flight paths exist within a 50 km radius of the Project area.
Sanderling (*Calidris alba*)	SL	M, Ma	Flightpath modelling	A migratory sandpiper typically found in small to large flocks, sometimes in the hundreds. They breed in the northern hemisphere, specifically in northern North America, northern Russia, and islands in the Arctic Ocean. They migrate south to spend the non-breeding season on sandy coastal shores of all continents except Antarctica. They are mainly coastal, however there are rare records of birds stopping inland on sandy shores of ephemeral brackish lakes or river-pools (Higgins & Davies, 1996). There are no records of the species in the vicinity of the Project area (ALA, 2023).	**Possible** – The presence of modelled flight paths in the vicinity of the Project area indicates there is a possibility for this species to occur transiently within the Project area, despite the lack of nearby records.
Sharp-tailed sandpiper (*Calidris acuminata*)	SL	M, Ma	ALA, WO, Flightpath modelling	Species typically inhabits tidal mudflats, saltmarshes, mangroves, wetlands, floodwater, irrigated agricultural land, ponds. Strong association with water. Widespread summer migrant to coastal and inland Australia (Pizzey and Knight, 2012).	**Possible** – Within a 50km radius of the Project area, three records exist within the ALA database. The Project area has several small, ephemeral waterholes that the species could potentially utilize.
Short-tailed Shearwater (*Ardenna tenuirostris*)	SL	M, Ma	Flightpath modelling	A medium-sized shearwater that is common in the Pacific Ocean, especially around Australia, New Zealand and up to the Bering Sea. Can be abundant in ocean waters off Alaska, gathering in enormous flocks; less common further south (Sullivan, et al., 2009).	**Unlikely** - no records or modelled flight paths exist within a 50 km radius of the Project area.

Common Name (Scientific Name)	Status		Source[3]	Description and Ecology	Likelihood of Occurrence
	NCA[1]	EPBC[2]			
Swinhoe's Snipe (*Gallinago megala*)	SL	M, Ma	Flightpath modelling	Very similar in morphology to Latham's snipe (*Gallinago hardwickii*). Swinhoe's Snipe breeds in central and southern Siberia. Few definite records exist for Swinhoe's Snipe in Australia. The species has been recorded in the north between the Kimberley Divide and Cape York Peninsula. During the non-breeding season Swinhoe's Snipe occurs at the edges of wetlands, such as wet paddy fields, swamps, and freshwater streams. The species is also known to occur in grasslands, drier cultivated areas (including crops of rapeseed and wheat) and market gardens (Higgins & Davies 1996).	**Unlikely** - no records or modelled flight paths exist within a 50 km radius of the Project area.
Terek Sandpiper (*Xenus cinereus*)	SL	M, Ma	Flightpath modelling	A small migratory wader that breeds in the northern hemisphere, specifically Russia, Ukraine, Finland, and northern Estonia. They migrate south for the boreal winter, occurring in coastal Africa, throughout southern Asia from the Persian Gulf east to Japan, Indomalaya and Indochina, New Guinea, Australia, and New Zealand (Marchant & Higgins, 1993). Approximately 1/8th of the global population spends the non-breeding season in Australia (Geering A, 2007). They are associated with coastal areas and prefer mangroves for roosting and soft wet intertidal mudflats or sheltered estuaries, embayments, harbors or lagoons for foraging (Marchant & Higgins, 1993). Inland records suggest there is some overland migration (Blakers, Davies, & Reilly, 1984). There is a single record in the vicinity of the Project area at Lake Moondarra, approximately 70km southwest of the Project area (ALA, 2023).	**Possible** – The presence of modelled flight paths in the vicinity of the Project area, and records at Lake Moondarra, indicate there is a possibility for this species to occur within the Project area.

Common Name (Scientific Name)	Status		Source[3]	Description and Ecology	Likelihood of Occurrence
	NCA[1]	EPBC[2]			
Wandering Albatross (*Diomedea exulans*)	V	V, M, Ma	Flightpath modelling	A large migratory bird with the longest wing-span of any ocean bird (2.5-3.5m). They are solitary or gregarious at sea. It breeds in colonies (Marchant & Higgins, Handbook of Australian, New Zealand and Antarctic Birds. Volume One - Ratites to Ducks, 1990). The Wandering Albatross has a circumpolar distribution. It breeds on six subantarctic island groups (Marchant & Higgins, 1990). In the Australasian region, it occurs inshore, offshore and in pelagic waters (Barton, 1979).	**Unlikely** - no records or modelled flight paths exist within a 50 km radius of the Project area.
Whimbrel (*Numenius phaeopus*)	SL	M, Ma	Flightpath modelling	A medium-sized migratory curlew that breeds in the northern hemisphere, mainly in Alaska but has also been observed breeding across northern Europe into Russia. They migrate south for the boreal winter and can occur through Central and South America, coastal Africa, the Persian Gulf, south-east Asia, New Guinea, Micronesia, Melanesia, Polynesia, and Australia. Only one subspecies, *Numenius phaeopus variegates*, occurs in the East Asian-Australasian Flyway. In Australia, Whimbrels are often found on the intertidal mudflats of sheltered coasts or harbors. Inland records suggest there is some overland movement, however there are no records of the Whimbrel the vicinity of the Project area (ALA, 2023).	**Possible** – The presence of modelled flight paths in the vicinity of the Project area indicates there is a possibility for this species to occur transiently within the Project area, despite the lack of nearby records.

Common Name (Scientific Name)	Status		Source[3]	Description and Ecology	Likelihood of Occurrence
	NCA[1]	EPBC[2]			
White-winged Black Tern (*Chlidonias leucopterus*)	SL	M, Ma	Flightpath modelling	A slender, compact migratory marsh tern that breeds in a wide range in the northern hemisphere, from Italy through Russia to Eastern China. The species migrates south for the boreal winter, occurring in sub-Saharan Africa, southern Asia, Indonesia, New Guinea, Australia, and New Zealand. Within Australia, White-winged Black Terns are common along most coastal areas except the south-east. They are commonly found on tidal wetlands and rarely on inland wetlands such as lakes, billabongs, rivers, floodplains, or reservoirs (Higgins & Davies, 1996) (Gochfeld & Burger, 1996). In the vicinity of the Project area, there are several records on Lake Moondarra and scattered records near Mt Isa City, approximately 70km southwest of the Project area, at Corella Dam, and at Chinaman Dam near Cloncurry (ALA, 2023).	**Unlikely** - no records or modelled flight paths exist within a 50 km radius of the Project area.
Wood Sandpiper (*Tringa glareola*)	SL	M, Ma	Flightpath modelling	A small, thin wader that is seen singly, in pairs or in small flocks. Occasionally they will flock in the hundreds. They associate freely with other waders (Higgins & Davies, 1996). This species is a regular summer (September – April) migrant to northern Australia, however Queensland records are scattered (Pizzey & Knight, 2012). Typical habitat includes well vegetated, shallow, freshwater wetlands such as swamps, billabongs, lakes, pools, and waterholes. They are typically associated with emergent, aquatic plants and areas dominated by taller fringing vegetation. This species will also use artificial wetlands including open sewage ponds, large farm dams and bore drains (Higgins & Davies, 1996).	**Unlikely** - no records or modelled flight paths exist within a 50 km radius of the Project area.

[1]NCA Status – Nature Conservation Act (1992) Status. LC – Least Concern, SL – Special Least Concern, NT – Near Threatened, V – Vulnerable, E – Endangered, CR – Critically Endangered.

[2]EPBC Status – Environment Protection and Biodiversity Conservation Act (1999) Status. V – Vulnerable, E – Endangered, CE – Critically Endangered, NL – Not Listed, M – Migratory, Ma - Marine.

[3]50 km search radius around central coordinate for records in: PMST – EPBC Act Protected Matters Report; WO – Wildlife Online Database, ALA – Atlas of Living Australia, Flightpath Modelling – Speculative mapping of flightpaths between know congregation sites. 2 km search radius around central coordinate for: MPH – Modelled Potential Habitat layer in Qspatial.

APPENDIX G: Species notes on potentially occurring EVNT flora and fauna

Flora

Ipomoea antonschmidii

EPBC – Not listed. NCA – Near threatened.

A trailing vine with large, alternate, hairy leaves (Johnson, 1986). The flowers, which appear between January and June, are pink to mauve in colour and are open during the day, closing in the afternoon. The seeds are found inside dry capsules. This species is currently known from a restricted area southwest of Lake Julius Dam, north-northeast of Mt. Isa. It grows on shallow, red, stoney soils in *Eucalyptus leucophloia* woodland (Johnson, 1986). Records within the past 20 years have been centred around gunpowder creek, north of Mt. Isa (Atlas of Living Australia, 2023).

Fauna

Australian painted snipe *(Rostratula australis)*

EPBC – Endangered, Marine. NCA – Endangered

The Australian painted snipe (*Rostratula australis*) is a cryptic species that is largely seasonal, following wet season inundations. It is a stocky, wading shore bird with a shorter beak than other snipe species and distinctive white comma-shaped eye markings (Pizzey & Knight, The Field Guide to the Birds of Australia, 2012). Unlike other snipe species in Australia, the Australian painted snipe does not seasonally migrate outside of Australia, though migration within the country does occur. The species generally inhabits shallow terrestrial freshwater (occasionally brackish) wetlands, including temporary and permanent lakes, swamps and claypans. They also use inundated or waterlogged grassland or saltmarsh, dams, rice crops, sewage farms and bore drains. Typical sites include those with rank emergent tussocks of grass, sedges, rushes or reeds, or samphire; often with scattered clumps of lignum Muehlenbeckia or canegrass or sometimes tea-tree (Melaleuca). The Australian Painted Snipe sometimes utilises areas that are lined with trees, or that have some scattered fallen or washed-up timber (Marchant & Higgins, 1993)

Australian Painted Snipe breeding habitat requirements may be quite specific: shallow wetlands with areas of bare wet mud and mixed heights of low vegetation. Nest records are all, or nearly all, from or near small islands in freshwater wetlands, with a combination of very shallow water, exposed mud, dense low cover and sometimes some tall dense cover (Rogers, et al., 2005). Gilgai micro relief, comprising extensive systems of small mounds (e.g. 1 to 3 m in diameter) and hollows (e.g. up to 0.5 m deep), is especially suitable; wetlands with gilgai are abundant in seasonal and other temporary wetlands of Australia, especially in the Murray Darling, arid and savannah regions on clay soils. The Australian Painted Snipe can use modified habitats, such as low-lying woodlands converted to grazing pasture, rice farms, sewage farms, dams, bores and irrigation schemes, however they do not necessarily breed in such habitats (Marchant & Higgins, 1993).

The Australian painted snipe is well distributed across the country, though the bulk of the records for this species are along the southeast coast of Australia, from Brisbane to Adelaide (Atlas of Living Australia, 2023).

The species has a historical population stronghold in the Murray-Darling basin, with a much patchier distribution in the north of its range, generally relying on water and rainfall events (TSSC, 2013; Pizzey & Knight, The Field Guide to the Birds of Australia, 2012).

The Australian painted snipe is primarily threatened by habitat degradation. This is particularly evident in one of the most important habitat areas for this species, the Murray-Darling basin. A history of water mismanagement for irrigation, wetland degradation, and drought in recent years has significantly reduced suitable habitat for the species (DSEWPC 2013). Climate change is also implicated is exacerbating these negative effects and is predicted to increase in severity. This species is also threatened by grazing, introduced predators, and invasion of weeds in wetland habitats (TSSC, 2013).

The Australian painted snipe has previously been included as a subspecies of the greater painted snipe (*Rostratula benghalensis*), a related species that occurs in Africa and Asia. The species is listed "marine" under this alternate naming. The name *Rostratula australis* is considered most appropriate here, as the species is distinguishable from *R. benghalensis* on morphology (TSSC, 2013). The Australian painted snipe is cryptic, secretive, and usually difficult to detect. Appearance in northern Australia is considered seasonal, following wet season inundations.

One record exists approximately 40 km southwest of the site. Due to the habitat requirements of this species, there is no suitable habitat within the ML, however low quality suitable habitat exists in in pockets along Dugald River and Cabbage Tree Creek. No suitable breeding habitat is found near the site as the species has specific breeding habitat requirements. There is the potential for the species to transit through the site to reach suitable habitat elsewhere.

Black-eared cuckoo *(Chalcites osculans)*

EPBC – Marine. NCA – Least concern

Black-eared cuckoo (*Chalcites osculans*) are widespread across Australia however, they are more often seen in drier shrublands and woodlands. Their distribution is dictated by the range of their principal host, the speckled warbler. They are a rarely seen species due to their soft call and cryptic nature. Black-eared cuckoos typically inhabit drier woodlands, scrublands, mallee, mulga, saltmarsh, and riverside thickets (Pizzey & Knight, The Field Guide to the Birds of Australia, 2012). They are widespread across Australia and the population is currently stable (BirdLife International, 2023).

As this species is widespread across Australia, it is possible that it could inhabit the site. Two records have been recorded on ALA within a 50km radius of the site. The habitat within the site is suitable as they inhabit a range of habitats.

Carpentarian grasswren *(Amytornis dorotheae)*

EPBC – Endangered. NCA – Endangered

The Carpentarian grasswren is endemic to the southern Gulf of Carpentaria region of northern Australia. The largest remaining specific population of Carpentarian grasswrens exists in the Mount Isa region of Queensland (Threatened Species Scientific Committee, 2016).

Generally confined to long-unburnt mature *Triodia* spp. hummock grassland or very open low woodland with *Triodia* understorey, avoiding recently (3 to 4 years previously) burnt areas, forages for seeds and insects around sandstone outcropping, on the ground, in rock crevices, leaf litter under *Triodia* hummocks and shrubs. Grasswrens normally abandon burnt areas unless substantial unburnt pockets of spinifex remain. Breeding season is November to March. (Threatened Species Scientific Committee, 2016).

Prior to site survey, the desktop searches identified that the Carpentarian grasswren had the potential to be found on site as there is a proximal record. However, suitable habitat for the Carpentarian grasswren is not present within the project area. The species requires hummocking Trioda species, groundtruthing of the site revealed no hummocking grasses. Fauna surveys have been conducted on the Knapdale range for ten years, of which the Carpentarian grasswren has not been recorded. The related Kalkadoon grasswren has been recorded on the range on multiple occasions, proving that survey methods utilised are suitable for recording this genus of grasswren. The two species are known to occur in close proximity north of Mount Isa, however they tend to be found in separate habitats due to habitat preference. The Kalkadoon grasswren tends to occur at higher elevations on massive, rocky outcrops, hills, and ranges, while the Carpentarian grasswren occurs at lower elevations on stony, skeletal soils among large, mature hummock grass. Habitat on the Knapdale range is similar to that of the habitats preferred by the Kalkadoon grasswren. Habitat which is more suitable to the Carpentarian grasswren can be found east of the Knapdale range, between the range and the Dugald River; however after years of survey, no Carpentarian grasswrens have been found. The habitats the the Carpentarian grasswrens occupy are vastly different from habitat on the Knapdale Range where impacts are expected. It is unlikely that the Carpentarian grasswren will be impacted by this project, as the habitat impacted by the turbines is unsuitable for the species.

Caspian tern (*Hydroprogne caspia*)

EPBC – Migratory, Marine. NCA – Special least concern

The Caspian tern (*Hydroprogne caspia*) is the largest tern in Australia with an easily distinguished heavy, red bill. They are gregarious during breeding season and mostly single or in small groups outside of breeding. Occasionally groups of up to 30 can occur, often in fishing areas or whilst roosting. This species can aggregate into flocks during migration (Higgins and Davies 1996).

In Queensland, distribution is widespread in coastal regions, but they have been recorded in western districts such as Lake Eyre Drainage Basin, north-west to the Gulf Country, north to Mt Isa and Cloncurry. There are also scattered accounts or central Queensland (Higgins and Davies 1996).

Preferred habitat includes sheltered coastal embayment and those with sandy or muddy margins. They will also use artificial water sources including reservoirs, sewage ponds and saltworks (Higgins and Davis 1996).

Some of the threats to Caspian terns include habitat loss and degradation through the introduction of exotic plant species, human disturbance and trampling by livestock of breeding sites and exposure to contaminants (Birdlife International 2023).

In Australia, the Caspian Tern is a resident and present throughout the year at sites where breeding occurs year round and also at some sites where breeding is protracted (e.g. Darwin and WA). At some sites where breeding does not occur, seasonal patterns that are consistent with passage (migration) occurring (Higgins & Davies, 1996).

It is possible for the species to be a temporary resident of the site. Fifteen records exist on ALA within a 50km radius of the site; however, the site has no large bodies of water to provide suitable habitat. It is possible the species could use the site when travelling from one waterhole to another.

Cattle egret (*Bubulcus ibis)*

EPBC – Marine. NCA – Least concern

The Cattle egret (*Bubulcus ibis*) is a small, stocky, and mostly white egret. The common name comes from its association with cattle as it eats ticks and flies off the backs of livestock (Marchant & Higgins, Handbook of Australian, New Zealand and Antarctic Birds. Volume One - Ratites to Ducks, 1990). It is a widespread and common species of egret. Cattle egrets breed in colonies, mainly in the central coast from Newcastle to Bundaberg, however there are scattered minor colonies throughout Queensland. When not breeding they are found in most areas that have suitable habitat (Marchant & Higgins, Handbook of Australian, New Zealand and Antarctic Birds. Volume One - Ratites to Ducks, 1990). Typical habitat includes tropical and temperate grasslands, wooded lands, and terrestrial wetlands. Occasionally they are recorded in arid and semi-arid areas.

Threats to cattle egret in Australia include persecution of large colonies in urban areas and habitat destruction (BirdLife International, 2009).

It is possible for the cattle egret to utilize habitat within the site. Within a 50km radius of the site, ALA has three records od the species. The lack of a permanent water source makes the site an unsuitable habitat for most of the year.

Common greenshank/ greenshank *(Tringa nebularia)*

EPBC – Migratory, Marine. NCA – Special least concern

The Common greenshank (*Tringa nebularia*) is a heavily-built wading bird with a long bill that is slightly upturned. This species is seen both singly and in large flocks in coastal and inland wetlands. It does not breed within Australia but does occur in all types of wetlands and has the widest distribution of any shorebird (Higgins & Davies, 1996).

Typical habitat includes large mudflats and saltmarsh, mangroves, or seagrass. They can also utilize permanent and ephemeral terrestrial wetlands including swamps, lakes, dams, rivers, creeks, and billabongs as well as artificial wetlands.

Threats include loss and modification of habitat and silt pollution, weeds, and pest invasion (AGDEH, 2005).

Fork-tailed swift *(Apus pacificus)*

EPBC – Marine, Migratory. NCA – Special least concern

The fork-tailed swift (*Apus pacificus*) is a slender swift with a distinct forked tail that breeds in the northern hemisphere and migrates to Australia for the southern summer. It is widespread across Australia with records scattered throughout most of Australia (Department of Climate Change, Energy, the Environment and Water., 2023). The species is almost exclusively aerial and has been recorded in most habitats across Australia, including open inland plains, riparian woodland and tea-tree swamps, low scrub, heathland, or saltmarsh (DAWE, 2021).

Threats may include predation by feral animals. Due to the wide range of the species and its reluctancy to land, potential threats are thought to be negligible (BirdLife International, 2009).

Considering the extreme aerial affiliation of this species, terrestrial habitat is of lower significance. As habitat is not a suitable predictor for where this species is found, occurrence data has been mapped. It is possible for this species to transit across the ML, as they are widespread and highly mobile.

Glossy ibis (*Plegadis falcinellus*)

EPBC – Marine, Migratory. NCA – Special least concern.

The glossy ibis (*Plegadis falcinellus*) is the smallest ibis in Australia. They are found singularly, in pairs or in small flocks. Occasionally large flocks can occur. They are often found in the company of other ibis such as straw-necked ibis (*Threskiornis spinicollis*) or Australian White Ibis (*Threskiornis molucca*). Generally, glossy ibis are known to occur east of the Kimberley in WA and Eyre Peninsular in SA. Preferred habitat includes freshwater marshes at the edges of lakes, rivers, lagoons, flood-plains, wet meadows, swamps and sewage ponds. The species has also been recorded in permanent wetlands and coastal areas during drought (Marchant & Higgins, Handbook of Australian, New Zealand and Antarctic Birds. Volume One - Ratites to Ducks, 1990).

Threats to this species include wetland degradation and destruction for example water diversion and drainage, irrigation and hydroelectric power production (Snow & Perrins, 1998). Clearing, grazing and invasion of exotic plants and fish species also pose a threat to the species through habitat modification.

Grey falcon (*Falco hypoleucos*)

EPBC – Vulnerable. NCA - Vulnerable

The grey falcon (*Falco hypoleucos*) is pale grey coloured falcon with distinct yellow legs and eye ring. It is a proficient predator, predominantly of smaller birds, which it observes and pursues from elevated perches. The grey falcon breeds from June to November, typically in old raptor or covid nests which are built high in large trees such as eucalypts near water courses. As with similar species, the grey falcon inhabits a wide array of habitats, from inland plains and deserts to well-timbered watercourses. It may be sedentary, dispersive, or migratory and is considered rare to very rare throughout its range (Pizzey & Knight, The Field Guide to the Birds of Australia, 2012).

The grey falcon is considered to have numerous known and potential threats. The most significant of these are predation by feral cats, grazing and habitat degradation by introduced herbivores and climate change. These threatening processes are additionally accentuated by another factor, the overall low population size for this species. Recent estimates consider the total number of mature grey falcon adults to be less than 1000 across its entire extensive range (Threatened Species Scientific Committee, 2020).

The small overall population size and density of the grey falcon impose significant challenges to detectability (Threatened Species Scientific Committee, 2020).

Latham's snipe *(Gallinago hardwickii)*

EPBC – Migratory, Marine. NCA – Special least concern

Latham's snipe *(Gallinago hardwickii)* is a medium sized wading bird, though it is the largest wader in Australia. Latham's snipes are typically found singularly or in small, loose groups of less than a dozen birds (Higgins & Davies, 1996). They are a non-breeding visitor to south-eastern Australia and a passage migrant through northern Australia. Typically inhabits soft wet ground, or shallow waters with green or dead growth, sometimes tussocks, including wet parts of paddocks, dam seepage, irrigation, mangrove fringes, saltmarshes (Pizzey & Knight, The Field Guide to the Birds of Australia, 2012).

Threats include habitat loss caused by the drainage and modification of wetlands (Naarding, 1984).

Painted honeyeater (*Grantiella picta*)

EPBC – Vulnerable. NCA – Vulnerable

The painted honeyeater (*Grantiella picta)* is a medium sized honeyeater with a white underside, a black upper with golden accents on wings and tail feathers. It feeds primarily on mistletoe berries and nectar (if seasonally available) and insects (Pizzey & Knight, The Field Guide to the Birds of Australia, 2012). As its diet suggests, this species has a heavy association with mistletoe plants, particularly those on larger, mature trees (Department of the Environment, 2015). This species forms a cup-style nest in foliage, fashioned from plant fibres and spider web. It breeds primarily through the spring and summer in Queensland and may migrate to breed. A mistletoe specialist, the painted honeyeater tends to favour areas with significant patches of mistletoe plants, particularly those on larger, mature trees. This species is nomadic, with its movements influenced by the availability of fruiting mistletoe and rainfall (Pizzey & Knight, The Field Guide to the Birds of Australia, 2012). The painted honeyeater is rare across most of its range and highly seasonal in areas.

Purple-crowned Fairy-wren (*Malurus coronatus*)

EPBC – Not listed. NCA – Vulnerable.

The Purple-crowned Fairy-wren (*Malurus coronatus*) is a small bird that is warm-brown above, and white below, with a long blue tail, dark bill, dark eyes, and brownish legs and feet (Higgins et al. 2001). Adult females have a dark grey forehead, crown, and nape, and a chestnut mask around the bill and eyes with contrasting white eye-rings. During the non-breeding season, adult males look much the same, except the mask is usually dark and the eye-rings more grey than white. In the breeding season, males develop a purple colouring on the forehead, crown, and nape, with a black spot in the centre of the crown and the mask becoming completely

black (Higgins et al. 2001; Rowley & Russell 1993). It is probable the record near the Project area was the eastern subspecies (*Malurus coronatus macgillivrayi*), which occurs along most rivers draining into south-western and southern Gulf of Carpentaria from Roper River in Northern Territory to Leichhardt and Flinders Rivers in Queensland. A natural biogeographic barrier of approximately 300 km of unsuitable habitat separates this subspecies from the western subspecies (*Malurus coronatus coronatus*).

Rainbow bee-eater (*Merops ornatus*)

EPBC – Marine. NCA – Least concern

The rainbow bee-eater (*Merops ornatus*) is a strikingly coloured small bird that is abundant across most of Australia. This species is either a breeding resident (northern Australia), seasonal breeding migrant (southeast and southwest Australia) or passage migrant (inland and dry west coast), depending on location. When not breeding, this species inhabits a large varety of habitats, including open woodlands, riverbanks, beaches, mangroves. The rainbow bee-eater utilises perching vantage points, from large dead trees to powerlines from which it will swoop into the air to take airborne prey. It feeds on insects captured during flight, including bees, wasps, flies, dragonflies and similar (Pizzey & Knight, The Field Guide to the Birds of Australia, 2012).

The rainbow bee-eater is abundant across most of Australia and is one of the country's most recognisable species. Known and current threats to this species are minimal. However, cane toads are implicated in the reduced nesting success of the rainbow bee-eater. Cane toads can access the nests of rainbow bee-eaters, and are reported to feed on eggs and young, as well as evict nesting adults from nest burrows (Department of Sustainability, Environment, Water, Population and Communities, 2011).

Sharp-tailed sandpiper *(Calidris acuminata)*

EPBC – Migratory, Marine. NCA – Special least concern

The sharp-tailed sandpiper (*Calidris acuminata*) is a small-medium wader that spends the non-breeding season in Australia. The Australian population migrates mostly to the south-east and is widespread both inland and in coastal locations. Many of the inland's records are birds on passage. Most records in Queensland are along the coast with scattered records inland, particularly in central and south-western regions (Higgins & Davies, 1996).

The species typically inhabits tidal mudflats, saltmarshes, mangroves, wetlands, floodwater, irrigated agricultural land, ponds. It has a strong association with water (Pizzey & Knight, The Field Guide to the Birds of Australia, 2012).

Threats to this species within Australia are mostly from habitat degradation due to water pollution, invasion of mudflat weeds, changes to the hydrological regime and exposure to acid sulphate soils (Department of the Environment, Water, Heritage and the Arts, 2009).

White-bellied sea-eagle *(Haliaeetus leucogaster)*

EPBC – Migratory. NCA – Least concern

White-bellied sea-eagles (*Haliaeetus leucogaster*) are a large raptor with long, broad wings and a wedge-shaped tail. The plumage is predominantly white and grey. They are often seen singly or in pairs. This species

is distributed along the coastline of mainland Australia and Tasmania. It extends inland along some of the larger waterways. Inland limits of the species are restricted in south-central and south-western Australia, however there are scattered records from inland Queensland (Marchant & Higgins, Handbook of Australian, New Zealand and Antarctic Birds. Volume One - Ratites to Ducks, 1990).

Preferred habitat includes coastal areas, terrestrial wetlands in tropical and temperate regions. Habitats occupied by white-bellied sea eagle typically include the presence of large areas of open water (large rivers, swamps, lakes and the ocean).

Threats include loss of habitat due to land development and the disturbance of nesting pairs (Dennis, 1996). Other threats include poisoning and shooting (Barnett, 1980).

Habitat within the Dulgald River and Cabbage Tree Creek may provide temporary habitat during dispersal to larger inland bodies of water. Records in the area are primarily around the Leichhardt River, Lake Moondarra, and other perennial water sources. The project area does not include any perennial water sources that would provide suitable habitat for the white-bellied sea eagle. The species may transit across the site, but proposed flight paths between large perennial water sources in the area do not cross the Knapdale range.

Mammal

Purple-necked rock wallaby (*Petrogale purpureicollis*)

EPBC – Not listed. NCA - Vulnerable

The purple-necked rock wallaby (*Petrogale purpureicollis*) is a comparatively small wallaby species. Their weight ranges from 4.7 to 7.0 kg, their head-body length ranges from 500 – 610 mm, and their tail length ranges from 450 – 600 mm (Menkhorst & Knight, A Field Guide to the Mammals of Australia, 2011). Their body is light brown, with a paler underside and a characteristic purple-mauve colouration over the neck, face, head, and sometimes upper chest and shoulders. They have a dark brown stripe extending from the eyes to between the ears along the midline of the top of the head (Menkhorst & Knight, 2011). The purple-necked rock wallaby favours habitat which includes boulder piles, rocky slopes, cliffs and gorges in limestone areas, and sandstone and quartzite outcrops amongst dry Eucalyptus and Acacia woodlands. It also inhabits spinifex grasslands in association with the rocky areas (Rowland, 2012). They are largely nocturnal in summer, crepuscular or partially diurnal in other months. The purple-necked rock wallaby shelters during day among rocks or within boulder piles. In cooler months, they tend to sit in regular sites on rocks to bask in the sun in early morning and sometimes in afternoon. They move off the rocks in late afternoon or evening to feed in surrounding woodland (Mittermeier & Wilson, 2015). They are known to occur in the vicinity of the site due to the presence of nearby records, and hummock grassland and mulga, which are preferable to the species (Menkhorst and Knight, 2011). However, they have a strong reliance of rocky outcrops and boulder piles which are not available within the study area.

Short-beaked echidna (*Tachyglossus aculeatus)*

EPBC – Not listed. NCA – Special least concern

The short-beaked echidna (*Tachyglossus aculeatus*) is one of Australia's five monotreme species. It is highly specialised and feeds exclusively on ants and termites with an elongated, protrusible tongue. It is Australia's

most widely distributed mammal, inhabiting almost every terrestrial environment on the continent (Menkhorst & Knight, A Field Guide to the Mammals of Australia, 2011). They rely on fallen logs, tree stumps and understory vegetation for cover.

Threats to echidnas include predation by feral carnivores such as domestic dogs, foxes, and feral cats, as well as habitat loss.

Reptile

Merten's water monitor (*Varanus mertensi*)

EPBC – Not listed. NCA – Endangered

Merten's monitor (*Varanus mertensi*) is a moderately large semi-aquatic monitor. It has a broad distribution that encompasses coastal and inland waters across far north Australia from the Kimberley to Cape York. This species is rarely seen far from water. It is often seen basking on branches overhanging water or on rocks in the middle of streams.

Threats include toxicity from ingesting cane toads. Mertens water monitors can easily consume a cane toad large enough to result in death of the monitor (Smith & Phillips, 2006).

APPENDIX H: Spatial Analysis of Migratory Bird Flight Paths

Figure 1: Asian Dowitcher - Potential Migratory Routes

Legend

- Dugald River Mine Leases
- Asian Dowitcher



Client: Minerals and Metals Group
Project number: 2023.03001
CRS: WGS 84 EPSG:4326
Date: 6 December 2023

Print as A3

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Digital data for this report is available on the Queensland Government Spatial Portal at https://qldspatial.information.qld.gov.au.

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Figure 2: Bar-tailed Godwit - Potential Migratory Routes

Legend

- Dugald River Mine Leases
- Bar-tailed godwit records
- Bar-tailed Godwit

Dugald River Mine Leases

200 0 200 400 km

1:10,000,000

Client: Minerals and Metals Group
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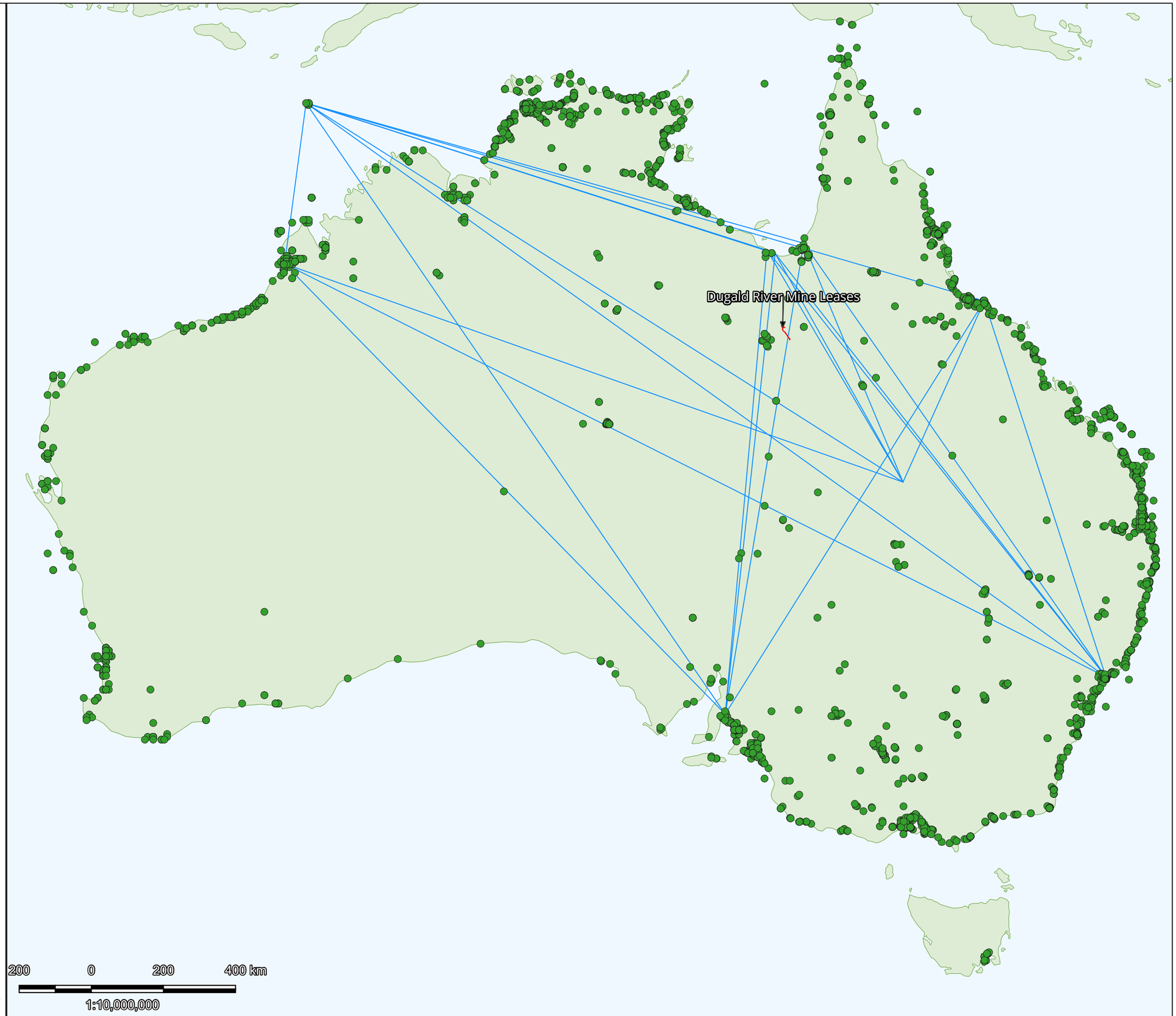
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Figure 3: Black-tailed Godwit - Potential Migratory Routes

Legend

- Dugald River Mine Leases
- Black-tailed Godwit Records
- Black-tailed Godwit



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Project number: 2023.03001
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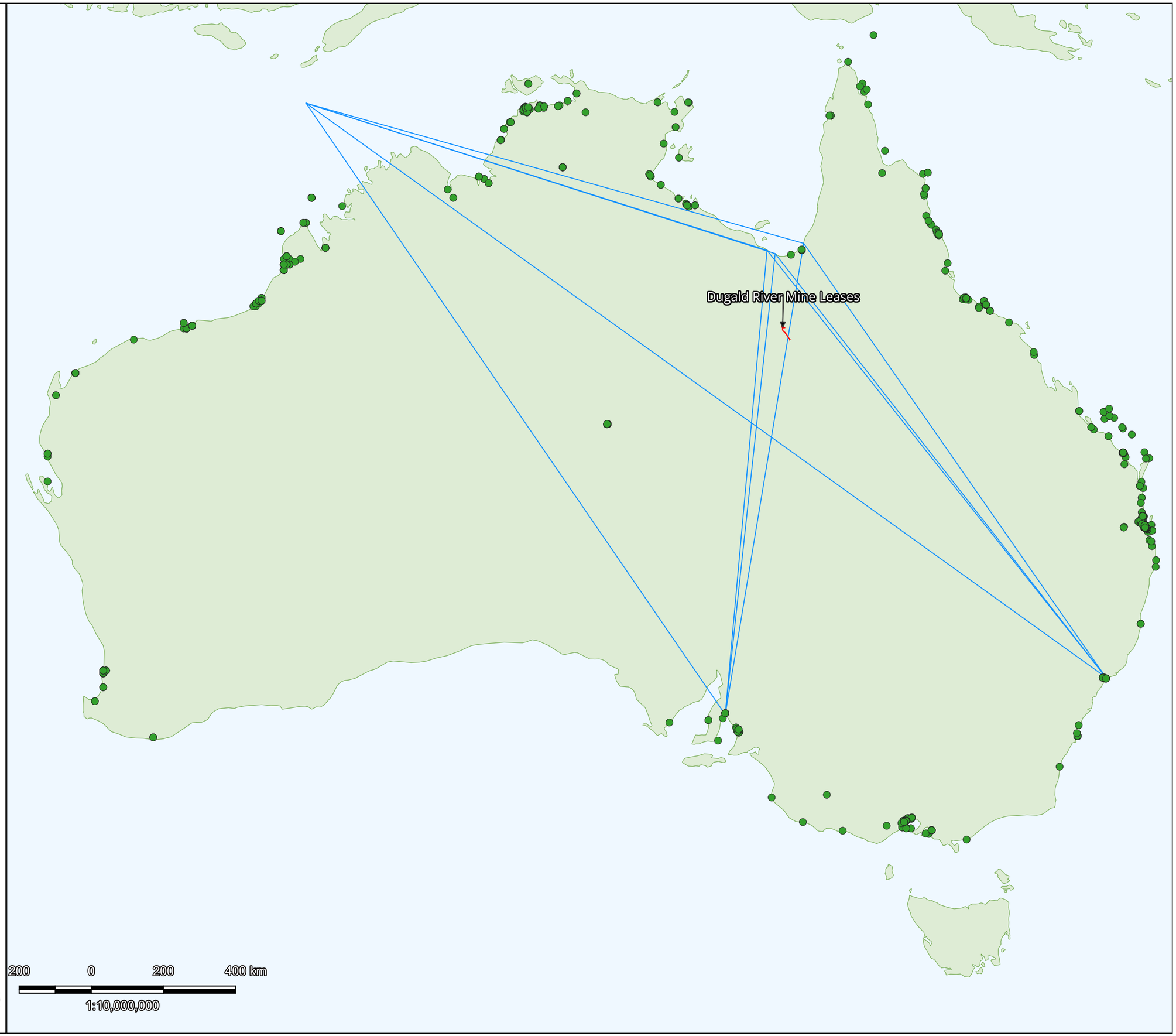
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Figure 4: Broad-billed Sandpiper - Potential Migratory Routes

Legend

- Dugald River Mine Leases
- Broad-billed Sandpiper Records
- Broad-billed Sandpiper



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Figure 5: Caspian Tern - Potential Migratory Routes

Legend

- Dugald River Mine Leases
- Caspian Tern



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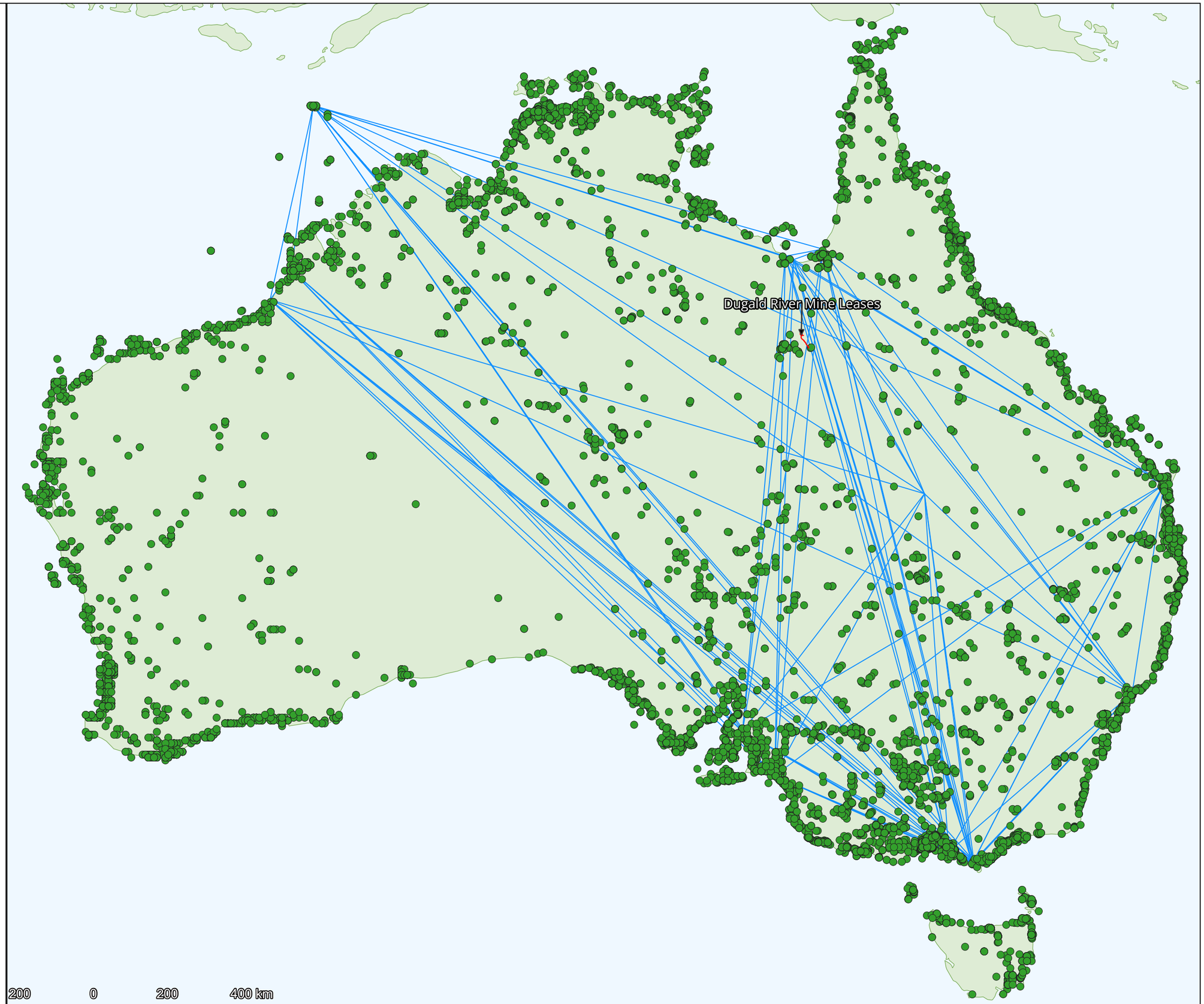
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Figure 6. Common Greenshank - Potential Migratory Routes

Legend

- Dugald River Mine Leases
- Common Greenshank Records
- Common Greenshank



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Figure 7. Common Redshank - Potential Migratory Routes

Legend

- Dugald River Mine Leases
- Common Redshank



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Figure 8. Common Sandpiper - Potential Migratory Routes

Legend

- Dugald River Mine Leases
- Common Sandpiper



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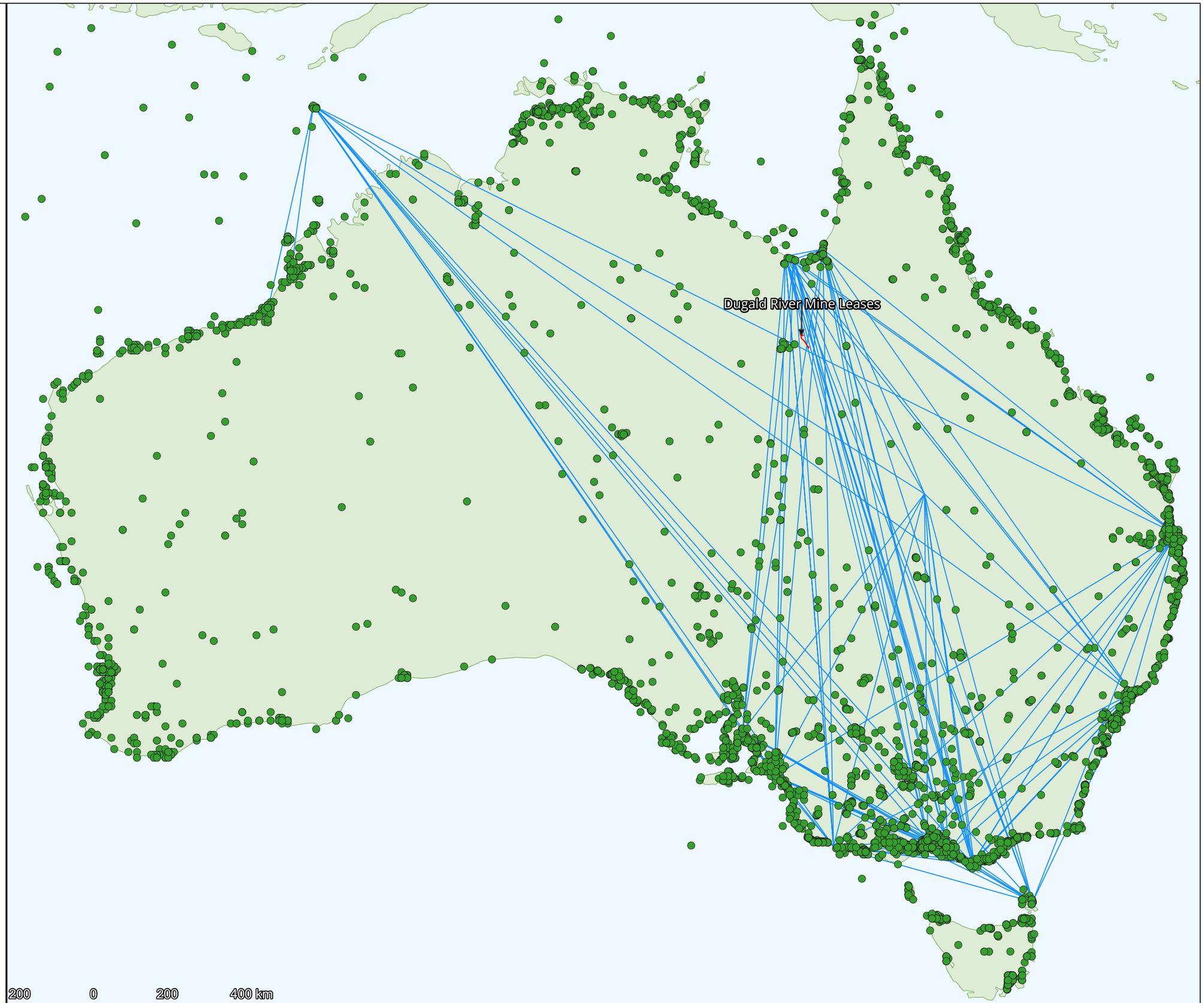
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Figure 9. Curlew Sandpiper - Potential Migratory Routes

Legend

- Dugald River Mine Leases
- Curlew Sandpiper Records
- Curlew Sandpiper



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Figure 10. Double Banded Plover - Potential Migratory Routes

Legend

- Dugald River Mine Leases
- Double Banded Plover



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Figure 11. Eastern Curlew - Potential Migratory Routes

Legend

- Dugald River Mine Leases
- Eastern Curlew Records
- Eastern Curlew

Dugald River Mine Leases

200 0 200 400 km

1:10,000,000

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Figure 12. Great Knot - Potential Migratory Routes

Legend

- Dugald River Mine Leases
- Great Knot Records
- Great Knot

Dugald River Mine Leases

200 0 200 400 km

1:10,000,000

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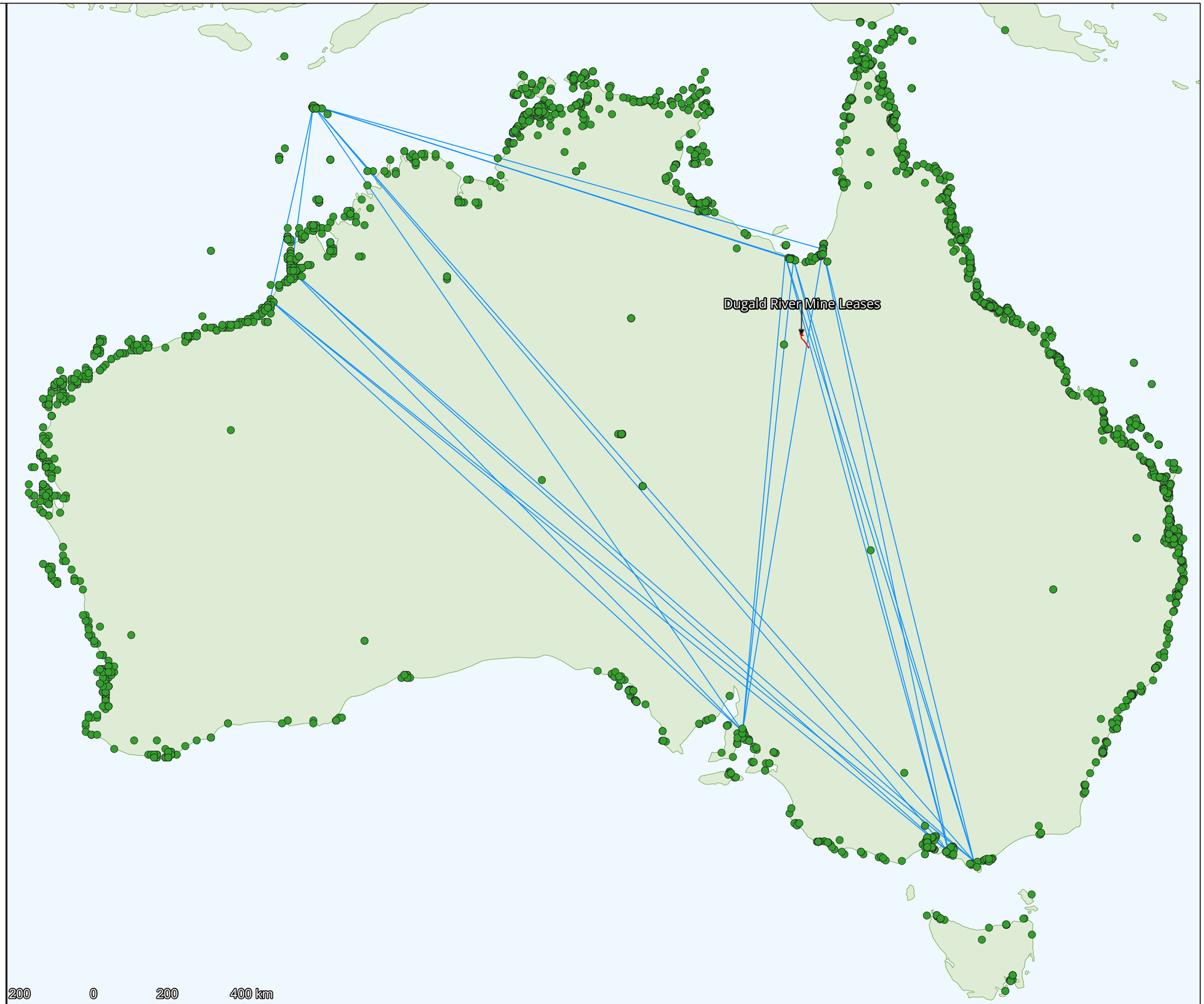
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Figure 13. Greater Sand Plover - Potential Migratory Routes

Legend

- Dugald River Mine Leases
- Greater Sand Plover Records
- Greater Sand Plover



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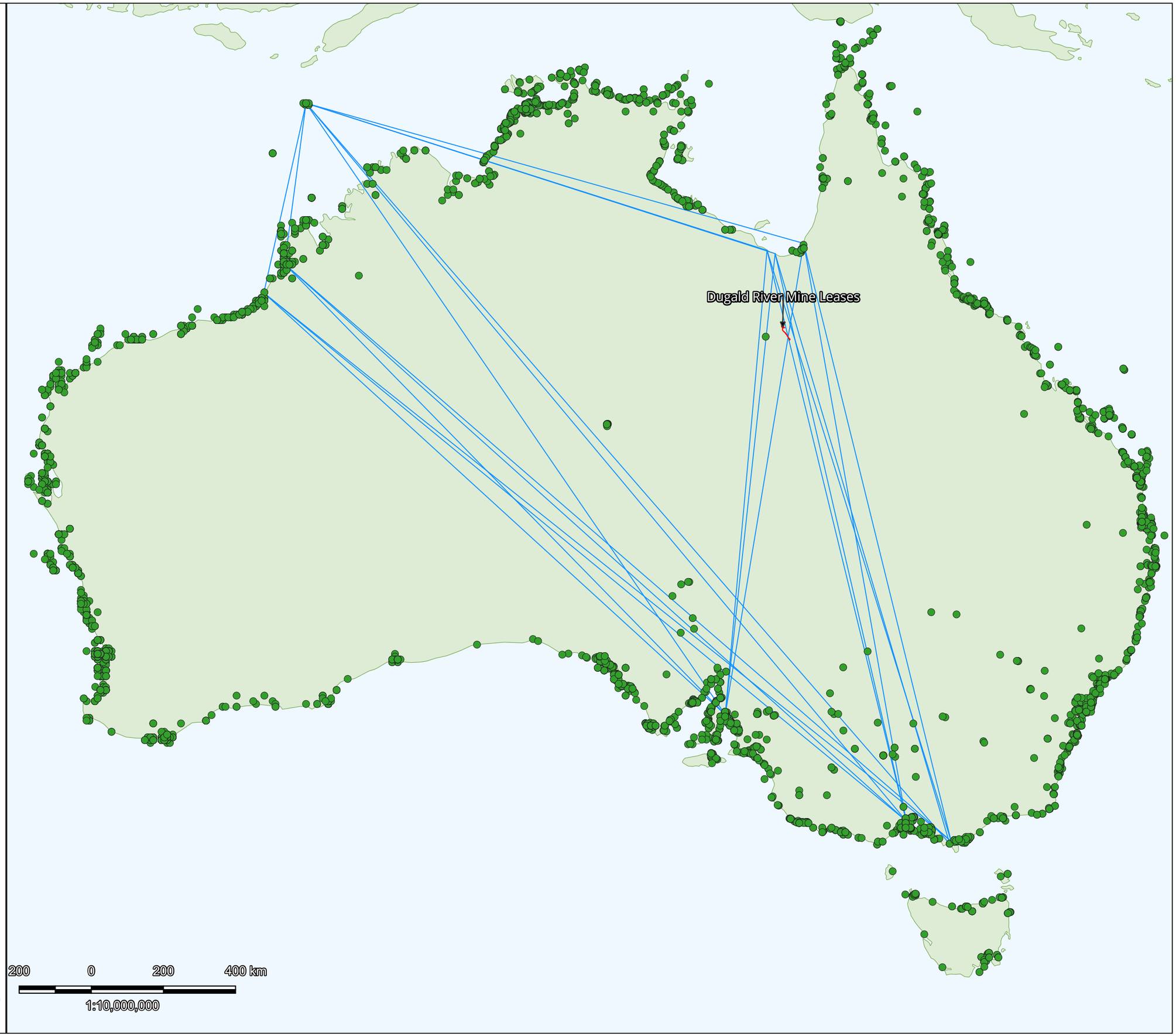
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Figure 14. Grey Plover - Potential Migratory Routes

Legend

- Dugald River Mine Leases
- Grey Plover Records
- Grey Plover



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Figure 15. Grey-billed Tattler - Potential Migratory Routes

Legend

- Dugald River Mine Leases
- Grey-billed Tattler Records
- Grey-billed Tattler

Dugald River Mine Leases

200 0 200 400 km

1:10,000,000

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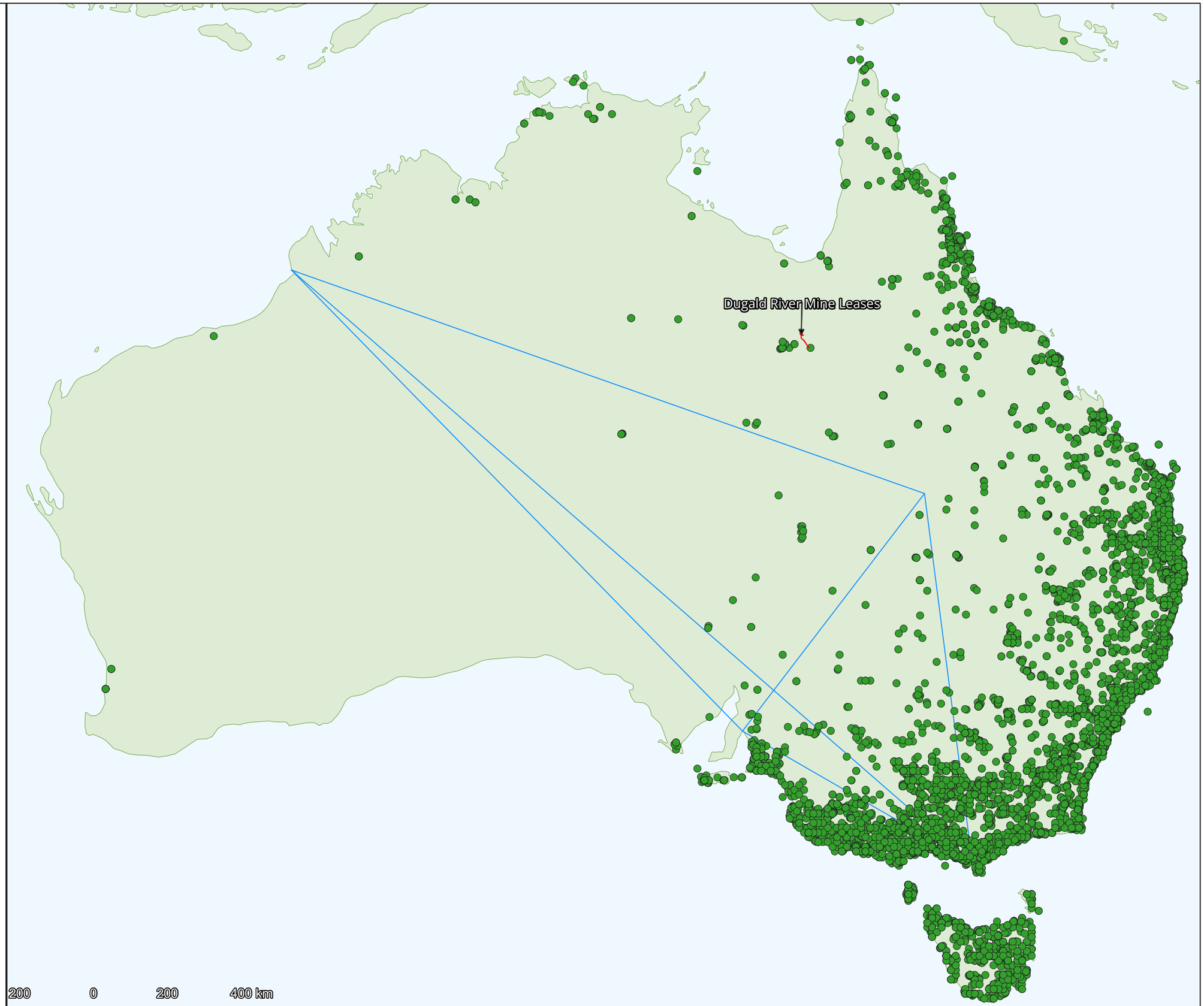
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Figure 16. Latham's Snipe - Potential Migratory Routes

Legend

- Dugald River Mine Leases
- Latham's Snipe Records
- Latham's Snipe



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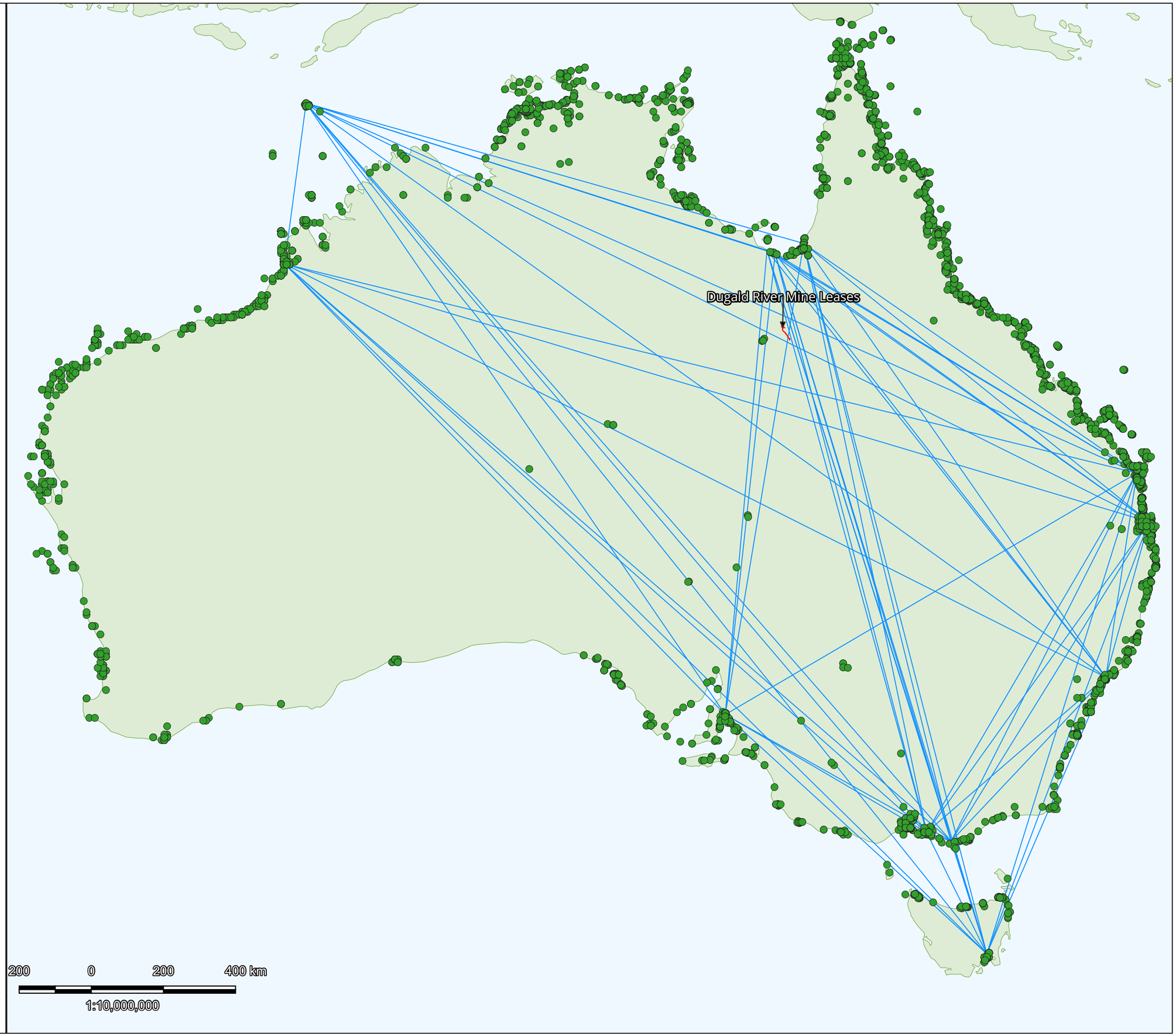
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Figure 17. Lesser Sand Plover - Potential Migratory Routes

Legend

- Dugald River Mine Leases
- Lesser Sand Plover Records
- Lesser Sand Plover



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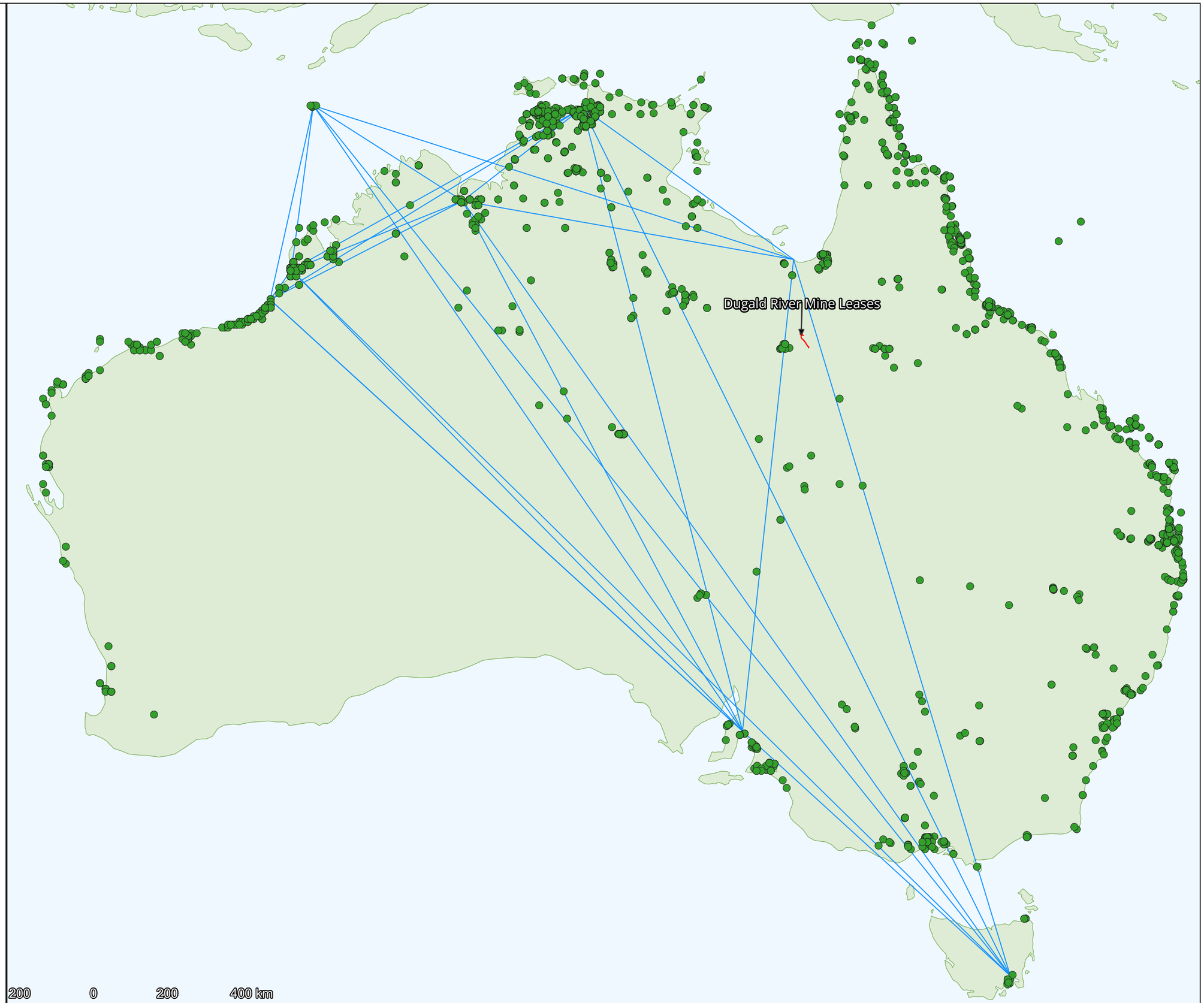
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Figure 18. Little Curlew - Potential Migratory Routes

Legend

- Dugald River Mine Leases
- Little Curlew Records
- Little Curlew



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Figure 19. Little Ringed Plover - Potential Migratory Routes

Legend

- Dugald River Mine Leases
- Little Ringed Plover



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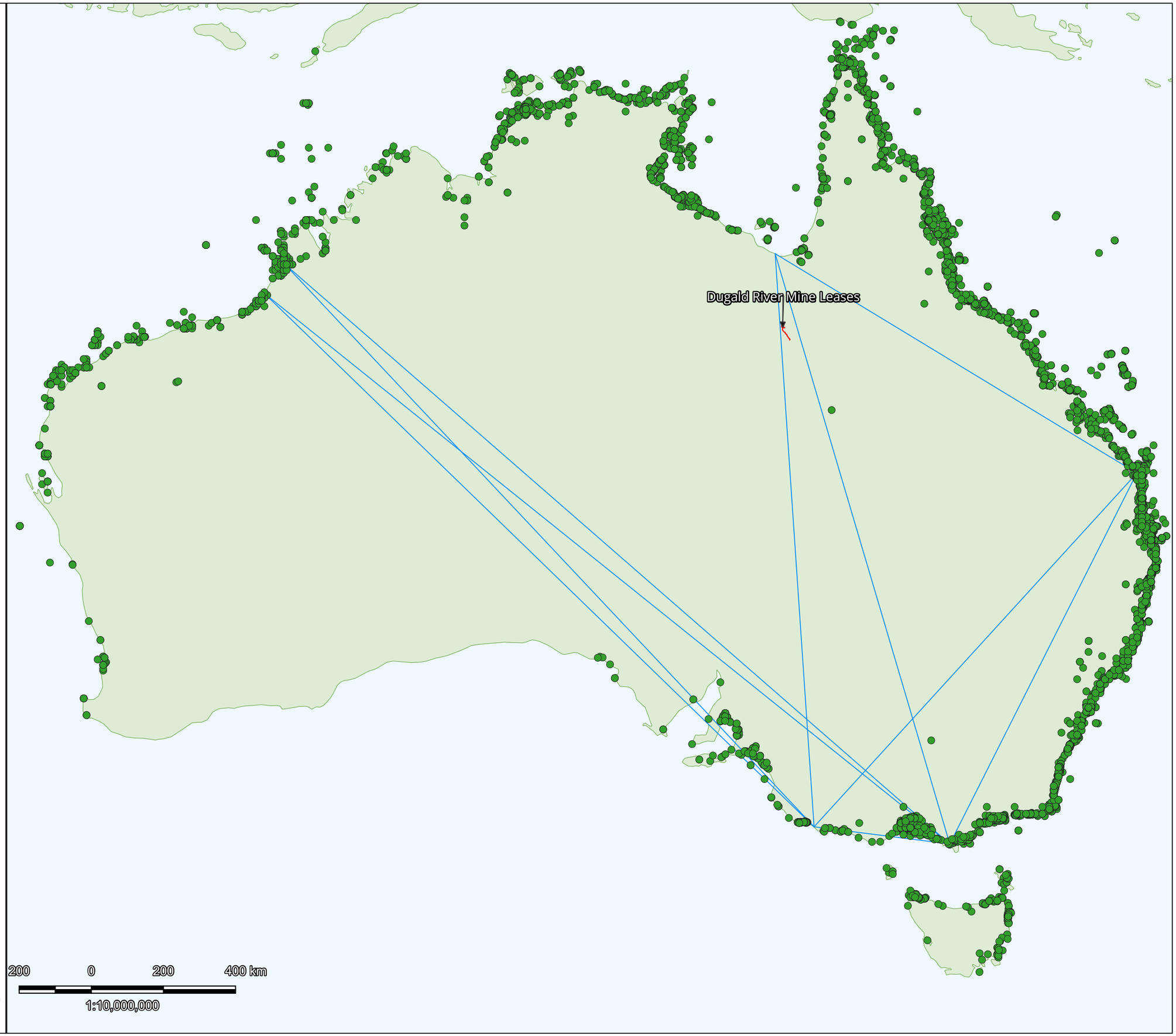
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Figure 20. Little Tern - Potential Migratory Routes

Legend

- Dugald River Mine Leases
- Little Tern Records
- Little Tern



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Figure 21. Long-toed Stint - Potential Migratory Routes

Legend

- Dugald River Mine Leases
- Long-toed Stint



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Figure 22. Marsh Sandpiper - Potential Migratory Routes

Legend

- Dugald River Mine Leases
- Marsh Sandpiper Records
- Marsh Sandpiper

Dugald River Mine Leases

200 0 200 400 km

1:10,000,000

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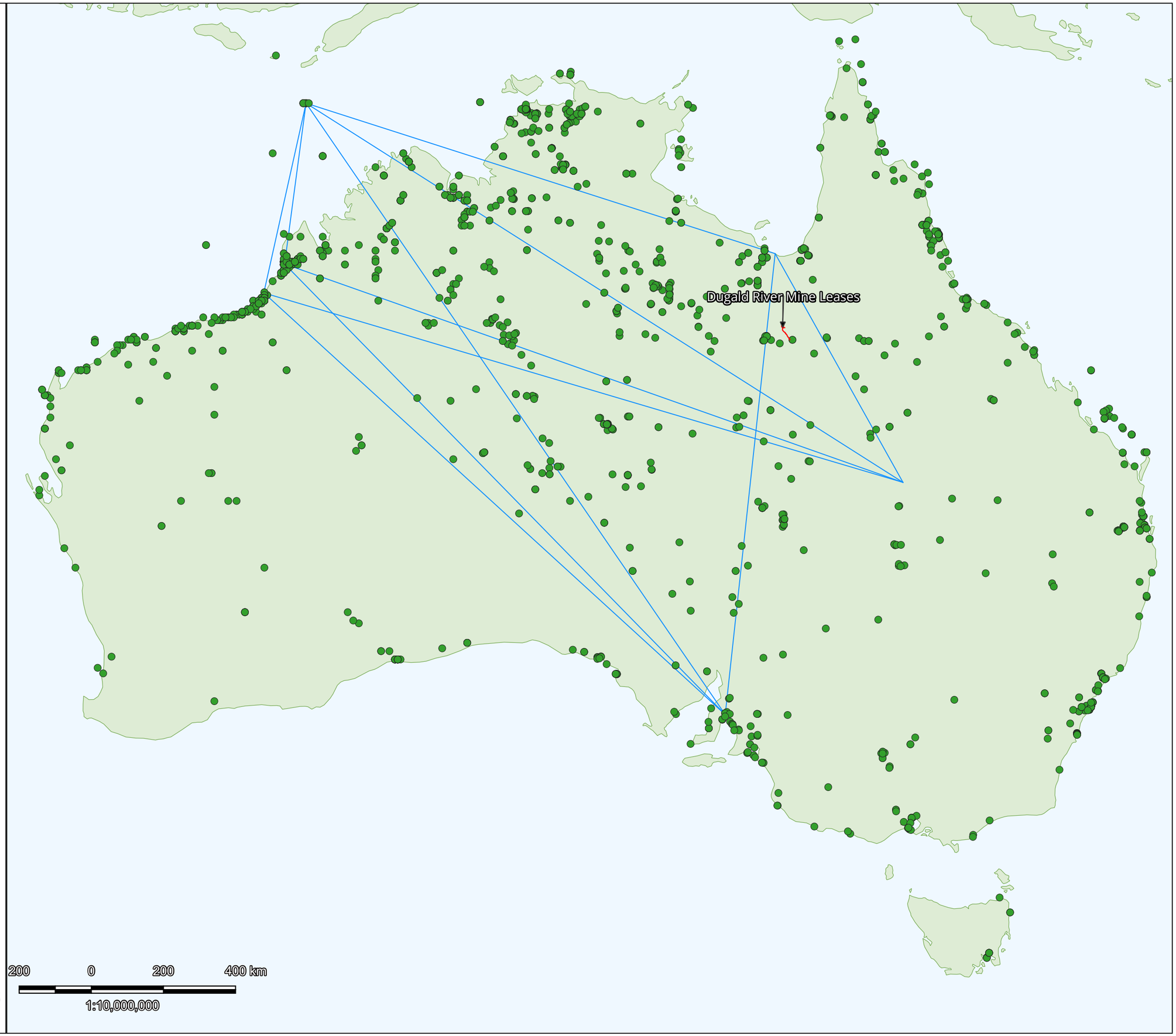
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Figure 23. Oriental Plover - Potential Migratory Routes

Legend

- Dugald River Mine Leases
- Oriental Plover Records
- Oriental Plover



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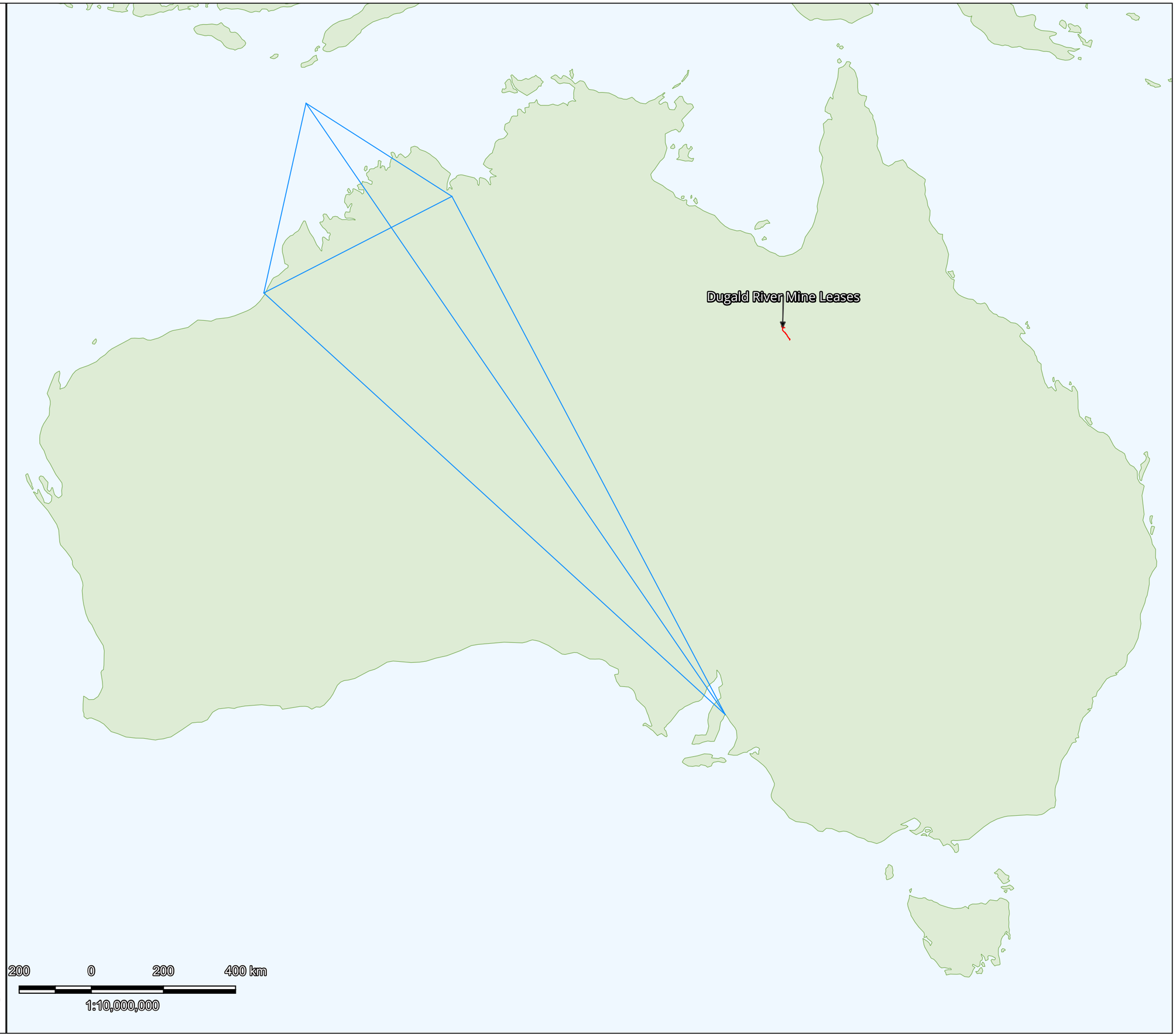
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Figure 24. Oriental Pratincole - Potential Migratory Routes

Legend

- Dugald River Mine Leases
- Oriental Pratincole



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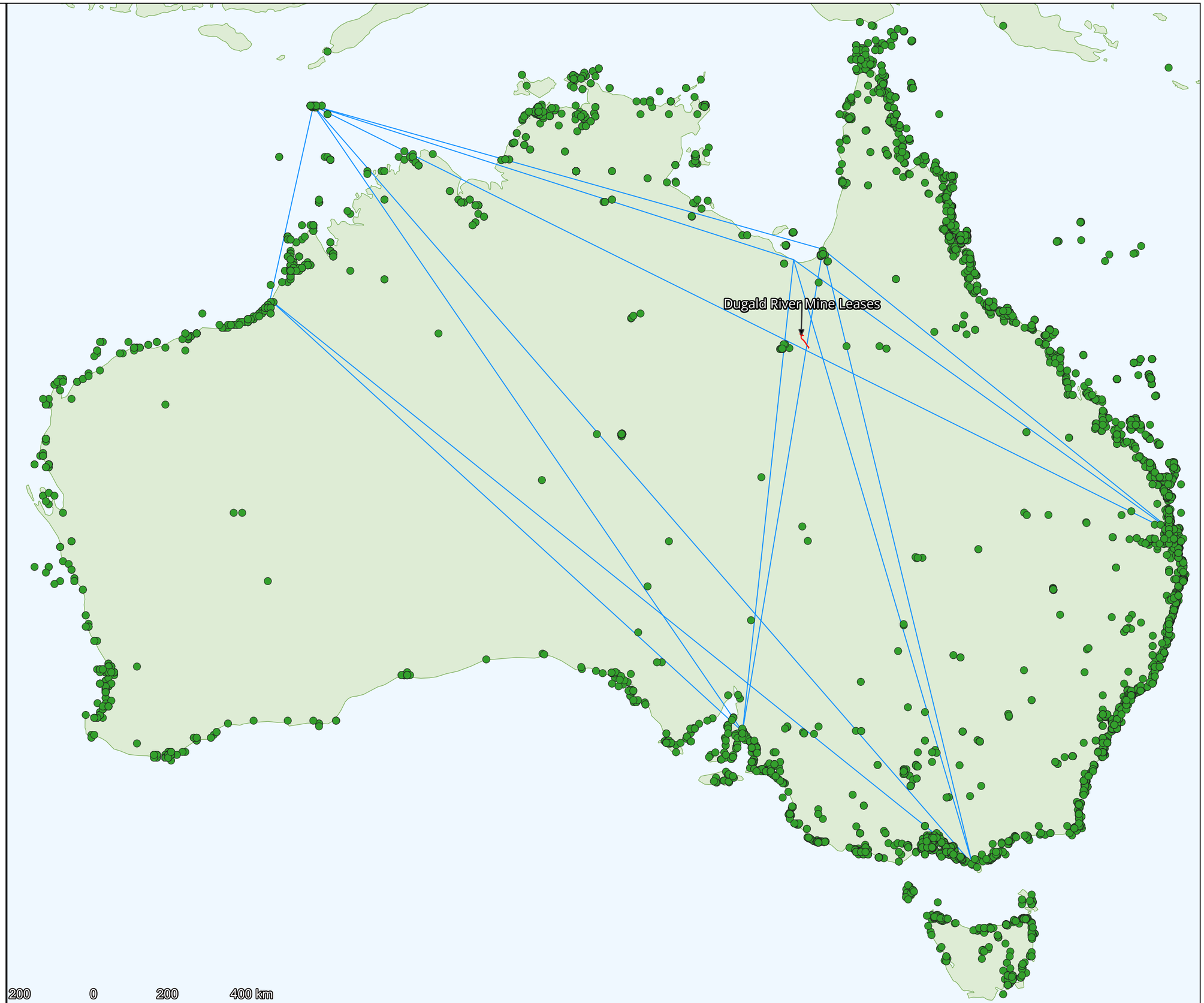
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Figure 25. Pacific Golden Plover - Potential Migratory Routes

Legend

- Dugald River Mine Leases
- Pacific Golden Plover Records
- Pacific Golden Plover



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Figure 26. Pectoral Sandpiper - Potential Migratory Routes

Legend

- Dugald River Mine Leases
- Pectoral Sandpiper



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Figure 27. Red Knot - Potential Migratory Routes

Legend

- Dugald River Mine Leases
- Red Knot Records
- Red Knot

Dugald River Mine Leases

200 0 200 400 km

1:10,000,000

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Figure 28. Red-necked Phalarope - Potential Migratory Routes

Legend

- Dugald River Mine Leases
- Red-necked Phalarope



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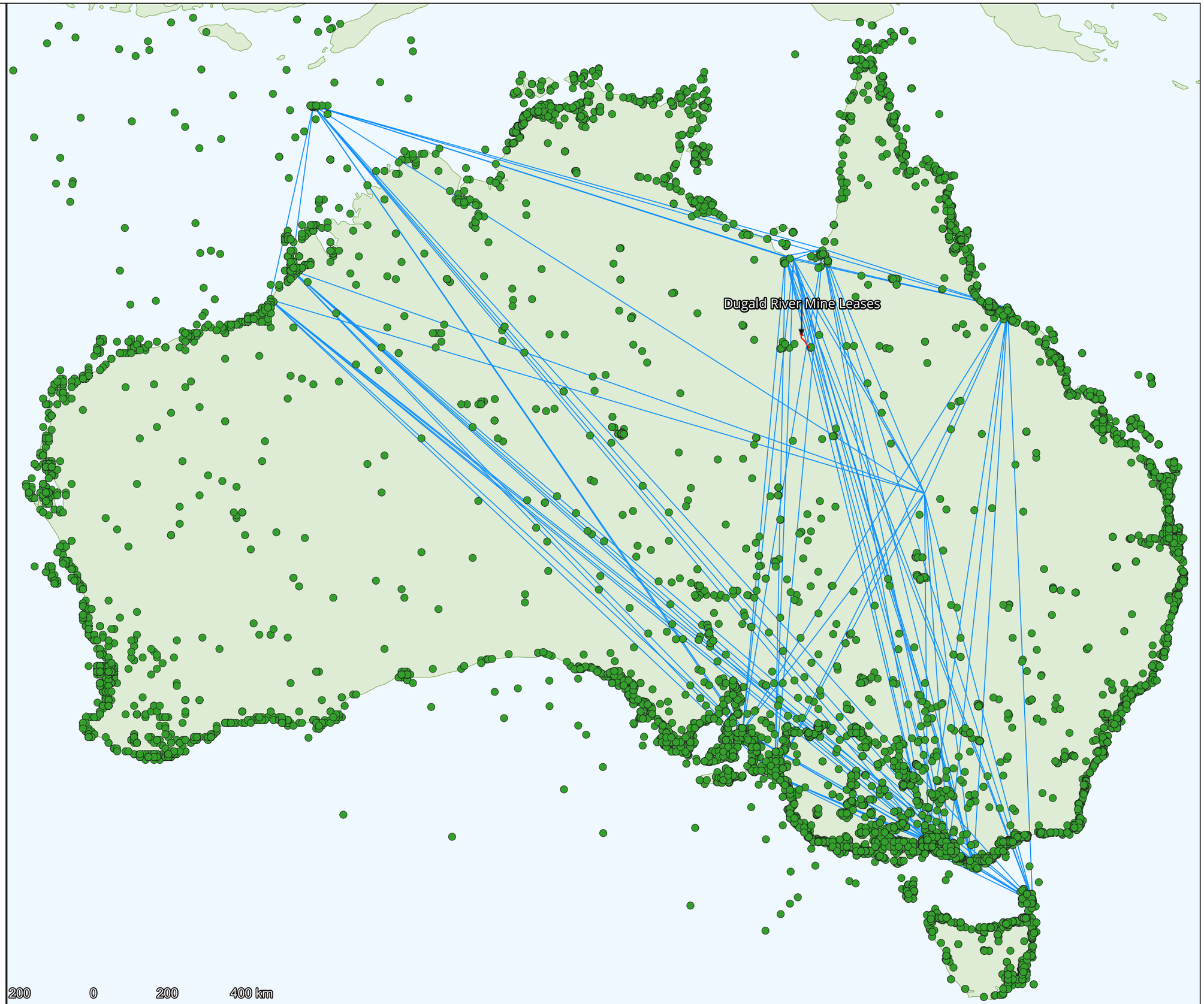
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Figure 29. Red-necked Stint - Potential Migratory Routes

Legend

- Dugald River Mine Leases
- Red-necked Stint Records
- Red-necked Stint



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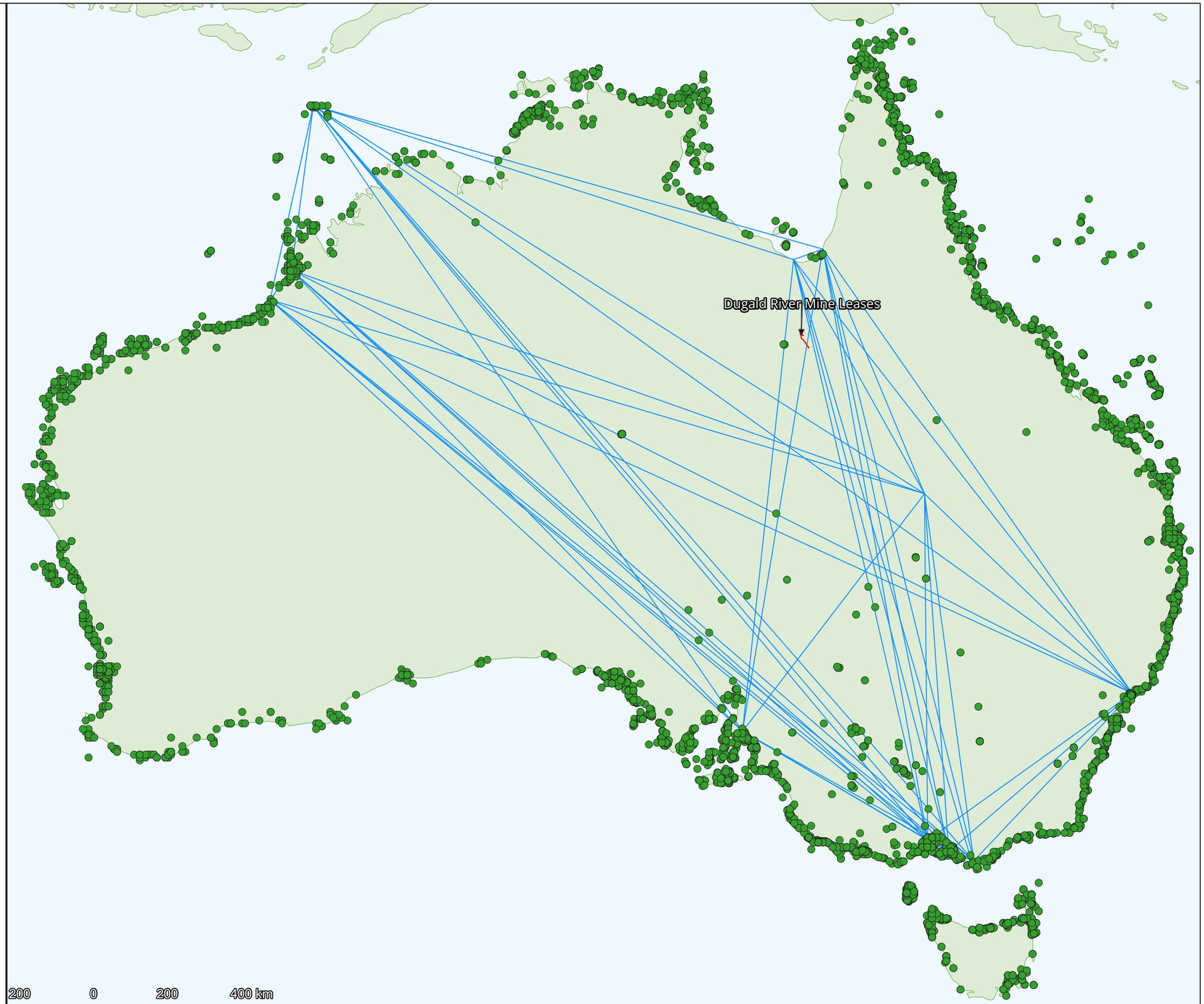
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Figure 30. Ruddy Turnstone - Potential Migratory Routes

Legend

- Dugald River Mine Leases
- Ruddy Turnstone Records
- Ruddy Turnstone



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Figure 31. Ruff - Potential Migratory Routes

Legend

- Dugald River Mine Leases
- Ruff



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Figure 32. Sanderling - Potential Migratory Routes

Legend

- Dugald River Mine Leases
- Sanderling Records
- Sanderling

Dugald River Mine Leases

200 0 200 400 km

1:10,000,000

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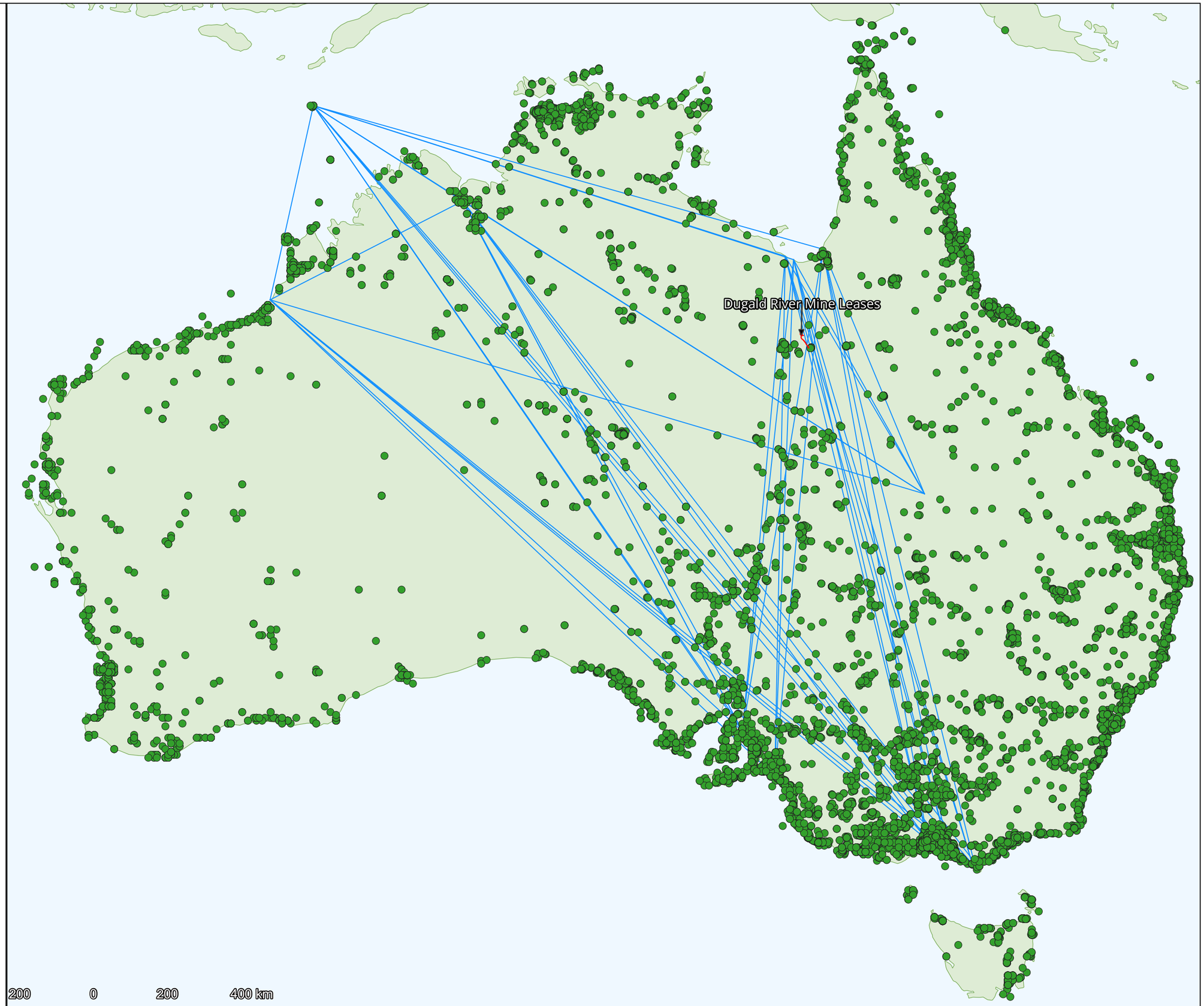
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Figure 33. Sharp-tailed Sandpiper - Potential Migratory Routes

Legend

- Dugald River Mine Leases
- Sharp-tailed Sandpiper Records
- Sharp-tailed Sandpiper



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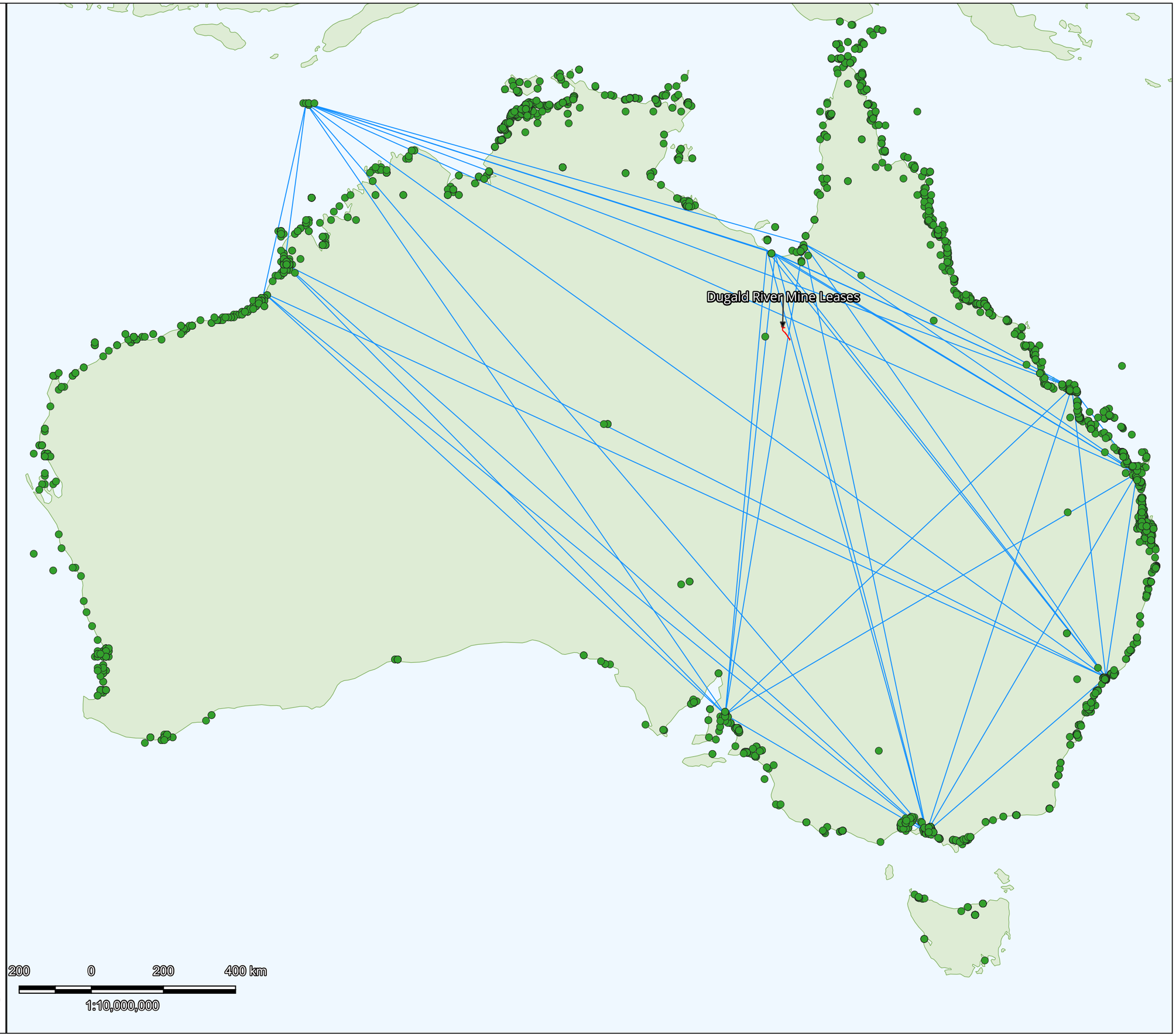
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Figure 34. Terek Sandpiper - Potential Migratory Routes

Legend

- Dugald River Mine Leases
- Terek Sandpiper Records
- Terek Sandpiper



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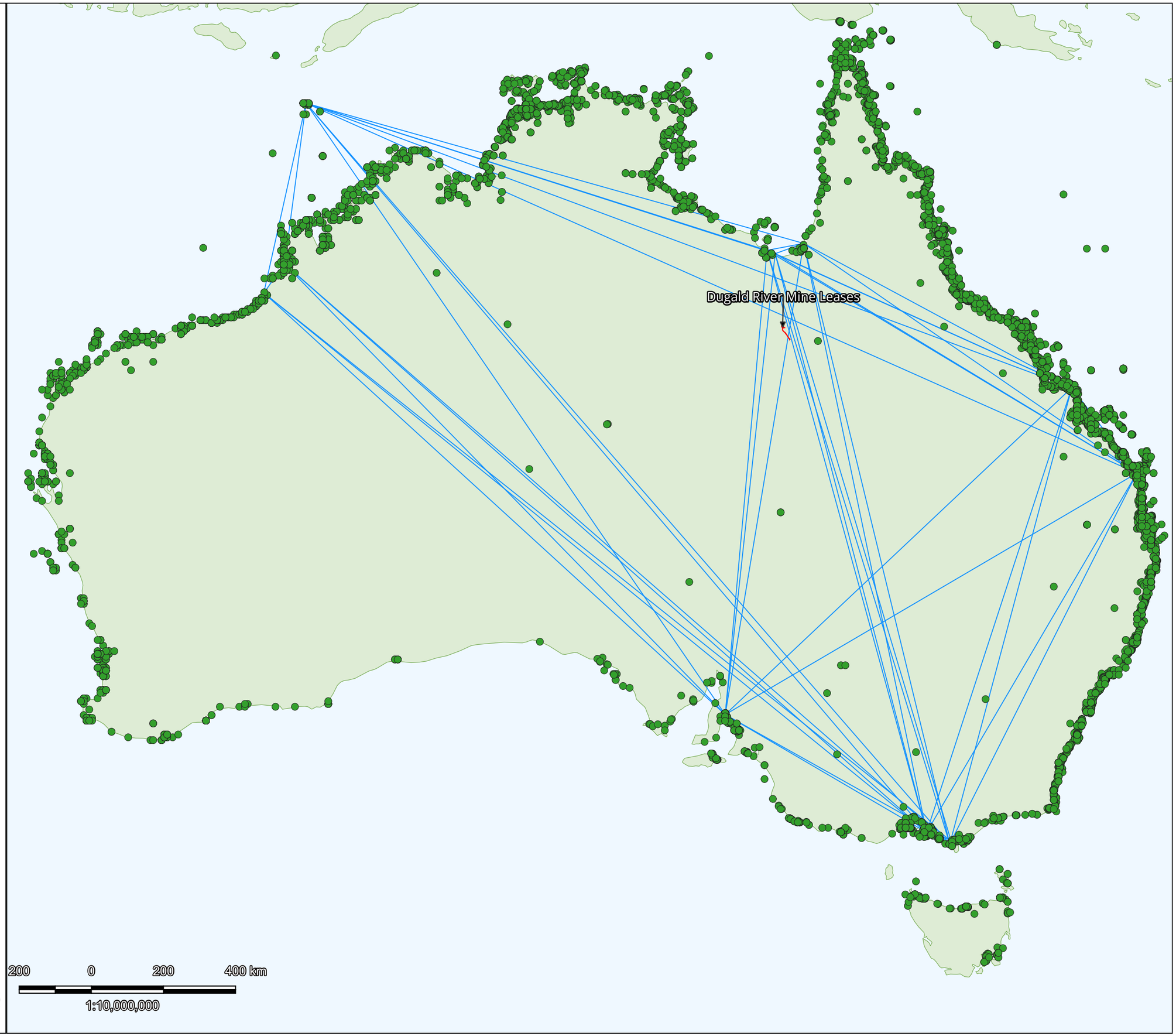
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Figure 35. Whimbrel - Potential Migratory Routes

Legend

- Dugald River Mine Leases
- Whimbrel Records
- Whimbrel



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Figure 36. White-winged Black Tern- Potential Migratory Routes

Legend

- Dugald River Mine Leases
- White-winged Black Tern



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Figure 37. Wood Sandpiper - Potential Migratory Routes

Legend

- Dugald River Mine Leases
- Wood Sandpiper



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APPENDIX I: EcoSmart Fauna Survey Report



DUGALD RIVER WIND FARM FAUNA SURVEY RESULTS

Dugald River Mine

PREPARED FOR MMG AUSTRALIA PTY LTD
November 2023

Dugald River Wind Farm Fauna Survey Results

Dugald River Mine

Prepared for MMG Australia Ltd

November 2023

ECOSMART ECOLOGY
48 Streeton Parade
Everton Park QLD 4053 Australia

Tel: +61 7 3162 1161

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Project Number:	MMG_2303
Project Manager:	Mark Sanders
Document Author(s):	Jarrad Barnes, Mark Sanders
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1.0 INTRODUCTION

1.1 Background

EcoSmart Ecology has been engaged by MMG Ltd to report on terrestrial fauna surveys conducted on the Knapdale Range between 2013 and 2023. The purpose of the report is to provide baseline information for a proposed wind farm on the Knapdale Range within the existing Dugald River Mine lease footprint (Figure 1.1). In addition to baseline reporting, EcoSmart Ecology have been engaged to conduct Bird and Bat Utilisation Surveys (BBUS) to assess the potential collision risk of bird and bat species with wind turbines. This report includes preliminary results from two BBUS monitoring periods.

Nine locations across the Knapdale Range have been selected for potential installation of wind turbines. Construction of turbine pads and access tracks requires 75.05 ha of additional land clearing within the lease footprint. Final turbine selection remains unconfirmed, so all analysis is based on the precautionary principle and assumes that the largest possible turbines will be installed. Presently these are Goldwind GW 165-5.2/5.6/6.0MW turbines, with a hub height above the ground of 130 m and a turbine blade diameter of 165m.

1.2 Survey Location

The Knapdale Range is located approximately 20 km to the north-west of Quamby in the Mount Isa Inlier bioregion in north-west Queensland. The range occupies approximately 295 km^2 and runs north-south for a distance of approximately 12 km, rising to a peak of 85 m above the surrounding plains at its highest point. At its widest point the range is approximately 2 km wide, though for most of its length it is closer to 1.5 km in width. The top of the range is characterised by a rocky undulating plateau. Along the range small gullies and waterlines drop from the plateau, forming broken rocky slopes with scattered large boulders or cliff-faces. Other steep rocky areas are also present, particularly along the western slopes. Steep slopes with large rock outcrops are less abundant in the southern third of the range, and along the very north-east tip, though small isolated rock outcrops can be present.

The Knapdale Range is a prominent range of hills formed by Knapdale Quartzite. The Dugald River deposit is located within the Mt Roseby Corridor (3-4 km wide north-to-south trending high strain domain) and is comprised of the Mt Roseby Schist Formation (1686±7 Ma) that includes the local Hangingwall Calc-silicates, Dugald River Slate (DRS) and the Footwall Limestone. It is situated within the Mt Albert Group between the older Knapdale Quartzite (1728±5 Ma) and the younger Coocerina Formation that outcrop to the west of the Knapdale Range (R. Cooper pers. comm.).

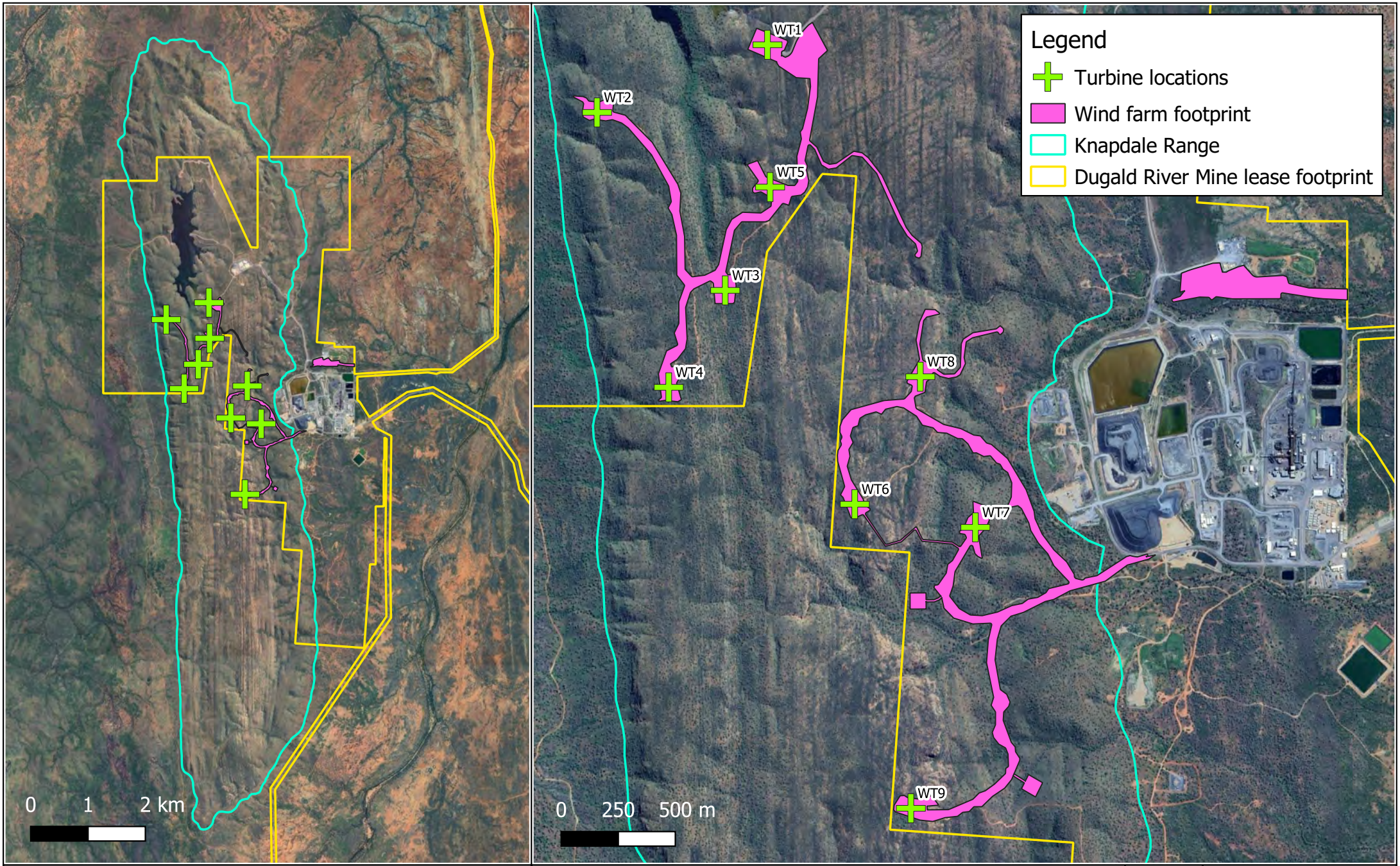


Figure 1
The Knapdale Range, existing Dugald River Mine lease footprint, and additional proposed wind farm footprint and turbine locations

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Project: Dugald River Wind Farm Vertebrate Fauna Assessment

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1.3 Study Team and Qualifications

Consistent with Eyre et al. (2014), Table 1.1 outlines the study team, their qualifications, and respective tasks.

Table 1.1. Study team and qualifications

Personnel	Qualifications	Experience	Tasks
Mark Sanders	BSc (Hons)	20+ yrs	Field monitoring, report preparation, data analysis, project management (2014 – 2023)
Angus McNab	MSc	10+ years	Field monitoring, report preparation, data analysis (2014 – 2016, 2019)
Katrin Lowe	PhD	10+ years	Field monitoring, report preparation (2016 - 2017, 2023)
Jarrad Barnes	BSc	7+ years	Field monitoring, report preparation, data analysis (2018 – 2023)
Anders Zimny	BSc	10+ years	Field monitoring (2015)
Jesse Rowland	MSc	10+ years	Field monitoring (2017)
Nick Kilvert	BSc	10+ years	Field monitoring (2014)
Henry Jackson	N/A	10 years	Field monitoring (2021)

2.0 METHODS

2.1 Desktop Assessment

A desktop assessment has conducted in the form of a WildNet fauna search, Protected Matters fauna search and an Atlas of Living Australia fauna search using a 25 km buffer around a central point on the Knapdale Range. This information was used to identify locally known EVNT (Endangered, Vulnerable and Near Threated) species which formed the basis for the habitat suitability assessment. An assessment of the likelihood of each of these species inhabiting and/or utilising the Knapdale Range was determined from local records and perceived habitat amenity determined through the field survey.

2.2 Fauna Survey Methods

2.2.1 Overall Survey Effort

A variety of survey techniques have been used across the Knapdale Range to survey fauna species. Most effort has been directed toward monitoring the effect, if any, of mining activities on populations of Purple-necked Rock-wallaby (*Petrogale purpureicollis*) and Carpentarian Pseudantechinus (*Pseudantechinus mimulus,* which was listed as a Matter of National Environmental Significance until 2021). These monitoring surveys have relied heavily on white-flash remote cameras. Over the years other methods have been used haphazardly to supplement the work. These activities, along with extensive traverses exploring the range, has provided a robust understanding of vertebrate species (noting some exceptions as detailed in Section 2.4) and habitat features present.

A summary of overall survey effort by year and survey method is provided in Table 2.1. Further information on each methodology is provided in the following sections. A list of all previous and ongoing monitoring locations is provided in Appendix A. Survey timing and monitoring conducted during each survey is provided in Appendix B.

2.2.2 White-flash Remote Camera Surveys

2.2.2.1 Purple-necked Rock-wallaby Monitoring

Purple-necked Rock-wallaby ("PNRW") populations on the Knapdale Range have been monitored by EcoSmart Ecology since 2014. Populations are monitored using a single white-flash PIR camera ("camera trap"). Between 2014 and 2015 only eight PNRW populations were monitored. Nine further sites were established in 2016, and a final site in 2017. All 18 sites (Figure 2.1) have been monitored twice yearly since 2017, once post-wet season and once pre-wet season. Since 2014, attractants including specialised macropod pellets, peanut butter/oat bait balls and lucerne have been used to increase rock-wallaby activity at the cameras. Prior to 2014 only lucerne was used as an attractant. Total trap effort to date is 1,525 trap-nights (Table 2.1).

Table 2.1. Survey effort by year and survey method

Method	Unit	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	TOTAL
BBUS – Anabat	Anabat-nights											16	16 Anabat-nights
BBUS – Bird Survey	Person hours											16	16 person hours
Bird Survey Transect	Person hours							3	6	4.5	6	9	28.5 person hours
PNRW white-flash camera	Trap-nights		80	80	115	170	180	180	180	180	180	180	1525 trap-nights
PSEUD white-flash camera	Trap-nights			269	480	480	480	480	480	480			3149 trap-nights
Pest black-flash camera	Trap-nights	20	20	20	20	20	20	20	20	20	20	20	200 trap-nights
Elliott Trap	Trap-nights			2000									2000 trap-nights
Pitfall Trap	Trap-nights										15	15	30 trap-nights
Foot traverses	Person hours		168	408	240	240	240	240	240	240	168	240	2424 person hours

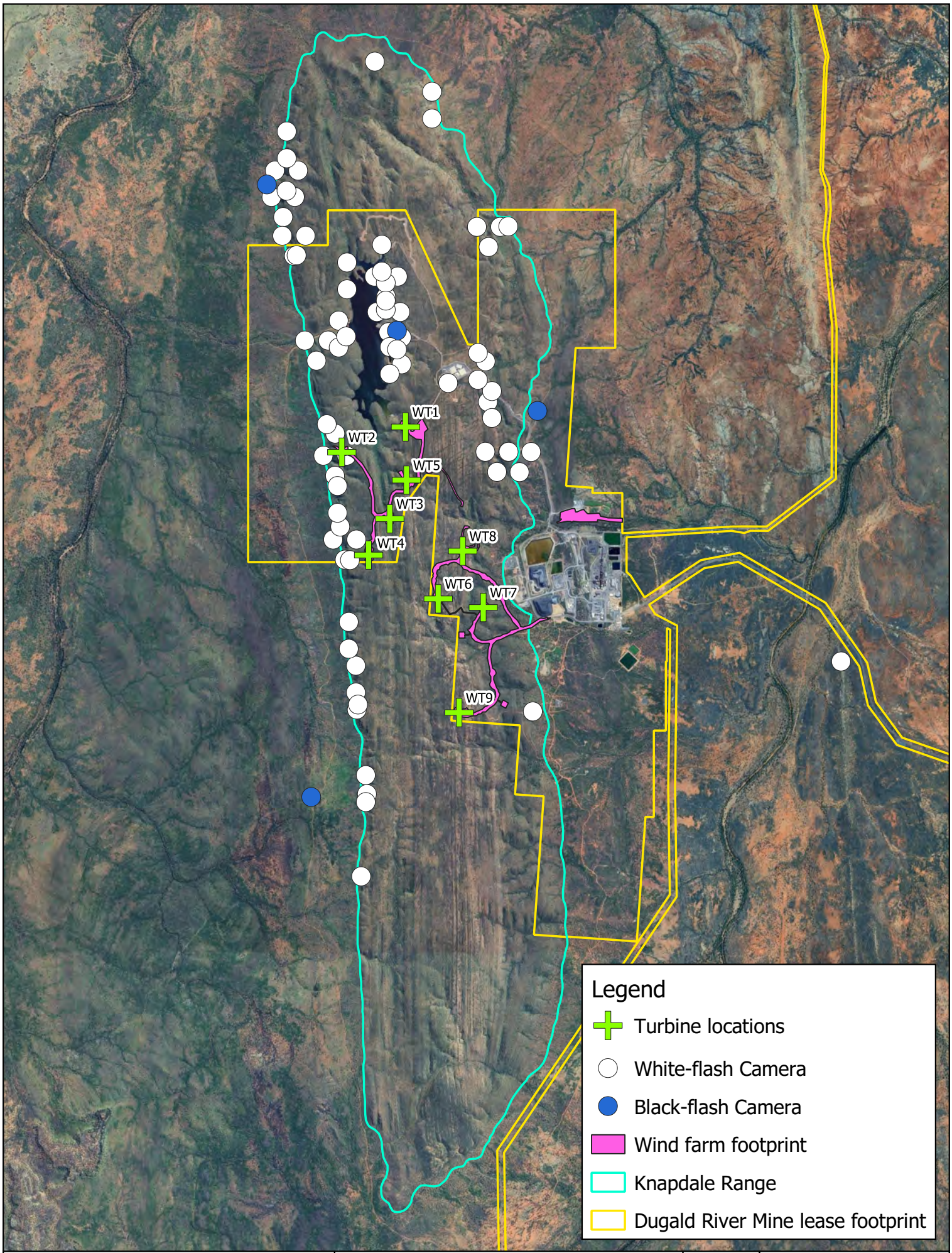


Figure 2.1
Remote field camera survey locations

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The number of recognisable individuals is recorded for each night, and for the survey duration, using indicators such as size, sex, reproductive status (i.e., pouch young), pelt/ear marks or damage. Juveniles at foot and pouch young (only if observed) are included in the count. Observers also record the total number of PNRW observed when setting and retrieving cameras. The highest number of PNRW observed by either method (camera or direct observation) is recorded as the population size for a given survey.

While the methodology targeted PNRW, the selected attractants (pellets, peanut butter/oat bait balls) will have been suitable to attract a wide variety of other vertebrate species and incidental records of all fauna species were noted.

2.2.2.2 Pseudantechinus targeted surveys

Following the unexpected appearance of Pseudantechinus during PNRW monitoring, a targeted survey for the species was conducted in 2015. The survey utilised both camera and Elliot trap methods with ten cameras located in close proximity to the Dugald River Mine, and a further 21 across the broader Knapdale Range.

Each camera was baited by smearing peanut butter over the rocks 2-3 m in front of the camera. Cameras were left in-situ and operational for a minimum of eight nights, though some were left for longer. Total white-flash camera effort in 2015 was 269 camera-trap-nights.

2.2.2.3 Ongoing Carpentarian Pseudantechinus Monitoring

Ongoing Carpentarian Pseudantechinus (*Pseudantechinus mimulus*) monitoring across the Knapdale Range was conducted using white-flash camera traps between 2016 and 2021. Two surveys were undertaken each year, once post-wet season and once pre-wet season. Each survey utilised 30 cameras located at independent locations in rocky habitats within the Knapdale Range (Figure 2.1). All cameras were operational for eight consecutive nights and baited by smearing peanut butter on the rocks. Cameras were checked and rebaited after the fourth or fifth night. Carpentarian Pseudantechinus was recorded as present or absent on each night. A supplementary list of other vertebrate species recorded on cameras was also recorded. Total camera trap effort across all monitoring years was 3,149 trap-nights.

2.2.3 Estimating Purple-necked Rock-wallaby abundance

An initial population estimate was calculated in 2014 by determining the mean number of rock-wallabies at 26 known sub-populations, and extrapolating this to an estimated 56 sub-populations based on interpretation of aerial imagery. Population sizes were not subsequently calculated in future surveys; however, a population estimate has been made in this report based on this same methodology using the most recent mean population size of the 18 permanently-monitored sub-populations across the Knapdale Range.

Trends in Purple-necked Rock-wallaby abundance between 2014 and 2022 at each sub-population have previously been determined by calculating the regression slope (i.e., number of recorded individuals over time) for each sub-population. Regression slopes >0 are were considered to be associated with an increase in sub-population size, and regression slopes <0 are with a decrease in sub-population size. While calculating a regression slope across the entire survey duration is useful in determining an overall change since monitoring began, it

does not provide information on the stability of a population; large, anomalous fluctuations in either a reduction or increase in PNRW numbers in a monitoring year may considerably impact the regression slope and lead to misinterpretation of the population dynamics at a colony.

Therefore, to determine if populations appear to be decreasing, increasing or stable over time, a regression slope was calculated for every monitoring period. The average of these slopes was then calculated with a 95% confidence interval. If the confidence interval includes 0, a population is considered likely to be stable, if the lower bound of the confidence interval is >0, the population is considered likely to be increasing, and if the upper bound of the confidence interval is <0, the population is considered likely to be decreasing.

2.2.4 Small Mammal (Elliot) Trapping

Elliot trapping to confirm the occurrence of Carpentarian Pseudantechinus was conducted in July 2015. Trapping was conducted at 20 locations, ten within close proximity to the Dugald River Mine and ten within the broader Knapdale Range (Figure 2.2).

At each site 25 Elliot traps were positioned approximately 5-10 m apart, in a straight line, U-shaped or circular fashion to maximise the rock area sampled. The traps, which were operational for four consecutive nights, were baited with peanut butter, oats and vanilla essence. All sites were visited daily to identify and release captured animals, as well as to rebait and maintain the traps. Total Elliott trap effort was 2000 trap-nights (Table 2.1).

2.2.5 Black-flash Camera Surveys

Black-flash surveys to observe pest predator species (cat, fox and dingo) have been conducted twice yearly since 2013, once post-wet season and once pre-wet season. The surveys utilise four black-flash ("covert") camera traps positioned at various locations around the Knapdale range (Figure 2.2). Chicken necks is used as an attractant. Cameras are operational for five nights per survey. Total pest camera survey effort to date is 200 trap-nights (Table 2.1).

2.2.6 Bird Surveys

Three permanent bird survey transects were established in October 2019. All three transects are located on the western edge of the Knapdale Range in three distinct vegetation types (Table 2.2). Transects are 500 m in length and have been surveyed twice per year since bird monitoring commenced. Two observers meander along the transect for a total duration of ~30 minutes. All bird species and the total number of individuals of each species heard or seen within 50 m of the transect are recorded. Species beyond 50 m are recorded but no counts are taken. Total bird survey effort to date is 28.5 person hours (Table 2.1).

Table 2.2. Vegetation descriptions of bird survey transects

Transect	Description
BRD01	Low, open eucalypt woodland with dense tussock grass and *Triodia pungens* ground layer
BRD02	Low, open eucalypt woodland with *Acacia* spp. shrub layer and *Triodia pungens* ground layer, adjacent ephemeral creek lined with *Lophostemon grandiflora*
BRD03	Low, open eucalypt woodland with *Acacia* spp. shrub layer, tussock grass and *Triodia pungens* ground layer and localised patches of *Acacia cambagei*; transitioning in north of transect to tall eucalypt woodland of *Corymbia aparrerinja* with *Acacia* spp. shrub layer and *Triodia pungens* ground layer

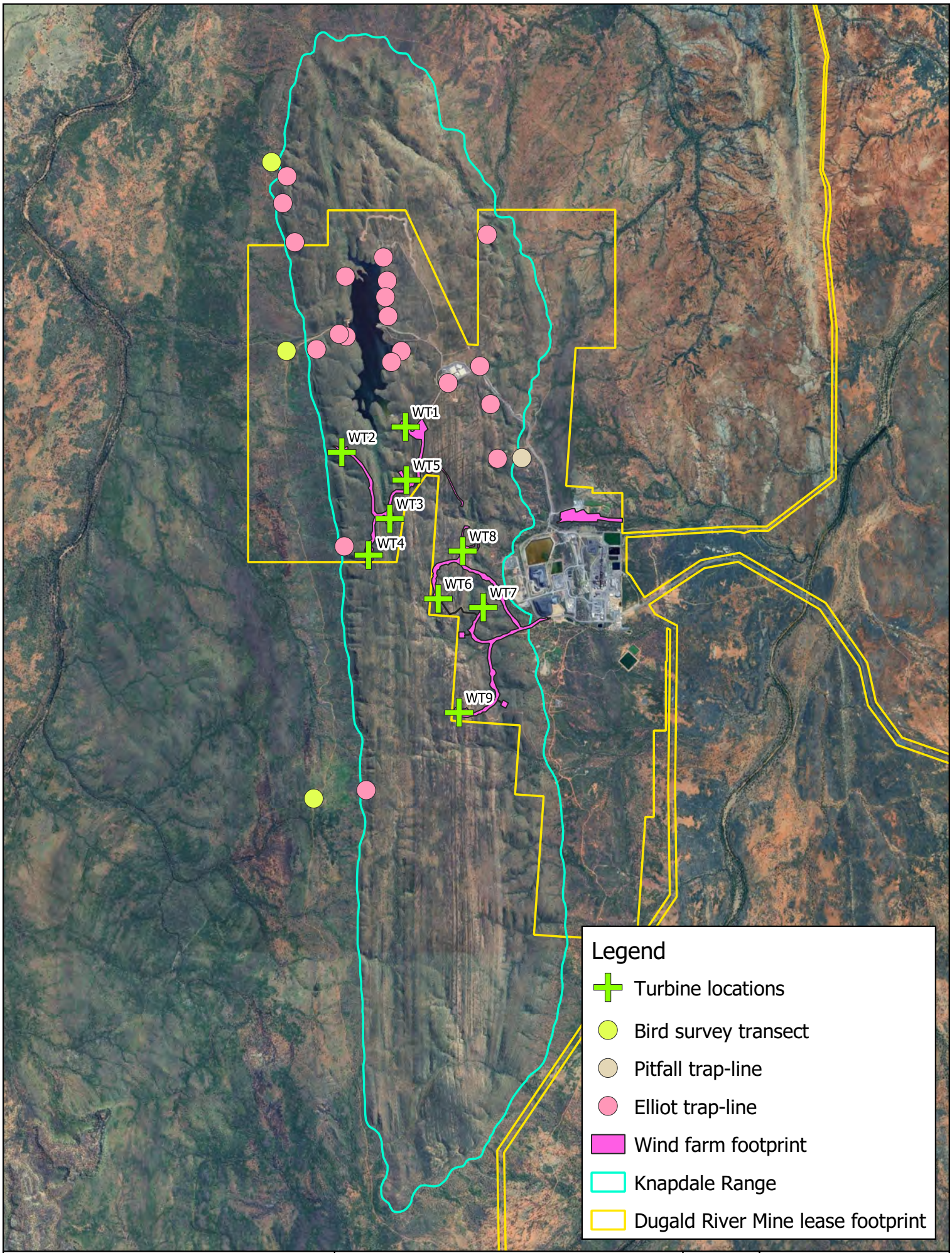


Figure 2.2
Elliot trap, pitfall trap, and bird survey locations

0 0.5 1 km

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2.2.7 Pitfall Traps

A single pitfall trap-line was established in 2022 (Figure 2.2) The trap-line consists of three 10L buckets spaced approximately 3 m apart. Pitfall traps are open for five nights and are checked within two hours of sunrise and two hours of sunset. Total pitfall trap effort to date is 30 trap-nights (Table 2.1).

2.2.8 Incidental Observations / Active Searches

Across all surveys, ecologists remain vigilant for all species seen or heard while traversing the Knapdale Range. Specific time spent traversing the range has not been recorded; however, a conservative estimate of six hours per person per day has been assumed to calculate overall effort (Table 2.1). Most incidental observations have been made while traversing between permanent monitoring locations; however, particular attention has also been paid to rocky gullies and waterholes which provide important water and foraging resources as well as daytime refugia for a wide range of species, especially birds and Purple-necked Rock-wallabies. Exact coordinates are recorded for EVNT and locally rare or significant fauna, but most incidental observations are supplied with a generic GPS coordinate.

2.2.9 Bird and Bat Utilisation Surveys (BBUS)

Nine potential turbine locations were considered for bird and bat utilisation surveys (BBUS). From these, four impact sites were selected for ongoing BBUS monitoring, in conjunction with four control sites (Figure 2.3). Each control site was set in a similar landscape position to turbine locations (i.e., a high point on the edge of the range), and a minimum of 500 m from any turbine location. Each impact and control site will be monitored twice yearly, once post-wet season and once pre-wet season. Two surveys have so far been conducted, one in May 2023, and one in September 2023. Surveys include bird monitoring and bat monitoring. Reporting guidelines largely follow those recommended by Lane and Associates (2005).

2.2.9.1 Bird Monitoring

Bird monitoring consists of three surveys conducted at each control and impact suite during the survey period, one within two hours after sunrise ("morning"), one within one hour 1 h either side of midday ("midday") and one within two hours before sunset ("afternoon"). No two surveys are conducted at any given location on the same day. Bird Utilisation Surveys (BUS) consist of 20 min of monitoring for all bird species flying above the canopy, with the following parameters recorded:

- Number of individuals
- Time first observed
- Distance from observer (in metres) when first observed
- Bearing (i.e., direction of bird/s relative to observer) when first observed
- Height relative to observer (in metres) when first observed
- Direction of flight when first observed

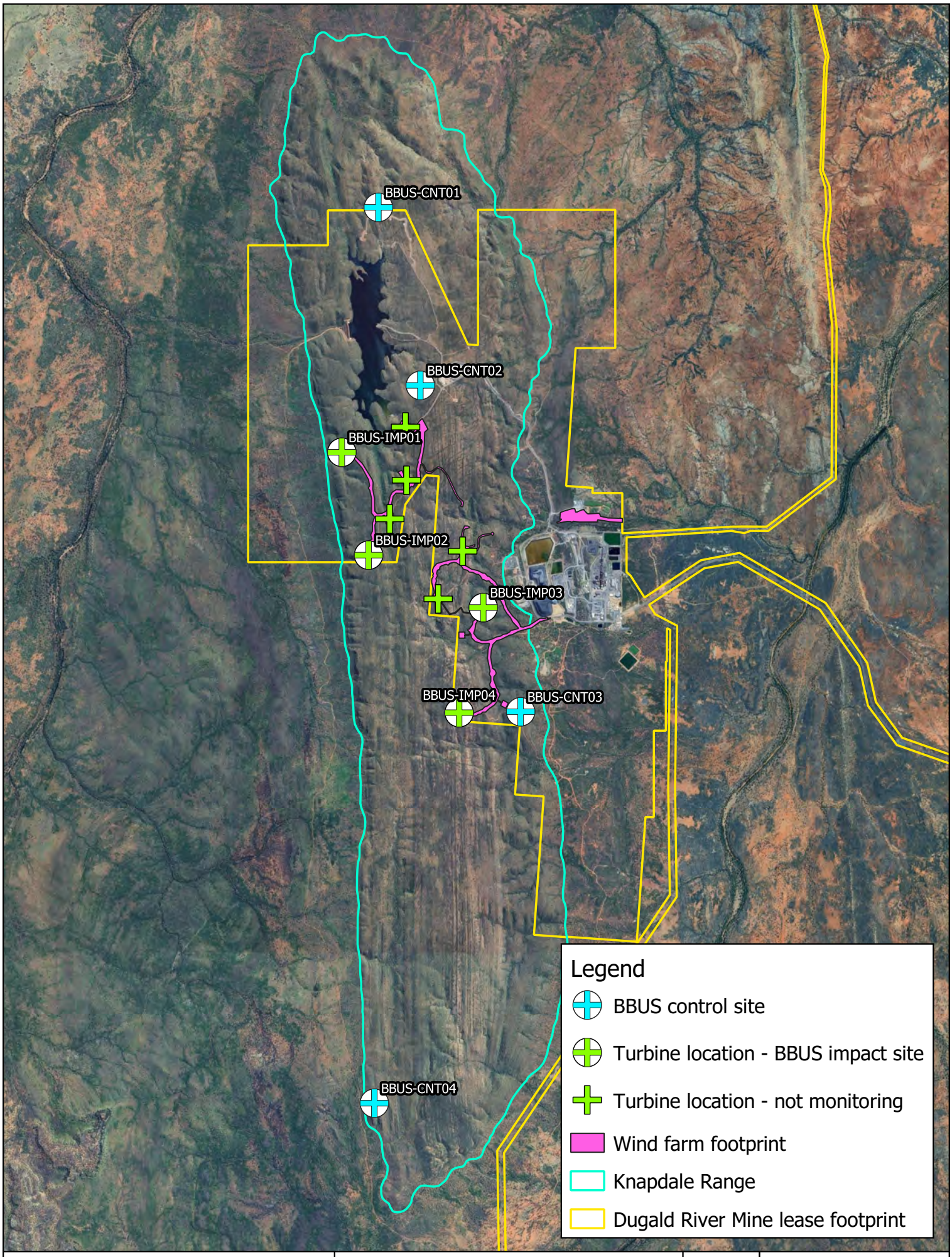


Figure 2.3
Bird and bat utilisation survey (BBUS) locations

0 0.5 1 km

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- Behaviour, categorised as one of:
  - Powered flight (i.e., flapping)
  - Gliding (i.e., directional unpowered glide)
  - Foraging (i.e., circular hunting pattern observed in raptors and woodswallows and/or hovering observed in some raptors e.g., Black-shouldered Kite)
  - Soaring/Thermaling (i.e., use of air currents to increase altitude)
- Minimum distance from observer (in metres) over the entire sub-survey
- Maximum height relative to observer (in metres) over the entire sub survey

A complete list of all other bird species observed below the canopy or heard calling within each survey is also recorded; however, only bird species flying above the canopy are considered in further analysis. Total BUS bird monitoring effort to date is 16 person-hours (Table 2.1).

2.2.9.2 Data Analysis

To determine which species are of greatest concern, species were sorted into two groups:

1. Species recorded within the rotor-swept area (RSA; i.e., the area of influence of the rotor specified as a range in metres above the ground). The RSA was considered for the largest possible turbine, the Goldwind GW 165-5.2/5.6/6.0MW. This rotor has a blade diameter of 165 m and a hub height of 130 m, for an RSA of 35 – 165 m above the ground.
2. Species recorded outside the RSA of the largest possible turbine

Species were then ranked based on the total number of individuals observed across all 48-surveys across May and September 2023.

To determine if most species likely to be present have been detected, a species accumulation curve (SACs) was produced using the *specaccum* function in the R package '*vegan'*. The SAC was produced using the "random" method, which randomly permutes the order of sub-survey blocks and, therefore, the order in which species are accumulated, and determines an average SAC (± standard deviation). Calculating an SAC using random permutations provides a more robust method of determining survey adequacy than a chronological "collector" method by minimising the effect of daily variation in occurrence (Thompson and Thompson 2007). The data informing the SAC were analysed to determine if the SAC showed signs of reaching an asymptote, or "levelling off". This was determined based on the suggested guidelines in Lane and Associates (2005) that a curve shows signs of levelling off if the final 10% of counts increase species richness by <10%.

2.2.9.3 Bat Monitoring

Bat monitoring utilises Anabat passive high-frequency sound recorders to capture the calls of microbats at each BBUS monitoring site. One Anabat unit is deployed at each site for a total of two consecutive nights per survey. A single recorder deployed at site BBUS-CNT02 failed to record during initial deployment in September 2023. This unit was redeployed for a single night at the end of the survey to accumulate one Anabat-night of data. Total BBUS Anabat effort to date is 16 Anabat-nights (Table 2.1).

2.3 FLORA SURVEYS

2.3.1 BBUS Site Assessment

Under the Regional Ecosystem (RE) framework the Knapdale Range is mapped as a heterogeneous polygon consisting of two RE types, 1.11.2a and 1.7.7a. Vegetation at each BBUS impact and control site was therefore categorised to verify which of these, or possibly alternative, REs are present at each monitoring location. The following were recorded at each site:

- Landform
- Dominant species within ground, shrub and tree strata
- Percent cover estimate of each stratum
- Height estimate (range) of shrub and tree strata

This is sufficient to exceed a Quaternary assessment; however, does not include all necessary data (basal area abundance, complete list of all woody species present) to attain a Tertiary assessment of the vegetation at each site (Neldner *et al.* 2019). Four photographs were taken at each site, one each facing north, east, south, and west to provide a visual representation of each site.

2.3.2 Weed Surveys

Weed surveys have not been systematically undertaken across the site; however, incidental notes and observations over 10 years have been collated. Observers are also vigilant for weeds at newly constructed turbine pads.

2.4 Survey Limitations

The following limitations have affected all surveys conducted by EcoSmart Ecology within the Knapdale Range and surrounding areas:

- No spotlighting effort has been undertaken, meaning nocturnal species are generally underrepresented unless they are rock-dwelling and thus have a higher likelihood of being recorded by camera traps or during sporadic opportunistic habitat searches;
- No searching has been conducted in wet conditions, so amphibians are likely underrepresented with only chance sightings recorded on camera or sporadic opportunistic habitat searches;
- Surveys have all been conducted either pre- or post-wet season (typically within Sept/Oct and Apr/May). Some species which may only occur after large rain events (e.g., some wading birds) may be underrepresented;
- Pitfall trapping has only recently commenced at a single location, so survey effort using this method is limited. While pitfall trapping may increase overall species inventory, many species likely to be detected by this method have been detected using other methods.

None of these limitations need to be overcome to detect EVNT species with the potential to occur across the Knapdale Range. Therefore, while addressing these limitations may increase overall species inventory, it will not increase the likelihood of detecting any EVNT species.

3.0 RESULTS AND DISCUSSION

3.1 Desktop Assessment

A desktop assessment identified 17 EVNT species known or with the potential to occur within 25 km of the Knapdale Range. A likelihood assessment was conducted to determine the potential for these species to occur on the Knapdale Range. One species was determined as present, the Purple-necked Rock-wallaby. Short-beaked Echidna, a species of special least concern under the Nature Conservation Act (NC Act) has also been recorded from the range.

Two other species are not expected to occur except as perhaps vagrant individuals; these species, The Painted Honeyeater and Grey Falcon, are considered to be 'Transient'.

All other species were categorised as "Will Not Occur" on the Knapdale Range. One species, the Mertens' Water Monitor, has been recorded in surveys at Longamundi Waterhole, but was categorised as "Will Not Occur" due to the lack of suitable habitat on the Knapdale Range. The complete assessment is provided in Appendix D.

3.2 Fauna

Fauna surveys since from 2014–2023 have recorded 153 vertebrate species across the Knapdale Range (Appendix C) including four native amphibians, 23 native reptiles, 104 native birds, and 18 native mammals. This includes several species notable under the NCA including a Vulnerable mammal (Purple-necked Rock-wallaby) and one Special Least Concern mammal (Short-beaked Echidna).

The NCA Endangered reptile, Mertens' Water Monitor (*Varanus mertensi*), has been recorded in the surrounding areas (i.e., the nearby Dugald River) but is not known from the Knapdale Range. To date this species has not been recorded within MMG's Dugald River mining lease and no suitable habitat for it occurs. No threatened species under the EPBC Act have been identified.

A single migratory species (Glossy Ibis) listed under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) has been recorded.

Two introduced mammals and one introduced amphibian have been regularly recorded.

3.2.1 Known Special Conservation Vertebrate Fauna

Following considerable survey and time spent traversing the Knapdale range, only two species of special conservation significance have been identified as present, the Purple-necked Rock-wallaby and Short-beaked Echidna. These species are discussed in further detail below.

3.2.1.1 Purple-necked Rock-wallaby

NCA: Vulnerable | EPBC: Not listed | Likelihood Assessment: Present

Occurrence and habitat

PNRW are known from multiple locations across the Knapdale Range in association with large rocky features. Purple-necked Rock-wallaby habitat is not uniform and instead occurs in discrete locations associated with complex rocky scree slopes, cliffs and gullies. This significantly influences PNRW distribution, with colonies occurring as discrete units of variable size across the landscape. Colony size is closely correlated with habitat quality; larger, more complex rocky features with more abundant sheltering opportunities support greater numbers than smaller, less complex features. Mixing between colonies within the Knapdale range is likely to be frequent. Larger more secure colonies probably act as 'source' populations, allowing dispersal to nearby habitats and facilitating recolonisation following local extinction of more marginal areas. Natural fluctuation of numbers within each colony is therefore expected.

Population size and trends

Initial estimates of the Purple-necked Rock-wallaby population on the Knapdale Range calculated in 2014 were for a total population size of 137 individuals (EcoSmart Ecology 2014). This was based on an average of 2.45 individuals per colony across 56 possible locations (both known populations, and populations hypothesised to be present based on aerial imagery interpretation). Purple-necked Rock-wallaby sub-population sizes have fluctuated over 10 years of monitoring (Table 3.1); however, average population size across the Knapdale Range was at its highest ever-recorded value (4.83±2.12 individuals per colony) in September 2022 (EcoSmart Ecology 2022). Based on these most recent estimates and on the 56 sub-populations assumed in 2014, the current total population size on the Knapdale Range may be as high as 270 individuals. As noted in 2014, this estimate should be used conservatively as 30 locations were only hypothesised to support populations, with no visual inspection of these locations conducted. Some locations have become or will soon be inundated by the filling of the tailings storage facility (TSF) dam, meaning the actual number of potential colonies is likely fewer than estimated in 2014. The average population size per colony across all monitoring periods (i.e., average population size from Apr 2014 to Sep 2022) is 3.3±1.07 individuals (Table 3.1).

Table 3.1. Purple-necked Rock-wallaby abundance recorded using trail cameras from 2014 to 2022

Site	2014		2015		2016		2017		2018		2019		2020		2021		2022		Mean	Slope
	Apr	Aug	May	Sep	May	Aug	May	Aug	May	Oct	Apr	Oct	Apr	Sep	Apr	Sep	May	Oct		
CNT01	1	2	1	2	3	1	3	4	0	2	1	2	1	3	2	3	3	3	1.9	0.0004
CNT02	4	3	5	5	4	3	3	2	2	4	3	3	3	5	2	4	3	5	3.5	0.0000
CNT03	2	3	5	6	3	3	3	3	2	1	2	1	3	4	2	2	2	3	2.9	-0.0004
CNT04	1	4	6	6	2	3	3	4	3	5	1	6	2	9	9	8	14	11	3.9	0.0024
IMP01	3	3	4	5	3	4	4	4	4	2	5	3	2	4	4	4	2	4	3.7	-0.0001
IMP02	1	3	#	4	4	3	2	3	#	4	2	4	4	3	2	3	3	4	3.1	0.0003
IMP03	2	3	1	3	3	3	4	4	2	4	3	2	3	3	#	4	4	6	2.9	0.0007
IMP04	0	0	0	0	0	0	0	1	2	0	1	2	2	0	0	0	1	2	0.6	0.0006
KR01					4	4	2	4	3	3	3	1	1	#	3	4	4	5	2.8	0.0004
KR05						3	3	1	3	0	2	3	0	4	1	4	4	4	2.1	0.0008
KR07						4	3	4	4	5	6	3	4	4	2	5	3	4	4.1	-0.0002
KR10						2	3	1	4	4	5	2	3	4	2	6	4	5	3.2	0.0008
KR13						4	4	4	3	4	3	4	2	4	0	5	4	7	3.6	0.0007
KR14						3	2	#	5	4	3	0	3	6	2	4	7	7	3.3	0.0019
KR16						2	2	2	1	3	0	1	1	2	0	3	4	2	1.6	0.0004
KR18							4	4	3	1	2	4	1	5	1	4	4	6	3.4	0.0011
KR19							3	5	5	5	0	0	2	2	2	4	2	5	2.7	-0.0006
KR20							3	#	2	4	4	5	3	5	3	4	2	4	3.8	-0.0001

equipment failure

Purple-necked Rock-wallaby sub-population sizes have varied between 2014 and 2022, and not all sub-populations have varied at the same rate. Regression slopes calculated in 2022 are shown in Figure 3.1. As of September 2022, most locations showed an overall increase in population. However, recent surveys have occurred following exceptional rainfall years due to La Niña and likely reflect increased forage resource availability supporting larger numbers of PNRW.

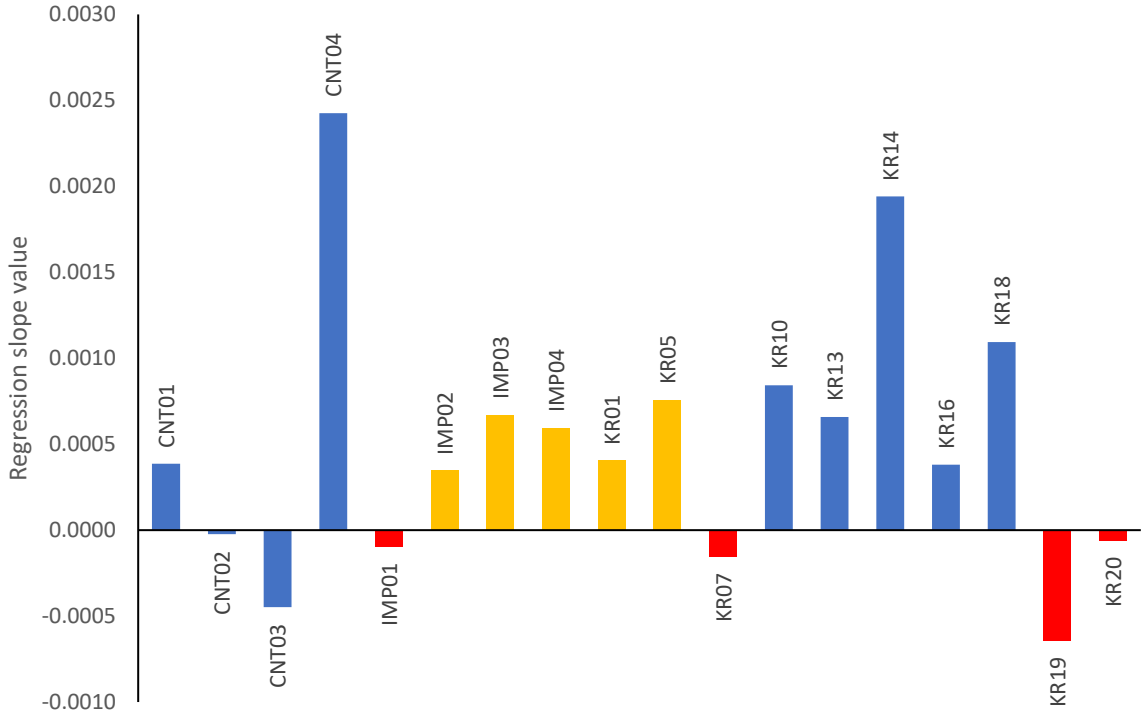


Figure 3.1. Regression slopes for PNRW colonies. Positive regression values suggest an increase in PNRW numbers, negative values suggest a decline – the greater the value the more abrupt the change. Sites coloured blue are located considerable distance from the effects of mining (> 1 km), sites coloured red are immediately adjacent the TSF, sites coloured yellow are near to other mining impacts (village, access roads, exploration etc).

Monitoring camera KR19 was the first to be inundated by rising water levels in the TSF dam and shows a strong decreasing population trend. This perhaps supports the understanding that PNRW are unable to tolerate direct loss of shelter habitat.

Since 2022, a new vehicle track made conducting watches at one known colony easier, and this location has had colony watches conducted on it across three monitoring periods. While not sufficient effort to determine population trends, this colony is known to contain at least 6–8 individual PNRW, well above the average population size as of September 2022. Given the size of this colony and its position in relation to the proposed wind farm footprint (~600 m south of WT7, see Figure 3.2) it may act as a source population from which individuals may return if disturbance occurs during construction.

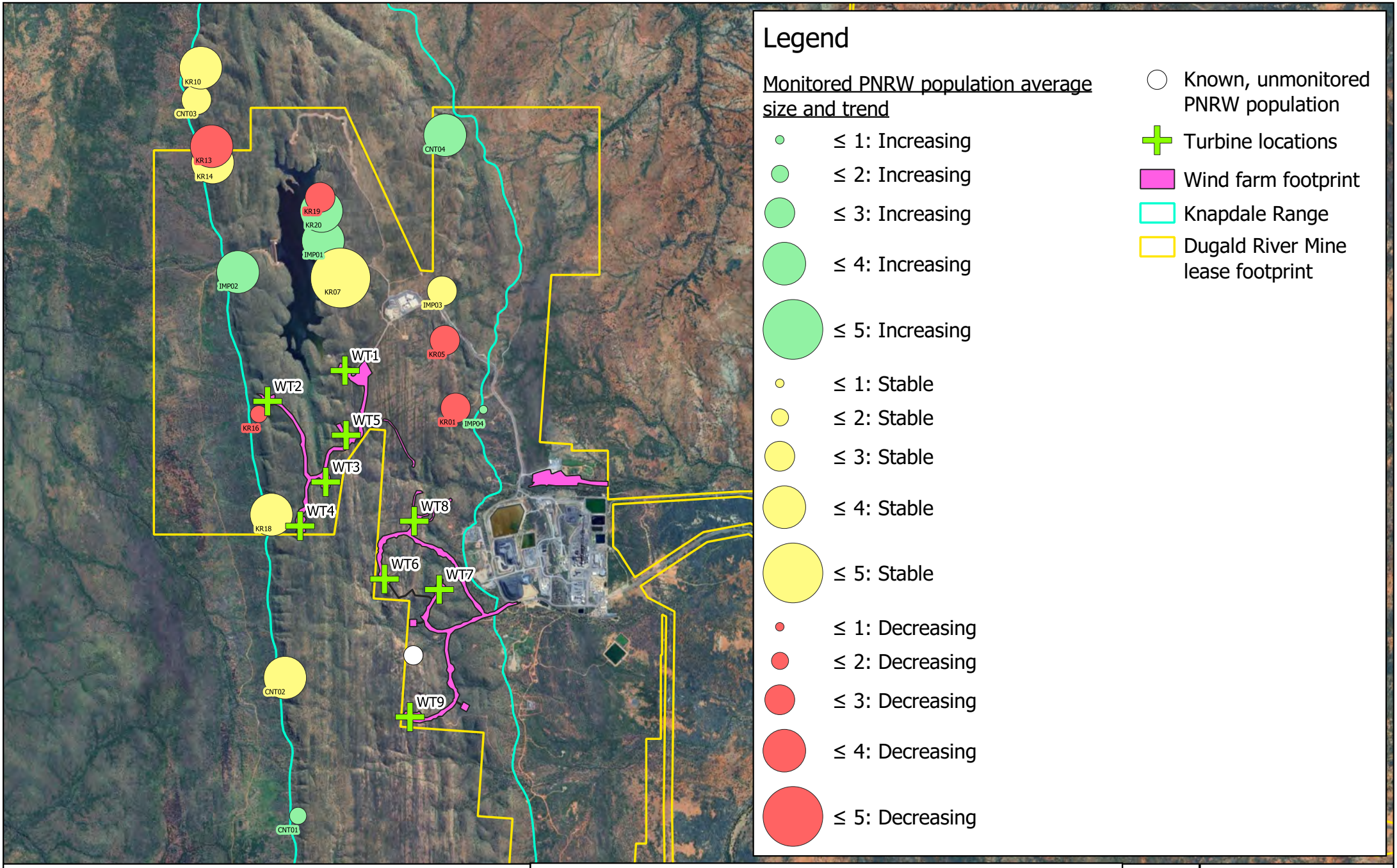


Figure 3.2
Monitored Purple-necked Rock-wallaby (PNRW) colony average population size and trend. A known, unmonitored population is also shown; however, no average population size estimate is available for this location. Further detail in Section 3.2.1.1.

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Impact considerations

Shelter habitat, rather than forage habitat, is the limiting resource for PNRW across the Knapdale Range. Construction activities across the Knapdale Range therefore need to consider the impacts of any proposed activities on PNRW shelter habitat, rather than on foraging habitat.

The currently proposed turbine locations are not located at any known PNRW colonies; however, some are nearby. Turbine pads WT2 and WT4 are ~150 m NE and ~300 m ESE of PNRW populations at monitoring sites KR16 and KR18. The colony at KR16 is below average in size (1.6 individuals) and is in decline. Reasons for decline at this location are not fully understood. Site KR18 is a larger colony with an above average population size across monitoring periods (3.4 individuals), a population trend currently indicated as stable. This site is also more rugged and has more shelter opportunities than KR16 and may therefore provide greater protection from predators and any perceived disturbance from construction.

Currently proposed tracks and 5 m buffer footprint do not traverse any known or visually suitable PNRW shelter habitat. Two PNRW vehicle deaths have occurred on the Dugald River Mine village road since its operation. Risks associated with vehicle strike on access roads to the turbines is considerably less, probably negligible, due to lower vehicle speed and less frequent use (especially during operation).

3.2.1.2 Short-beaked Echidna

NCA: Special Least Concern | EPBC: Not listed | Likelihood Assessment: Present

Short-beaked Echidna is infrequently recorded across the Knapdale Range, by both direct and indirect (e.g., scats) observation, and the entire range constitutes high amenity shelter and foraging habitat. The construction of turbine pads and associated infrastructure, especially roads has the potential to impact on Short-beaked Echidna shelter and foraging habitat via direct disturbance of this habitat. However, the spatial extent of impacts are minor constituting ~0.17% of the Knapdale Range. Impacts are not expected to prevent the species from utilising remaining habitat outside the construction footprint.

3.2.2 Other Special Conservation Fauna

Two species identified within the desktop assessment, the Grey Falcon and Painted Honeyeater, are highly mobile and able to traverse large expanses of unsuitable or sub-optimal habitats. These species have been recorded within the local area and have some chance to occur, at least theoretically. However habitats on the Knapdale Range are suboptimal at best and resident populations do not occur, nor could the possibly occur due to low or no habitat amenity. These species are considered 'transient' in nature and discussed below.

A third species, the Carpentarian Grasswren, is also discussed below for greater clarity but will not occur on the Knapdale Range.

3.2.2.1 Grey Falcon

NCA: Vulnerable | EPBC: Vulnerable | Likelihood Assessment: Transient

The Grey Falcon (*Falco hypoleucos*) has never been recorded on site and is considered unlikely to occur. Nearby records are sparse and infrequent, indicating transiency rather than residency in the broader region. The Grey Falcon is most commonly observed on vast, featureless plains with scattered trees, ecosystems which typically predominate further south and west of the Knapdale Range. Even during irruptive events of other birds favoured as prey by the Grey Falcon (e.g., Budgerigars), the species has never been observed. Future observations of the species across the Knapdale Range cannot be discounted, but the area is unlikely to support a resident pair or to have any other significant conservation value for the species.

3.2.2.2 Painted Honeyeater

NCA: Vulnerable | EPBC: Vulnerable | Likelihood Assessment: Unlikely

The Painted Honeyeater (*Grantiella picta*) has never been recorded on site in 10 years of survey and is considered unlikely to occur. This species is a mistletoe specialist, relying heavily on mistletoe plants for its entire life cycle. Painted Honeyeaters typically inhabit *Eucalyptus* and *Acacia* forests and woodlands where mistletoe, particularly Grey Mistletoe (*Amyema quandang*), is abundant. Despite the presence of suitable host trees for Grey Mistletoe, particularly Gidgee (*Acacia cambagei*), on the flat lands at the base of the Knapdale Range, this mistletoe has not been observed on site. While detailed mistletoe surveys have not been conducted, only one species has been observed on the Knapdale Range, Collared Mistletoe (*Lysiana spathulata*). This species has been observed parasitising several tree and shrub species, notably Arid Peach (*Terminalia aridicola*), False Sandalwood (*Santalum lanceolatum*) and Red Wattle (*Acacia monticola*) and appears to occur only sparsely across the Knapdale Range. Combined with the geographic location of the Knapdale Range towards the northwestern edge of the Painted Honeyeater's range, the presence and scarceness of a single, unfavoured mistletoe species indicates that Painted Honeyeaters are highly unlikely to occur on site, even as a vagrant.

3.2.2.3 Carpentarian Grasswren

NCA: Endangered | EPBC: Endangered | Likelihood Assessment: Will Not Occur

In ten years of survey, monitoring and observations, the Carpentarian Grasswren (*Amytornis dorotheae*) has never been recorded on the Knapdale Range. The related Kalkadoon Grasswren (*Amytornis ballarae*) is frequently recorded across the entire Knapdale Range during targeted surveys and monitoring as well as through incidental observations. The prevalence of records of Kalkadoon Grasswren across multiple years indicates that survey methods utilised over the past ten years are suitable for recording this genus of birds, and provides further support for the assertion that Carpentarian Grasswren will not occur on the range. Kalkadoon and Carpentarian Grasswren are known to occur in close proximity in certain locations north of Mount Isa. At these locations, the two species appear to separate by habitat type, with Kalkadoon Grasswren occurring at higher elevations on massive, rocky outcrops, hills and ranges (e.g. locations similar to the Knapdale Range), and Carpentarian Grasswren occurring at lower elevations on stony, skeletal soils among large, mature hummock grass (*Triodia* spp.).

Low to moderate amenity habitat for Carpentarian Grasswren occurs on the rolling plains to the east of the Knapdale Range (i.e., between the Knapdale Range and Dugald River). However, this area has been traversed by EcoSmart ecologists and no Carpentarian Grasswrens have been recorded. Importantly, these habitats are considerably different from the Knapdale Range where turbine impacts are expected. Habitat on the Knapdale Range is unsuitable.

3.2.3 Migratory Species

NCA: Special Least Concern | EPBC: Migratory | Likelihood Assessment: Will Not Occur

A single record of Glossy Ibis (*Falcinellus plegadis*) is known from the Knapdale Range from 2021. An individual bird was observed on beached tailings in the TSF dam among a small flock of Pied Stilts (*Himantopus leucocephalus*). This observation followed a significant rainfall event (>40mm) on the Range, and this may have contributed to the presence of this species at this location. It is unlikely that the TSF dam provided suitable foraging resources due to the composition of tailings sediments, and this location was more likely utilised as a staging area (i.e., rest site) than a long-term foraging location. Glossy Ibis has not been subsequently recorded on the Knapdale Range and is unlikely to occur in the future.

3.2.4 Pest Species

A total of four terrestrial vertebrate pests have been historically recorded on camera across the Knapdale Range: Feral Cat (*Felis catus*), Dingo/Dog (*Canis familiaris/C. dingo*), Feral Pig (*Sus scrofa*). A fourth, Cane Toad (*Rhinella marina*), has been incidentally observed during surveys.

3.2.5 Bird Utilisation

A total of 30 bird species have been recorded flying above the canopy across four impact and four control sites (Table 3.2). Aerial insectivores and raptors are the most commonly observed birds observed at bird utilisation monitoring locations. These groups form largely permanent populations on the Knapdale Range and are frequently observed thermaling (i.e., using warm updrafts to rise through the air column) and actively foraging within the potential RSA. To date ten species of bird have been identified as species of concern due to observations within the potential rotor-swept area (RSA). These include (in decreasing order of number of individuals recorded):

- Little Woodswallow (Artamus minor)
- Black-faced Woodswallow (Artamus cinereus)
- Fairy Martin (Petrochelidon ariel)
- Brown Falcon (Falco berigora)
- White-necked Heron (Ardea pacifica)
- Wedge-tailed Eagle (Aquila audax)
- Black-shouldered Kite (Elanus axillaris)
- Whistling Kite (Haliastur sphenurus)
- Black Kite (Milvus migrans)
- Varied Lorikeet (Psitteuteles versicolor)

Of these species, >10 individuals of all three aerial insectivores (Woodswallows and Fairy Martin) have been recorded during BUS monitoring, while most raptor observations are singletons with the exception of Brown Falcon (3 individuals recorded).

In addition to these species, other birds at risk (due to similar behaviour) which have been observed on the Knapdale Range but not during BUS surveys include:

- Masked Woodswallow (Artamus personatus)
- White-browed Woodswallow (Artamus superciliosus)
- White-breasted Woodswallow (Artamus leucorhynchus)
- Collared Sparrowhawk (Accipiter cirrocephalus)
- Brown Goshawk (Accipiter fasciatus)
- Spotted Harrier (Circus assimilis)
- Nankeen Kestrel (Falco cenchroides)
- Australian Hobby (Falco longipennis)
- Black Falcon (Falco subniger)
- Black-breasted Buzzard (Hamirostra melanosternon)

Of these species, Black Falcon has only been observed once during ten years and is unlikely to be a regular occurrence across the Knapdale Range. All other species have been observed in multiple years and have the potential to occur within the potential RSA at any time during daylight operation and should also therefore be considered species of concern.

A species accumulation curve for all 48 surveys is shown in Figure 3.3. The curve shows species accumulation approaching an asymptote with fewer than three new species added in the final ten surveys (i.e., the final 20% of counts increased the total count by less than 10%).

Table 3.2. Ranked list of bird species recorded across impact and control sites within and outside the rotor-swept area (RSA). Species are ranked by total count across two surveys.

Within/Outside Rotor-swept Area (RSA)	*Scientific Name* Common Name	Status*		Count		
		NCA	EPBC	May 2023	Sep 2023	Total
Within RSA	*Artamus minor* Little Woodswallow	LC		5	28	33
	Artamus cinereus Black-faced Woodswallow	LC			18	18
	Petrochelidon ariel Fairy Martin	LC			12	12
	Falco berigora Brown Falcon	LC		2	1	3
	Ardea pacifica White-necked Heron	LC		2		2
	Aquila audax Wedge-tailed Eagle	LC		1		1
	Elanus axillaris Black-shouldered Kite	LC		1		1
	Haliastur sphenurus Whistling Kite	LC		1		1
	Milvus migrans Black Kite	LC			1	1
	Psitteuteles versicolor Varied Lorikeet	LC			1	1

Within/Outside Rotor-swept Area (RSA)	*Scientific Name* Common Name	Status*		Count		
		NCA	EPBC	May 2023	Sep 2023	Total
Outside RSA	*Geopelia cuneata* Diamond Dove	LC			43	43
	Melopsittacus undulatus Budgerigar	LC		22	15	37
	Artamus minor Little Woodswallow	LC		4	21	25
	Psitteuteles versicolor Varied Lorikeet	LC		6	18	24
	Petrochelidon ariel Fairy Martin	LC		1	18	19
	Ptilotula plumula Grey-fronted Honeyeater	LC		7	7	14
	Coracina novaehollandiae Black-faced Cuckoo-shrike	LC		1	11	12
	Philemon citreogularis Little Friarbird	LC		7	3	10
	Dicaeum hirundinaceum Mistletoebird	LC		1	8	9
	Nymphicus hollandicus Cockatiel	LC			7	7
	Taeniopygia guttata Zebra Finch	LC		6	1	7
	Ptilotula keartlandi Grey-headed Honeyeater	LC		2	3	5
	Hamirostra melanosternon Black-breasted Buzzard	LC			2	2
	Artamus cinereus Black-faced Woodswallow	LC		1	1	2
	Accipiter fasciatus Brown Goshawk	LC		2		2
	Ardea alba Eastern Great Egret	LC		2		2
	Conopophila rufogularis Rufous-throated Honeyeater	LC			2	2
	Corvus coronoides Australian Raven	LC		1	1	2
	Eolophus roseicapilla Galah	LC			2	2
	Falco berigora Brown Falcon	LC		2		2
	Emblema pictum Painted Finch	LC		2		2
	Cracticus nigrogularis Pied Butcherbird	LC		1		1
	Elanus axillaris Black-shouldered Kite	LC			1	1
	Merops ornatus Rainbow Bee-eater	LC			1	1
	Philemon argenticeps Silver-crowned Friarbird	LC		1		1
	Rhipidura leucophrys Willie Wagtail	LC			1	1

* NCA = *Nature Conservation Act 1992*; EPBC = *Environment Protection and Biodiversity Conservation Act 1999*; CR = Critically Endangered; EN = Endangered; VU = Vulnerable; NT = Near Threatened; SLC = Special Least Concern; LC = Least Concern; Mig = Migratory

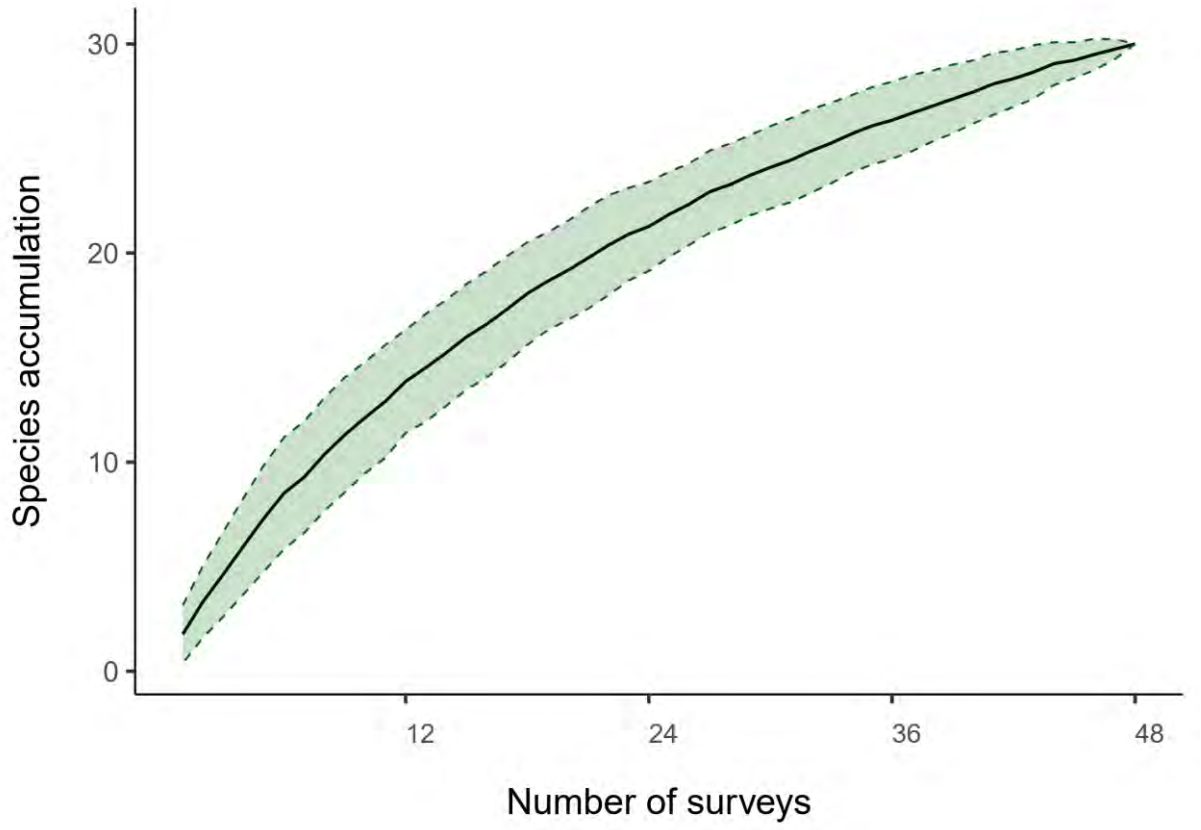


Figure 3.3. Species accumulation curve (SAC) based on bird monitoring undertaken during bird and bat utilisation surveys (BBUS) across four impact and four control sites in May and September 2023. SAC is based on "random" method, utilising random subsampling without replacement (±s.d.).

3.2.6 Bat Utilisation

A total of 13 bat calls were positively identified to genus level in at least one recording across two surveys at four impact and four control sites. A further six profiles could not be positively determined; however, possible species for all six call profiles were positively identified in other calls during surveys. Of the 13 bat taxa identified on Anabat, two taxa (*Chalinolobus gouldii* and *Taphozous* sp.) accounted for over 60% of identified calls, and 98% of calls were attributable to just six taxa.

While no data is available on how high these species fly, most microbat species are typically thought to forage within or just above the canopy. In most cases this places bat activity below the RSA, especially when turbines are as high as those proposed for Dugald River[1]. However, pilot studies using acoustic recorded attached to weather balloons tethered at 100 m have detected Eastern Bent-winged Bats (*Miniopterus orianae oceanensis*), indicating this species is at risk of collision from wind turbines (Pennay & Mills 2018 cited in Van Harten *et al.* 2022). It is conceivable other microbat species may fly at similar altitudes and will therefore occur within the RSA, at least occasionally. This is likely especially true of *Taphozous* spp. and Yellow-bellied Sheathtail Bat (*Saccolaimus flaviventris*), which often forage relatively high above the canopy

[1] Assuming final turbine size is as defined in Section 1.1.

(G. Ford pers. comm.). These taxa were also among the most recorded calls on Anabat at BBUS monitoring sites. The death of Gould's Wattled Bat (*Chalinolobus gouldii*) and White-striped Freetail Bat (*Austronomus australis*) have also been recorded at wind turbines in Victorian (Moloney *et al.* 2019), and both species are present on the Knapdale Range.

Table 3.3. Ranked list of bat species recorded across four impact and four control sites. Species are ranked by total number of calls across two surveys (NB: this is not equivalent to a total count of individuals).

Confidence	*Scientific Name* Common Name	Status*		Number of calls		
		NCA	EPBC	May	Sep	Total
Positive Identification	*Chalinolobus gouldii* Gould's Wattled Bat	LC		1204	2349	3553
	Taphozous sp.			352	1114	1466
	Chaerephon jobensis Northern Freetail Bat	LC		749	465	1214
	Saccolaimus flaviventris Yellow-bellied Sheathtail Bat	LC		79	698	777
	Scotorepens greyii Little Broad-nosed Bat	LC		51	571	622
	Vespadelus baverstocki Inland Forest Bat	LC		21	254	275
	Chalinolobus nigrogriseus Hoary Wattled Bat	LC		21	36	57
	Vespadelus finlaysoni Finlayson's Cave Bat	LC		31	10	41
	Ozimops lumsdenae Northern Free-tailed Bat	LC		30	10	40
	Scotorepens balstoni Inland Broad-nosed Bat	LC		8	14	22
	Ozimops sp.			13	3	16
	Austronomus australis White-striped Freetail Bat	LC		4	1	5
	Nyctophilus sp.			1	3	4
Uncertain Identification	*C. gouldii* or *Ozimops* sp.			505	133	638
	C. nigrogriseus or *S. greyii*			11	73	84
	S. greyii or *V. baverstocki*			21	51	72
	C. gouldii or *S. balstoni*			30	10	40
	O. lumsdenae or *Taphozous* sp.			2	6	8
	S. balstoni or *Ozimops* sp.			3	5	8

* NCA = *Nature Conservation Act 1992*; EPBC = *Environment Protection and Biodiversity Conservation Act 1999*; CR = Critically Endangered; EN = Endangered; VU = Vulnerable; NT = Near Threatened; SLC = Special Least Concern; LC = Least Concern; Mig = Migratory

Four bat roosts are known on the Knapdale Range (Figure 2.2), although there may be more to be discovered. Two are abandoned mine shafts (not associated with the DRM operation) and two are natural caves. While there has been no attempt to estimate the number of bats in these features, incidental observation suggests the two artificial roosts contain far fewer bats, possibly not exceeding 20-30 individuals. In contrast, the natural structures have many individuals, likely numbering in the low 100s. Most bats within these roosts are *Taphozous* spp., although the appearance of Finlayson's Cave Bat (*Vespadelus finlaysoni*) on Anabat recorders indicates it too is likely present.

One of the natural cave roosts is located ~300 m ENE of turbine WT4 while the second is located near PNRW monitoring site CNT04 ~2.4 km from the nearest turbine. While bats from both roosts are likely to fly through the turbine field during nighttime foraging bouts, individuals using the roost near WT4 are at far greater risk.

The presence on the Knapdale Range of potentially high-flying bat species, and unknown population sizes suggests a need for further data collection around bat presence and site utilisation.

3.3 Flora and Vegetation

3.3.1 BBUS Sites

All BBUS impact and control sites consist of open *Eucalyptus*/*Corymbia* woodland, typically with an *Acacia* spp. shrub layer, and are dominated by a ground cover of *Triodia pungens*. Complete descriptions and photos of each site are provided in Appendix E. Following comparison with Regional Ecosystem technical descriptions (Queensland Herbarium 2023), all sites have been classified as RE1.11.2a.

3.3.2 Weeds

Several weedy species have been observed or recorded across the Knapdale Range and surrounding areas. No systematic surveys have been conducted for weedy species; however, the following are the most commonly observed:

- Kapok Weed (*Aerva javanica*). Common along roadside disturbance areas and drill pads, particularly within the Dugald River Mine footprint.
- Prickly Acacia (Vachellia nilotica). An obvious feature of flat lands at the southern edge of the Knapdale Range, typically in association with drainage lines and grazing country. This species does not appear to have become established on the rocky hills of the Knapdale Range.
- Buffel Grass (*Cenchrus* spp.). Most prolific on the western side of the range, particularly in association with drainage channels and grazing country; however, occasionally occurs higher up on rocky hills. This is a similar pattern to the spread of this species that has been observed by EcoSmart Ecology within the broader Mount Isa and Cloncurry region over the past decade.
- Farmer's Friends/Cobbler's Pegs (*Bidens* spp.). Typically seen in association rocky gullies and adjacent slopes. Generally sparsely distributed but may form dense localised patches.

Weedy species are not typically observed on the rocky upper slopes and plateaux of the Knapdale Range, nor have they been recorded in association with proposed turbine pads.

3.4 Survey Adequacy

3.4.1 Fauna Surveys

Surveys conducted between 2013–2023 meet or exceed the survey effort requirements for most survey methods recommended by Eyre *et al.* (2022). Noted exceptions to this include all direct nocturnal survey methods (spotlighting, nocturnal bird call playback, nocturnal active

search), and funnel trapping, which has not been conducted. As noted in Section 2.4, while these methods may increase overall species inventory, they will not increase the likelihood of detecting any EVNT species with the potential to occur on the Knapdale Range. The surveys are adequate to assess fauna values specially protected under legislation.

3.4.2 Bird and Bat Utilisation Surveys

The species accumulation curve (SAC) indicates the rate of accumulation of bird species during BBUS monitoring at the turbine locations is approaching an asymptote. However visual inspection of the SAC suggests further species may yet be recorded. This is supported by cross-examination records from bird surveys and foot traverses (i.e., incidental observations) collected over years of ecological work at Dugald River. Not all of concern species (raptors and aerial insectivores) known from the Knapdale Range have been recorded during BBUS monitoring. However, at risk species not yet detected during BBUS have been considered on the basis of their known presence along the Knapdale Range. Due to this approach it seems unlikely any at risk species has been overlooked.

Acoustic bat monitoring provides evidence of which species are utilising a given site and provides no information on how these species use the site, specifically at what altitudes each species is foraging. Further, Anabat is not useful for estimating the abundance of species.

3.5 FURTHER WORKS

Targeted surveys from 2014-2023 have likely recorded all potential resident vertebrate fauna species across the Knapdale Range, and a high proportion of vagrants to date. No further survey effort is strictly necessary to improve understanding of which species occur at the Knapdale Range. However, ongoing bird utilisation surveys would clarify which bird species most commonly utilise the RSA airspace. Specifically, the species accumulation curve may not yet have reached an asymptote, so at least one additional monitoring period is required, although two additional monitoring periods is preferable. Two additional periods (i.e., one additional year of monitoring) will give extra power to determine which bird species most commonly occur within the potential RSA and will provide firmer insight into which species are likely to be affected by year-round operation of turbines (i.e., resident species vs. nomadic/vagrant species).

Further information is also required on how bat species utilise the airspace at future wind turbine locations. Ideally, radar telemetry would be employed to determine how bats move in 3D space at turbine sites; however, additional information may still be gained by deploying Anabat units on temporary masts at monitoring sites, ideally at heights within the RSA, or else as high as possible. Deploying Anabat detectors in such a manner will provide greater insight into which bat species, if any, are utilising the airspace within the RSA and, subsequently, determine which species, if any, are at greatest collision risk.

4.0 REFERENCES

Eyre T. J., Ferguson D. J., Smith G. C. *et al.* (2022) Terrestrial Vertebrate Fauna Survey Assessment Guidelines for Queensland, Version 4.0.

Lane and Associates B. (2005) Wind Farms and Birds: Interim Standards For Risk Assessment. [online]. Available from: https://tethys.pnnl.gov/sites/default/files/publications/BrettLane-2005.pdf.

Neldner V. J., Wilson B. A., Dillewaard H. A. *et al.* (2019) Methodology for surveying and mapping regional ecosystems and vegetation communities in Queensland.

Queensland Herbarium (2023) Regional Ecosystem Description Database (REDD). Version 13 (May 2023). [online]. Available from: https://www.qld.gov.au/environment/plants-animals/plants/ecosystems/descriptions/download.

Thompson G. G. & Thompson S. A. (2007) Using species accumulation curves to estimate trapping effort in fauna surveys and species richness. *Austral Ecology* 32 , 564–569.

Van Harten E., Lawrence R., Lumsden L. F., Reardon T., Bennett A. F. & Prowse T. A. A. (2022) Seasonal population dynamics and movement patterns of a critically endangered, cave-dwelling bat, (ed S. Parsons). *Wildlife Res.* 49 , 646–658.

Appendix A: Location of all past and ongoing monitoring locations across the Knapdale Range between 2013 and 2023

Method (Years Conducted)	Monitoring Location	Latitude (dec. deg.)	Longitude (dec. deg.)
Pest Monitoring Camera (2013 - Ongoing)	PEST1	-20.2732	140.1249
	PEST2	-20.2326	140.1503
	PEST3	-20.2088	140.1199
	PEST4	-20.2242	140.1345
Purple-necked Rock-wallaby Monitoring Camera (2014 - Ongoing)	CNT01	-20.2729	140.1312
	CNT02	-20.2609	140.1300
	CNT03	-20.2108	140.1218
	CNT04	-20.2139	140.1448
	IMP01	-20.2230	140.1335
	IMP02	-20.2257	140.1256
	IMP03	-20.2274	140.1445
	IMP04	-20.2377	140.1483
	KR01	-20.2375	140.1457
	KR05	-20.2317	140.1447
	KR07	-20.2262	140.1351
	KR10	-20.2080	140.1222
	KR13	-20.2148	140.1232
	KR14	-20.2162	140.1233
	KR16	-20.2381	140.1275
	KR18	-20.2468	140.1287
	KR19	-20.2193	140.1332
	KR20	-20.2204	140.1333
Carpentarian Pseudantechinus Initial Survey (2015)	DRM01	-20.2164	140.1330
	DRM02	-20.2189	140.1334
	DRM03	-20.2185	140.1287
	DRM04	-20.2206	140.1332
	DRM05	-20.2226	140.1335
	DRM06	-20.2263	140.1350
	DRM07	-20.2248	140.1288
	DRM08	-20.2275	140.1339
	DRM09	-20.2297	140.1403
	DRM10	-20.2245	140.1280
	KNAP01	-20.2141	140.1447
	KNAP02	-20.2279	140.1438
	KNAP03	-20.2319	140.1450
	KNAP04	-20.2376	140.1458
	KNAP05	-20.2261	140.1255

Method (Years Conducted)	Monitoring Location	Latitude (dec. deg.)	Longitude (dec. deg.)
	KNAP06	-20.2079	140.1222
	KNAP07	-20.2107	140.1217
	KNAP08	-20.2148	140.1231
	KNAP09	-20.2468	140.1286
	KNAP10	-20.2725	140.1311
	KNAP11	-20.2004	140.1385
	KNAP12	-20.1958	140.1320
	KNAP13	-20.2635	140.1302
	KNAP14	-20.2816	140.1305
	KNAP15	-20.2642	140.1498
	KNAP16	-20.2340	140.1267
	KNAP17	-20.2418	140.1279
	KNAP18	-20.2382	140.1276
	KNAP19	-20.2562	140.1291
	KNAP20	-20.2376	140.1483
	KNAP21	-20.2046	140.1221
	REG01	-20.3127	140.2463
	REG02	-20.3140	140.2455
	REG03	-20.3553	140.2685
	REG04	-20.3644	140.2781
	REG05	-20.2590	140.1843
	REG06	-20.3466	140.2579
	REG07	-20.3639	140.2712
	REG08	-20.7216	140.4780
	REG09	-20.7126	140.4803
Carpentarian Pseudantechinus Monitoring Camera (2016 - 2021)	PSEUD01	-20.2166	140.1327
	PSEUD02	-20.2193	140.1333
	PSEUD03	-20.2183	140.1291
	PSEUD04	-20.2210	140.1333
	PSEUD05	-20.2231	140.1338
	PSEUD06	-20.2261	140.1345
	PSEUD07	-20.2258	140.1254
	PSEUD08	-20.2271	140.1335
	PSEUD09	-20.2469	140.1287
	PSEUD10	-20.2245	140.1279
	PSEUD11	-20.2377	140.1457
	PSEUD12	-20.2320	140.1453

Method (Years Conducted)	Monitoring Location	Latitude (dec. deg.)	Longitude (dec. deg.)
	PSEUD13	-20.2279	140.1434
	PSEUD14	-20.2448	140.1282
	PSEUD15	-20.2483	140.1293
	PSEUD16	-20.2350	140.1276
	PSEUD17	-20.2420	140.1278
	PSEUD18	-20.2377	140.1276
	PSEUD19	-20.2562	140.1291
	PSEUD20	-20.2376	140.1483
	PSEUD21	-20.2607	140.1299
	PSEUD22	-20.2722	140.1310
	PSEUD23	-20.2640	140.1300
	PSEUD24	-20.2149	140.1227
	PSEUD25	-20.2109	140.1218
	PSEUD26	-20.2081	140.1220
	PSEUD27	-20.2046	140.1222
	PSEUD28	-20.2132	140.1470
	PSEUD29	-20.2004	140.1385
	PSEUD30	-20.2139	140.1450
Bird Survey Transect (2019 - Ongoing)	BRD01	-20.2734	140.1252
	BRD02	-20.2263	140.1221
	BRD03	-20.2064	140.1205
BBUS Monitoring Site (Bird and Bat Monitoring) (2023 - Ongoing)	BBUS-CNT01	-20.2112	140.1324
	BBUS-CNT02	-20.2299	140.1372
	BBUS-CNT03	-20.2642	140.1484
	BBUS-CNT04	-20.3054	140.1320
	BBUS-IMP01	-20.2369	140.1283
	BBUS-IMP02	-20.2478	140.1313
	BBUS-IMP03	-20.2533	140.1442
	BBUS-IMP04	-20.2643	140.1415

Appendix B: Timing of vertebrate fauna surveys across the Knapdale Range from 2014–2023

All monitoring conducted during each survey was conducted between the dates shown under "Start" and "End", but were not necessarily conducted over this entire period (e.g., bird surveys typically only conducted on one morning per survey).

Year	Period	Monitoring conducted*	Start	End
2014	Post-Wet Season	PNRW, PEST	11/04/2014	17/04/2014
	Pre-Wet Season	PNRW, PEST	7/08/2014	13/08/2014
2015	Post-Wet Season	PNRW, PEST	7/05/2015	14/05/2015
	Carpentarian Pseudantechinus Initial Survey		30/06/2015	10/07/2015
	Pre-Wet Season	PNRW, PEST	7/09/2015	14/09/2015
2016	Post-Wet Season	PNRW, PEST, PSEUD	11/05/2016	18/05/2016
	Pre-Wet Season	PNRW, PEST, PSEUD	18/09/2016	25/09/2016
2017	Post-Wet Season	PNRW, PEST, PSEUD	2/05/2017	11/05/2017
	Pre-Wet Season	PNRW, PEST, PSEUD	14/08/2017	23/08/2017
2018	Post-Wet Season	PNRW, PEST, PSEUD	2/05/2018	11/05/2018
	Pre-Wet Season	PNRW, PEST, PSEUD	10/10/2018	19/10/2018
2019	Post-Wet Season	PNRW, PEST, PSEUD	8/04/2019	17/04/2019
	Pre-Wet Season	PNRW, PEST, PSEUD, BIRD	1/10/2019	11/10/2019
2020	Post-Wet Season	PNRW, PEST, PSEUD, BIRD	7/04/2020	16/04/2020
	Pre-Wet Season	PNRW, PEST, PSEUD, BIRD	8/09/2020	17/09/2020
2021	Post-Wet Season	PNRW, PEST, PSEUD, BIRD	7/04/2021	16/04/2021
	Pre-Wet Season	PNRW, PEST, PSEUD, BIRD	27/08/2021	5/09/2021
2022	Post-Wet Season	PNRW, PEST, BIRD	17/05/2022	23/05/2022
	Pre-Wet Season	PNRW, PEST, BIRD, PIT	27/09/2022	3/10/2022
2023	Post-Wet Season	PNRW, PEST, BIRD, BBUS, PIT	2/05/2023	11/05/2023
	Pre-Wet Season	PNRW, PEST, BIRD, BBUS	5/09/2023	16/09/2023

* PNRW = Purple-necked Rock-wallaby monitoring; PEST = Pest monitoring; PSEUD = Carpentarian Pseudantechinus monitoring; BIRD = Bird survey transects; PIT = Pitfall traps; BBUS = Bird and Bat Utilisation Survey monitoring

Appendix C: Species recorded across the Knapdale Range and surrounding areas during surveys conducted between 2013 and 2023

Method of detection for each species is denoted by an 'X' in the relevant "Survey Method" column(s).

Scientific Name Common Name	Conservation Status*		Survey Method^					
	NCA	EPBC	BBUS	Bird Survey	Elliot Trap	Incidental	White-flash Camera	Black-flash Camera
AMPHIBIANS								
Cyclorana sp.							X	
Litoria caerulea Green Tree Frog	LC					X	X	
Litoria rubella Little Red Tree Frog	LC					X	X	
Litoria spaldingi Spalding's Rocket Frog	LC					X		
Rhinella marina *Cane Toad*	I	I				X	X	
REPTILES								
Aspidites melanocephalus Black-headed Python	LC					X		
Carlia amax Bauxite Rainbow-skink	LC					X		
Ctenophorus slateri Slater's Ring-tailed Dragon	LC					X	X	
Ctenotus lateralis Gravelly-soil Ctenotus	LC					X	X	
Ctenotus pantherinus Leopard Ctenotus	LC					X		
Ctenotus saxatilis Stony-soil Ctenotus	LC					X		
Delma borea Rusty-topped Delma	LC					X		
Delma nasuta Sharp-snouted Delma	LC					X		
Demansia quaesitor Sombre Whipsnake	LC					X		
Egernia hosmeri Hosmer's Skink	LC					X	X	

Scientific Name Common Name	Conservation Status*		Survey Method^					
	NCA	EPBC	BBUS	Bird Survey	Elliot Trap	Incidental	White-flash Camera	Black-flash Camera
Eremiascincus isolepis Northern Bar-lipped Skink	LC						X	
Gehyra robusta Robust Dtella	LC						X	
Heteronotia binoei Bynoe's Gecko	LC					X		
Lialis burtonis Burton's Legless Lizard	LC					X		
Liasis olivaceus Olive Python	LC					X	X	
Lophognathus horneri Horner's Dragon	LC					X		
Morethia ruficauda Lined Firetail Skink	LC					X	X	
Morethia taenioplura Firetail Skink	LC					X		
Proablepharus tenuis Northern Soil-crevice Skink	LC					X		
Pseudechis australis Mulga Snake	LC					X	X	
Pygopus steelescotti Northern Hooded Scaly-foot	LC					X		
Varanus acanthurus Ridge-tailed Monitor	LC						X	
Varanus glebopalma Black-palmed Rock Monitor	LC						X	
Varanus mertensi Mertens' Water Monitor	EN					X		
Varanus panoptes Yellow-spotted Monitor	LC					X		
Varanus sp.							X	
Varanus tristis Black-headed Monitor	LC					X	X	
AVES (birds)								

Scientific Name Common Name	Conservation Status*		Survey Method^					
	NCA	EPBC	BBUS	Bird Survey	Elliot Trap	Incidental	White-flash Camera	Black-flash Camera
Acanthagenys rufogularis Spiny-cheeked Honeyeater	LC					X	X	
Acanthiza chrysorrhoa Yellow-rumped Thornbill	LC			X		X		
Accipiter cirrocephalus Collared Sparrowhawk	LC					X		
Accipiter fasciatus Brown Goshawk	LC		X[B]	X		X		
Aegotheles cristatus Australian Owlet-nightjar	LC		X[B]			X	X	
Amytornis ballarae Kalkadoon Grasswren	LC		X[B]			X	X	
Anhinga novaehollandiae Australasian Darter	LC					X		
Aprosmictus erythropterus Red-winged Parrot	LC		X[B]	X		X		
Aquila audax Wedge-tailed Eagle	LC		X[B]	X		X		
Ardea alba Eastern Great Egret	LC		X[B]					
Ardea pacifica White-necked Heron	LC		X[B]					
Ardeotis australis Australian Bustard	LC					X		
Artamus cinereus Black-faced Woodswallow	LC		X[B]	X		X	X	
Artamus minor Little Woodswallow	LC		X[B]	X		X		
Artamus personatus Masked Woodswallow	LC			X		X		
Artamus superciliosus White-browed Woodswallow	LC			X		X		
Barnardius zonarius macgilvrayi Cloncurry Ringneck	LC			X		X		

Scientific Name Common Name	Conservation Status*		Survey Method^					
	NCA	EPBC	BBUS	Bird Survey	Elliot Trap	Incidental	White-flash Camera	Black-flash Camera
Cacatua galerita Sulphur-crested Cockatoo	LC		X[B]	X		X		
Cacomantis pallidus Pallid Cuckoo	LC			X				
Centropus phasianinus Pheasant Coucal	LC			X				
Certhionyx variegatus Pied Honeyeater	LC					X		
Chalcites basalis Horsefield's Bronze Cuckoo	LC			X				
Chlamydera maculata Spotted Bowerbird	LC		X[B]	X		X		
Circus assimilis Spotted Harrier	LC			X		X		
Cissomela pectoralis Banded Honeyeater	LC		X[B]	X		X		
Climacteris melanurus Black-tailed Treecreeper	LC		X[B]	X		X		
Colluricincla harmonica Grey Shrike-thrush	LC		X[B]	X		X	X	
Colluricincla megarhyncha Little Shrike-thrush	LC			X				
Conopophila rufogularis Rufous-throated Honeyeater	LC		X[B]	X		X		
Coracina novaehollandiae Black-faced Cuckoo-shrike	LC		X[B]	X		X		
Coracina papuensis White-bellied Cuckoo-shrike	LC			X		X		
Corvus coronoides Australian Raven	LC		X[B]	X		X	X	
Corvus sp.							X	
Cracticus nigrogularis Pied Butcherbird	LC		X[B]	X		X	X	
Cracticus torquatus Grey Butcherbird	LC			X				

Scientific Name Common Name	Conservation Status*		Survey Method^					
	NCA	EPBC	BBUS	Bird Survey	Elliot Trap	Incidental	White-flash Camera	Black-flash Camera
Cygnus atratus Black Swan	LC					X		
Daphoenositta chrysoptera Varied Sittella	LC					X		
Dicaeum hirundinaceum Mistletoebird	LC		X[B]	X		X		
Dromaius novaehollandiae Emu	LC			X				
Egretta novaehollandiae White-faced Heron	LC					X		
Elanus axillaris Black-shouldered Kite	LC		X[B]	X		X		
Elseyornis melanops Black-fronted Dotterel	LC					X		
Emblema pictum Painted Finch	LC		X[B]	X		X	X	
Eolophus roseicapilla Galah	LC		X[B]	X		X		
Epthianura tricolor Crimson Chat	LC					X		
Eudynamys orientalis Common Koel	LC					X		
Eurostopodus argus Spotted Nightjar	LC					X		
Falco berigora Brown Falcon	LC		X[B]	X		X		
Falco cenchroides Nankeen Kestrel	LC					X		
Falco longipennis Australian Hobby	LC					X		
Falco subniger Black Falcon	LC					X		
Gavicalis virescens Singing Honeyeater	LC			X		X		

Scientific Name Common Name	Conservation Status*		Survey Method^					
	NCA	EPBC	BBUS	Bird Survey	Elliot Trap	Incidental	White-flash Camera	Black-flash Camera
Geopelia cuneata Diamond Dove	LC		X[B]	X		X	X	
Geopelia placida Peaceful Dove	LC		X[B]	X		X	X	
Geophaps plumifera Spinifex Pigeon	LC		X[B]	X		X	X	
Gerygone fusca Western Gerygone	LC					X		
Grallina cyanoleuca Magpie Lark	LC		X[B]	X		X		
Gymnorhina tibicen Australian Magpie	LC		X[B]	X		X		
Haliastur sphenurus Whistling Kite	LC		X[B]			X		
Hamirostra melanosternon Black-breasted Buzzard	LC		X[B]			X		
Heteromunia pectoralis Pictorella Mannikin	LC					X		
Himantopus leucocephalus Pied Stilt	LC					X		
Lalage tricolor White-winged Triller	LC			X		X		
Lichenostomus penicillatus White-plumed Honeyeater	LC					X		
Lichmera indistincta Brown Honeyeater	LC		X[B]	X		X		
Malurus assimilis Purple-backed Fairy-wren	LC		X[B]	X		X		
Malurus melanocephalus Red-backed Fairy-wren	LC			X		X		
Manorina flavigula Yellow-throated Miner	LC			X		X		
Megalurus mathewsi Rufous Songlark	LC		X[B]	X		X		

Scientific Name Common Name	Conservation Status*		Survey Method^					
	NCA	EPBC	BBUS	Bird Survey	Elliot Trap	Incidental	White-flash Camera	Black-flash Camera
Melanodryas cucullata picata Northern Inland Hooded Robin	LC			X		X		
Melithreptus brevirostris Brown-headed Honeyeater	LC					X		
Melithreptus gularis Black-chinned Honeyeater	LC		X[B]	X		X		
Melopsittacus undulatus Budgerigar	LC		X[B]	X		X		
Merops ornatus Rainbow Bee-eater	LC		X[B]	X		X		
Microeca fascinans Jacky Winter	LC			X		X		
Milvus migrans Black Kite	LC		X[B]			X		
Myiagra nana Paperbark Flycatcher	LC			X		X		
Ninox boobook Southern Boobook	LC						X	
Nymphicus hollandicus Cocaktiel	LC		X[B]	X		X		
Ocyphaps lophotes Crested Pigeon	LC			X		X		
Oreoica gutturalis Crested Bellbird	LC		X[B]	X		X		
Oriolus sagittatus Olive-backed Oriole	LC		X[B]	X				
Pachycephala rufiventris Rufous Whistler	LC		X[B]	X		X		
Pardalotus rubricatus Red-browed Pardalote	LC		X[B]	X		X		
Pardalotus striatus Striated Pardalote	LC			X		X		
Petrochelidon ariel Fairy Martin	LC		X[B]			X		

Scientific Name Common Name	Conservation Status*		Survey Method^					
	NCA	EPBC	BBUS	Bird Survey	Elliot Trap	Incidental	White-flash Camera	Black-flash Camera
Petroica goodenovii Red-capped Robin	LC					X		
Phaps chalcoptera Common Bronzewing	LC		X[B]	X		X		
Philemon argenticeps Silver-crowned Friarbird	LC		X[B]	X		X		
Philemon citreogularis Little Friarbird	LC		X[B]	X		X		
Plegadis falcinellus Glossy Ibis	SLC	Mig				X		
Podargus strigoides Tawny Frogmouth	LC						X	
Poephila acuticauda Long-tailed Finch	LC			X		X		
Pomatostomus temporalis Grey-crowned Babbler	LC		X[B]	X		X		
Poodytes carteri Spinifexbird	LC		X[B]	X		X		
Psitteuteles versicolor Varied Lorikeet	LC		X[B]	X		X		
Ptilotula flavescens Yellow-tinted Honeyeater	LC					X		
Ptilotula keartlandi Grey-headed Honeyeater	LC		X[B]	X		X	X	
Ptilotula plumula Grey-fronted Honeyeater	LC		X[B]	X		X		
Rhipidura fuliginosa Grey Fantail	LC			X				
Rhipidura leucophrys Willie Wagtail	LC		X[B]	X		X	X	
Smicrornis brevirostris Weebill	LC		X[B]	X		X		
Synoicus ypsilophorus Brown Quail	LC			X		X		

Scientific Name Common Name	Conservation Status*		Survey Method^					
	NCA	EPBC	BBUS	Bird Survey	Elliot Trap	Incidental	White-flash Camera	Black-flash Camera
Tachybaptus novaehollandiae Australasian Grebe	LC					X		
Taeniopygia bichenovii Double-barred Finch	LC			X		X		
Taeniopygia guttata Zebra Finch	LC		X[B]	X		X		
Todiramphus pyrrhopygius Red-backed Kingfisher	LC		X[B]	X		X		
Turnix velox Little Button-quail	LC					X		
Tyto alba Eastern Barn Owl	LC					X		
MAMMALS								
Austronomus australis White-striped Freetail Bat	LC		X[A]					
Canis dingo Dingo	LC					X	X	X
Chaerephon jobensis Northern Freetail Bat	LC		X[A]					
Chalinolobus gouldii Gould's Wattled Bat	LC		X[A]					
Chalinolobus nigrogriseus Hoary Wattled Bat	LC		X[A]					
Felis catus Feral Cat	I	I					X	X
Notamacropus agilis Agile Wallaby	LC					X		
Nyctophilus sp.	LC		X[A]					
Osphranter robustus Common Wallaroo	LC					X	X	
Osphranter rufus Red Kangaroo	LC					X		
Ozimops lumsdenae Northern Free-tailed Bat	LC		X[A]					

Scientific Name Common Name	Conservation Status*		Survey Method^					
	NCA	EPBC	BBUS	Bird Survey	Elliot Trap	Incidental	White-flash Camera	Black-flash Camera
Ozimops sp.			X[A]					
Petrogale purpureicollis Purple-necked Rock-wallaby	NT					X	X	
Pseudantechinus mimulus Carpentarian False Antechinus	LC				X	X	X	
Saccolaimus flaviventris Yellow-bellied Sheathtail Bat	LC		X[A]					
Scotorepens balstoni Inland Broad-nosed Bat	LC		X[A]					
Scotorepens greyii Little Broad-nosed Bat	LC		X[A]					
Sus scrofa Feral Pig	I	I				X	X	X
Tachyglossus aculeatus Short-beaked Echidna	SLC					X	X	
Taphozous sp.			X[A]			X		
Taphozous troughtoni Troughton's Sheath-tailed Bat	LC					X		
Vespadelus baverstocki Inland Forest Bat	LC		X[A]					
Vespadelus finalysoni Finlayson's Cave Bat	LC		X[A]					
Zyzomys argurus Common Rock Rat	LC				X		X	

Appendix D: Likelihood assessment for threatened vertebrate species

Likelihood assessment for threatened vertebrate species either known from within 25 km of the Knapdale Range or identified as having the potential to occur within 25 km of the Knapdale Range based on EPBC Protected Matters search, Wildnet search, and Atlas of Living Australia search. The likelihood assessment relates directly to the species likelihood of occurrence on the Knapdale Range, not within 25 km of the Knapdale Range. Mobile fauna species which could occur on the Knapdale Range but are unlikely to represent a permanent population or a population relying on the site for long-term viability (vagrants) are assessed as 'Transient'.

Scientific Name Common Name	STATUS		Typical Habitat	Habitat at Knapdale Range	Local Records	Likelihood Assessment
	NCA	EPBC				
FISH						
Pristis pristis Freshwater Sawfish	LC	Vul	Channels of large freshwater rivers with permanent water	None present	No records within 25km of the Knapdale Range	Will not occur
REPTILES						
Acanthophis hawkei Plains Death Adder	Vul	Vul	Cracking soils on treeless floodplains across northern Australia	None present	No records within 25km of the Knapdale Range	Will not occur
Elseya lavarackorum Gulf Snapping Turtle	Vul	End	Deep, permanent pools of the Gregory and Nicholson River systems	None present	No records within 25km of the Knapdale Range	Will not occur
Varanus mertensi Mertens' Water Monitor	End		Freshwater bodies such as rivers, swamps and rocky waterholes, with overhanging trees and large rocks for basking	None present. Known suitable habitat exists on the Dugald River ~5km E.	Recorded during surveys at Longamundi on the Dugald River	Will not occur
AVES (birds)						

Scientific Name Common Name	STATUS		Typical Habitat	Habitat at Knapdale Range	Local Records	Likelihood Assessment
	NCA	EPBC				
Amytornis dorothaea Carpentarian Grasswren	End	End	Long-unburnt open woodland or grassland dominated by hummock grass (*Triodia* spp.) on stony soils or, in the north of its distribution, rocky outcrops. Appears to preference large, dense, mature clumps of hummock grass rather than small, sparse clumps.	None present. While visually suitable, the species preferred *Triodia longiceps* is not present and habitat is not representative of the species' typical habitat in the south of its range (i.e. stony, skeletal soils on valley floors).	No records within 25km of the Knapdale Range, nor within 10 y of survey effort	Will not occur
Calidris ferruginea Curlew Sandpiper	End	Cr End	Saline and freshwater wetlands, saltmarshes, estuaries, mudflats. Prefers areas with exposed mud for foraging.	None present	No records within 25km of the Knapdale Range. Only very rarely recorded in the broader region, most records associated with Lake Moondarra near Mount Isa	Will not occur
Erythrotriorchis radiatus Red Goshawk	End	Vul	Open forests, woodlands, wetlands, rainforest fringes, particularly along watercourses with large trees suitable for nesting	None suitable. Potential habitat may be present on the Dugald River.	No records within 25km of the Knapdale Range. Sparse regional records, almost always in association with major waterways, but all very old or undated, typically with poor spatial resolution.	Will not occur

Scientific Name Common Name	STATUS		Typical Habitat	Habitat at Knapdale Range	Local Records	Likelihood Assessment
	NCA	EPBC				
Erythrura gouldiae Gouldian Finch	End	End	Grassy *Eucalyptus* woodland close to water. Native grasses form important foraging habitat, and hollow-bearing eucalypts are used for breeding.	The entire Knapdale Range theoretically provides suitable foraging, breeding and watering habitat; however, most waterholes are ephemeral and hollow-bearing trees are relatively sparse. Large, persistent waterholes on the Dugald River (e.g., Longamundi), probably provide the most likely habitat for any vagrant birds.	No records within 25km of Knapdale Range. All QLD records have been subject to coordinate rounding, and the majority are undated. The most reliable recent records are >10y old from Chidna Station, near Gunpowder ~125km northwest of the Knapdale Range.	Will not occur
Falco hypoleucos Grey Falcon	NT	-	Lightly treed inland plains, gibber deserts, pastoral lands	Potential to occur across the entire Knapdale Range; however, the Range is more heavily treed, has more topographical relief, and is less arid than those habitats in which the species is typically recorded.	No records within 25km of the Knapdale Range. Many records undated, nearest recent record from 2019 near Cloncurry; however, other *Falco* species are often be confused by inexperienced observers for *F. hypoleucos* and records by inexperienced observers and/or without photographic evidence should be treated as circumspect.	Transient

Scientific Name Common Name	STATUS		Typical Habitat	Habitat at Knapdale Range	Local Records	Likelihood Assessment
	NCA	EPBC				
Grantiella picta Painted Honeyeater	Vul	Vul	Found mainly in dry open woodlands and forests, particularly box-ironbark woodlands. It may also occur in riparian forest, on plains with scattered eucalypts and in remnant trees on farmland and their occurrence is strongly associated with mistletoe.	Sparse trees with collared mistletoe (*Lysiana spathulata*), but these are scarce and neither *L. spathulate* nor its host trees are reported as being known habitat values for Painted Honeyeater	A single record from 2012 at Quamby Rodeo Grounds ~20km southeast. More distant records in the region are sparse and mostly >10y old, suggesting the species does not occur with any regularity in the broader region.	Unlikely
Numenius madagascariensis Eastern Curlew	End	Cr End	Coastal and intertidal zone	None present	No records within 25km of the Knapdale Range.	Will not occur
Plegadis falcinellus Glossy Ibis	SLC	Mig	Natural and artificial freshwater waterbodies including lakes, rivers, swamps, sewage ponds and irrigated crop fields. Can also occur on coastal water bodies e.g., estuaries, deltas and lagoons	TSF provided wading habitat in 2021 on beached tailings. Tailings were unlikely to support foraging resources and have since been inundated. It is highly unlikely that this area continues to provide habitat amenity.	A single record from the TSF dam in 2021 on beached tailings.	Present (Unlikely post-2021)
Pezoporus occidentalis Night Parrot	End	End	Relatively poorly understood, generally considered to favour spinifex grassland and chenopod shrubland on sandy or skeletal soils. In QLD known from breakaway habitats in and around Diamantina NP and Pullen Pullen Nature Refuge	Unlikely to be any present. Spinifex abounds but species is not known from rocky range country.	No records within 25km of the Knapdale Range. Nearest records from Diamantina NP and Pullen Pullen Nature Refuge >350km south.	Will not occur

Scientific Name Common Name	STATUS		Typical Habitat	Habitat at Knapdale Range	Local Records	Likelihood Assessment
	NCA	EPBC				
Rostratula australis Australian Painted Snipe	Vul	End	Found in a wide range of habitats including ephemeral swamps, dams, rice paddocks, waterlogged grasslands, roadside drains and even brackish waterways (Marchant and Higgins 1993).	None present	No records within 25km of the Knapdale Range	Will not occur
MAMMALS						
Macroderma gigas Ghost Bat	End	Vul	Habitats used for foraging vary from dry open woodlands to tropical rainforests (Wilmer 2012). Caves, rock crevices and old mines are used for roosting.	Two known abandoned mines within close proximity to the Range, and two known bat roosts in narrow caves. All locations are known to be inhabited by other microchiropterans, notably *Taphozous* spp.	No records within 25km of the Knapdale Range. Very sparse regional records, all >10y, most much older. Cluster of records associated with Camooweal Caves, and most recent regional record from 2011 just south of Chidna Station, ~125km northwest of the Knapdale Range. Species is likely regionally extinct.	Will not occur
Macrotis lagotis Greater Bilby	Vul	End	Soils which can be excavated for deep burrows. Largely confined to inland sandy deserts in NT and WA, with a restricted distribution in QLD on clay and stony soils in the Channel Country.	None present. Soils are skeletal and rocky, not suited to excavation.	No records within 25km of Knapdale Range	Will not occur
Petrogale purpureicollis Purple-necked Rock-wallaby	Vul	-	Massive rocky landforms, especially boulder piles, cliffs and gorges, with abundant caves and overhangs for daylight sheltering.	All large rocky outcrops, especially cliffs and rocky gullies dropping off the edge of the Range	Recorded annually during surveys at multiple known, monitored locations across the Knapdale Range	Present

Scientific Name Common Name	STATUS		Typical Habitat	Habitat at Knapdale Range	Local Records	Likelihood Assessment
	NCA	EPBC				
Sminthopsis douglasi Julia Creek Dunnart	End	Vul	Restricted to blacksoil clays with deep, wide cracks in Mitchell grass (*Astrebla* spp.) grasslands	None present	No records with 25km of the Knapdale Range	Will not occur
Tachyglossus aculeatus Short-beaked Echidna	SLC	-	Occurs in almost all terrestrial habitats except intensively managed farms.	Entire Knapdale Range	Regularly recorded on the Knapdale Range on survey cameras and during foot traverses	Present

Appendix E: Vegetation and landscape descriptions of impact (IMP) and control (CNT) BBUS survey sites

Vegetation and landscape descriptions of impact (IMP) and control (CNT) BBUS survey sites. Crown cover percentage and height range of trees and shrubs and percent cover of the ground stratum is given in parentheses after species list. Relevant notes pertaining to each site is given in square brackets after the description. Regional Ecosystem (RE) is provided based on the recorded description and comparison with technical descriptions in Kelman (2019).

<table>
<tr><th>Site</th><th>Description</th><th>RE</th></tr>
<tr><td>BBUS-IMP01</td><td>Open woodland of Corymbia capricornia/terminalis and occasional Eucalyptus leucophloia (25%, 3–5m) with Acacia monticola and sparse A. holosericea, Grevillea dryandri and Dodonaea dodecandra shrubs (30%, 0.5–3m) and Triodia pungens ground cover (90%) on rocky hill.
<table>
<tr><th>North</th><th>East</th><th>South</th><th>West</th></tr>
<tr><td>  </td><td>  </td><td>  </td><td>  </td></tr>
</table></td><td>1.11.2a</td></tr>
<tr><td>BBUS-IMP02</td><td>Open woodland of Eucalyptus leucophloia and occasional Corymbia capricornia/terminalis (15%, 4–5m) with Acacia monticola and sparse Santalum lanceolatum, Grevillea dryandri and A. gonoclada shrubs (25%, 1–2m) and Triodia pungens ground cover (80%) on rocky hill.
<table>
<tr><th>North</th><th>East</th><th>South</th><th>West</th></tr>
<tr><td>  </td><td>  </td><td>  </td><td>  </td></tr>
</table></td><td>1.11.2a</td></tr>
</table>

<table>
<tr><th>Site</th><th>Description</th><th>RE</th></tr>
<tr><td>BBUS-IMP03</td><td>Open woodland of Corymbia capricornia/terminalis, Eucalyptus leucophloia and sparse Grevillea mimosoides (15%, 4–6m) with Acacia monticola, A. holosericea, Tephrosia sp. and Santalum lanceolatum shrubs (15%, 2–4m) and ground cover of Triodia pungens and Cassytha sp. (90%) with sparse Cymbopogon bombicynus and Trichodesma zeylanicum on rocky hill.
<table>
<tr><th>North</th><th>East</th><th>South</th><th>West</th></tr>
<tr><td>  </td><td>  </td><td>  </td><td>  </td></tr>
</table></td><td>1.11.2a</td></tr>
<tr><td>BBUS-IMP04</td><td>Open woodland of Corymbia capricornia/terminalis and occasional Eucalyptus leucophloia (15%, 4–6m) with Acacia monticola and sparse A. retivenea, Tephrosia sp. and A. asperulacea shrubs (35%, 0.5–3m) and Triodia pungens ground cover (80%) on rocky hill adjacent steep gorge. [Vegetation gives way to open woodland of E. leucophloia, A. retivenea and T. pungens just south of turbine pad.]
<table>
<tr><th>North</th><th>East</th><th>South</th><th>West</th></tr>
<tr><td>  </td><td>  </td><td>  </td><td>  </td></tr>
</table></td><td>1.11.2a</td></tr>
</table>

<table>
<tr><th>Site</th><th colspan="4">Description</th><th>RE</th></tr>
<tr><td rowspan="3">BBUS-CNT01</td><td colspan="4">Open woodland of Corymbia capricornia/terminalis (10%, 4–5m) with Acacia monticola, A. retivenea and sparse Eremophila latrobei, Tephrosia sp., Grevillea dryandra and A. asperulacea shrubs (20%, 0.5–3m) and Triodia pungens ground cover (75%) on rocky hill.</td><td rowspan="3">1.11.2a</td></tr>
<tr><td>North</td><td>East</td><td>South</td><td>West</td></tr>
<tr><td>  </td><td>  </td><td>  </td><td>  </td></tr>
<tr><td rowspan="3">BBUS-CNT02</td><td colspan="4">Open Corymbia capricornia/terminalis woodland (10%, 2–4m) with Acacia monticola, Dodonaea dodecandra, Eremophila latrobei, Grevillea dryandri and sparse A. retivenea and Santalum lanceolatum shrubs (60%, 0.5–3m) and Triodia pungens ground cover (75%) on rocky hill.</td><td rowspan="3">1.11.2a</td></tr>
<tr><td>North</td><td>East</td><td>South</td><td>West</td></tr>
<tr><td>  </td><td>  </td><td>  </td><td>  </td></tr>
<tr><td rowspan="3">BBUS-CNT03</td><td colspan="4">Open woodland of Eucalyptus leucophloia (15%, 4–6m) with Acacia retivenea and Tephrosia sp. shrubs (5%, 1–2m) and Triodia pungens ground cover (90%) on rocky hill. [A. monticola dominates shrub layer on slopes just east of turbine pad.]</td><td rowspan="3">1.11.2a</td></tr>
<tr><td>North</td><td>East</td><td>South</td><td>West</td></tr>
<tr><td>  </td><td>  </td><td>  </td><td>  </td></tr>
</table>

<table>
<tr><th>Site</th><th>Description</th><th>RE</th></tr>
<tr><td rowspan="3">BBUS-CNT04</td><td colspan="3">Open woodland of Eucalyptus leucophloia (30%, 4–5m) with Acacia retivenea and Crotalaria sp. shrubs (15%, 1-3m) and Triodia pungens ground cover (80%) on rocky ridge. [Tephrosia sp. occurs in nearby gully, Acacia monticola joins shrub/tree strata on eastern slope of ridge.]</td><td rowspan="3">1.11.2a</td></tr>
<tr><td>North</td><td>East</td><td>South</td><td>West</td></tr>
<tr><td>  </td><td>  </td><td>  </td><td>  </td></tr>
</table>

APPENDIX I: AARC Flora and Fauna Report






Dugald River Project

Terrestrial Flora and Fauna Assessment

Prepared for:
MMG Australia Limited

July 2011

AustralAsian Resource Consultants

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LIST OF ABBREVIATIONS

°C	-	degrees Celsius
AARC	-	AustralAsian Resource Consultants Pty Ltd
DEEDI	-	Department of Employment, Economic Development and Innovation
DERM	-	Department of Environment and Resource Management
EPBC Act	-	*Environment Protection and Biodiversity Conservation Act 1999*
ERE	-	Endangered Regional Ecosystem
ESA	-	Environmentally Sensitive Area
ha	-	hectares
km	-	kilometres
LP Act	-	*Land Protection (Pest and Stock Route Management) Act 2002*

m	-	metres
MLA	-	Mining Lease Application
mm	-	millimetres
MMG	-	MMG Australia Limited
Mt	-	Million tonnes
NC Act	-	*Nature Conservation Act 1992*
NCWR	-	*Nature Conservation (Wildlife) Regulation 2006*
NSW	-	New South Wales
QGEOP	-	*Queensland Government Environmental Offsets Policy*
RE	-	Regional Ecosystem
REDD	-	Regional Ecosystem Description Database
TSF	-	Tailings Storage Facility
VM Act	-	*Vegetation Management Act 1999*
VMR	-	*Vegetation Management Regulation 2000*
WoNS	-	Weed of National Significance

EXECUTIVE SUMMARY

AustralAsian Resource Consultants Pty Ltd was commissioned by the MMG Australia Limited to conduct a Terrestrial and Aquatic Flora and Fauna Assessment for the proposed Dugald River Project site. The survey also included environmental assessment of three infrastructure corridors associated with the Project: the powerline, access road and water pipeline.

A total of five surveys were conducted on the Project site and associated corridors. The initial wet season survey was undertaken over nine consecutive days between the 27th of March and the 4th of April 2008. The dry season survey and an initial assessment of the corridors was undertaken over ten consecutive days between the 4th and 13th of August 2008. An additional three day assessment of the powerline corridor was conducted from the 1st to the 3rd of October 2008. A three day assessment of modifications to the alignment of the water pipeline corridor and access road corridor was conducted from the 7th to 9th of April 2010. An additional wet season survey occurred between 21st to 31st of March 2011, to capture additional ephemeral floral species and supplement the existing fauna catalogue from previous surveys.

To assess the environmental values of flora and fauna communities on the Project site and corridors, AARC undertook the following scope of works:

- A literature and database review to identify species of conservation significance known from the region. This enabled these species to be targeted during the field survey components of the study;
- Standard field survey methodologies to determine the composition of species inhabiting the Project site and corridors, particularly species of conservation significance; and
- Preparation of a report describing significant ecological factors and outlining possible management strategies to reduce any foreseeable impacts associated with the proposed activities.

SITE DESCRIPTION

The Project site is located approximately 85 kilometres north-east of Mount Isa and 65 kilometres north-west of Cloncurry, in north-western Queensland. The Project is located adjacent to the proposed Roseby Copper Project.

MMG Australia Limited is proposing to develop a zinc/lead and copper mining and processing operation at the Project site. The Dugald River Project will process approximately 2 million tonnes of zinc/lead ore per year, and an additional 1 million tonnes of copper ore per year. Mining will be conducted using underground techniques with portals near the proposed ore processing plant.

FIELD SURVEY METHODS

Scoping of the Project site and corridors was conducted using aerial photography and broad ground-truthing using four-wheel drive vehicles and where terrain proved impassable, on-foot. Site scoping also allowed for the identification of boundaries of Regional Ecosystems, so that mapping of the Regional Ecosystems could be produced.

A number of Secondary transects were surveyed to obtain a detailed floristic inventory of the dominant and associated woody plants within each vegetation type. In order to map and confirm the extent of the vegetation communities, Quaternary plots were used along the boundaries of the

communities. The quality of communities was assessed with regard to their likely value and viability as a representative vegetation type.

Primary fauna transects and additional secondary sites were located in areas representative of the Project"s vegetation types and habitat types. In addition, habitats potentially inhabited by species of conservation significance were targeted and thoroughly assessed for species occurrence. A range of trapping and survey techniques were employed at each study site including but not limited to pitfall trapping, Elliottt trapping, funnel trapping, harp trapping, habitat searching, avian observation, ANABAT recording and spotlighting. Incidental/opportunistic records were included in the species list to produce a comprehensive fauna species list for the Project site and corridors.

SURVEY RESULTS – PROJECT SITE

Flora

In summary, eight vegetation communities comprise the Project site with a total of 222 flora species identified. No flora species identified are of conservation significance and 17 species are introduced.

All eight vegetation communities were classed as Remnant Vegetation as defined in the *Queensland Vegetation Management Act 1999*. A summary of the conservation significance of all distinct vegetation communities occurring on the Project site and their equivalent Regional Ecosystems is provided in the table below.

Summary of the Conservation Significance of Vegetation Communities – Project site

Vegetation Community	Regional Ecosystem Equivalents	Environment Protection and Biodiversity Conservation Act 1999 Status	Queensland Vegetation Regulation 2000	Department of Environment and Resource Management Biodiversity Status
Snappy Gum Open Woodland on steep hills and strike ridges	1.11.2a	Not Listed	Least Concern	No Concern at Present
Snappy Gum Open Woodland on foothills	1.11.2e	Not Listed	Least Concern	No Concern at Present
Cloncurry Box Open Woodland on low broad hills	1.11.3a	Not Listed	Least Concern	No Concern at Present
Cloncurry Box Open Woodland on hills	1.11.3x1	Not Listed	Least Concern	No Concern at Present
Mixed Bloodwood Riparian Woodland	1.3.6b	Not Listed	Least Concern	Of Concern
River Red Gum Riparian Woodland	1.3.7b	Not Listed	Least Concern	Endangered
Gidgee Open Woodland	1.11.2x2	Not Listed	Least Concern	No Concern at Present

Silver Box/ Cloncurry Box Open Woodland on red earths	1.5.4x3	Not Listed	Least Concern	Of Concern

One vegetation community on the Project site (1.3.7b – River Red Gum Riparian Woodland) is listed as „Endangered" under the *Department of Environment and Resource Management Biodiversity Status* due to severe degradation and high grazing pressure. The overall condition of this community on the Project site is reduced by cattle grazing and weed invasion, in particularly alteration of groundcover by a dominant Buffel Grass (*Pennisetum ciliare*). Based on proposed disturbance plans for the Project and current infrastructure, an additional area of 16.72 ha will necessitate clearing of this community.

The Silver Box/Cloncurry Box Open Woodland (1.5.4x3) is listed as „Of Concern" under the *Department of Environment and Resource Management Biodiversity Status* due to high grazing pressure and weed invasion. The overall condition of this community within the Project site is relatively healthy, with little invasion of introduced species. Based on proposed disturbance plans for the Project, 23.57 ha will be cleared within this community.

The Mixed Bloodwood Riparian Woodland (1.3.6b) is listed as „Of Concern" under the *Department of Environment and Resource Management Biodiversity Status* due to high grazing pressure, changed fire regimes and weed invasion. Based on the proposed plans for the Project no clearing is required. Assuming mitigation strategies are implemented, and disturbance is minimised, the community is unlikely to be significantly impacted at a regional scale.

Fauna

A combined total of 113 vertebrate fauna species were identified on the Project site during the flora and fauna assessment, comprising 16 reptiles, 65 birds, 26 mammals and 6 amphibians.

Three bird species listed as Migratory and/or Marine under the *Environment Protection and Biodiversity Conservation Act 1999* were observed on the Project site, the Whistling Kite (*Haliastur sphenurus*), Rainbow Bee-eater (*Merops ornatus*) and Sacred Kingfisher (*Todiramphus sanctus*). Although common throughout their respective ranges within Australia, they are protected under international agreements incorporated by the *Environment Protection and Biodiversity Conservation Act 1999*. The distribution of each listed species identified is widespread throughout northern and eastern Australia, and the local populations on the Project site are unlikely to constitute an „ecologically significant proportion" of the total population of these species. Furthermore, the Project site is not at the limit of these species" range, nor are these species considered to be declining within the region. Therefore, it is unlikely the Project will have a significant impact on the regional populations of these species. Mining activities involved with the Project are not expected to have a significant impact on matters of national environmental significance.

The Purple-necked Rock-wallaby (*Petrogale purpureicollis*) was identified along the Knapdale Range within the Project site. This species is listed as „Vulnerable" under the Nature Conservation (Wildlife) Regulation 2006.

Four introduced species were identified on the Project site including the House Mouse (*Mus musculus*), Feral Cat (*Felis catus*), Feral Pig (*Sus scrofa*) and Dingo (*Canis familiaris dingo*), the latter three of which are declared as Class 2 pests under the *Land Protection (Pest and Stock Route Management) Act 2002*.

SURVEY RESULTS – POWERLINE CORRIDOR

The Minerals and Metals Group propose to construct a powerline from the Project site to Chumvale Substation, which is located approximately 10 kilometres west of Cloncurry on the Barkly Highway. The powerline corridor will be approximately 60 kilometres in length and a width of 400 metres was surveyed along the corridor.

Six vegetation communities inhabit the powerline corridor. Communities are listed and described in the table below, each with their corresponding conservation status.

Vegetation Communities and Corresponding Conservation Status within the Powerline Corridor

Vegetation Community / Regional Ecosystem	Environment Protection and Biodiversity Conservation Act 1999 Status	Queensland Vegetation Management Regulation 2000	Department of Environment and Resource Management Biodiversity Status
Snappy Gum Open Woodland / 1.11.2a	Not Listed	Least Concern	No Concern at Present
Cloncurry Box Open Woodland / 1.11.3x1	Not Listed	Least Concern	No Concern at Present
River Red Gum Riparian Woodland / 1.3.7a / 1.3.7b	Not Listed	Least Concern	Endangered
Gidgee Open Woodland / 1.11.2x2	Not Listed	Least Concern	No Concern at Present
Mixed Bloodwood Riparian Woodland / 1.3.6b	Not Listed	Least Concern	Of Concern
Non-remnant Grassland	Not Listed	Not Listed	Not Listed

Based on proposed disturbance plans for the Project it is estimated that clearing will be required within all vegetation communities identified. The *Policy for Vegetation Management Offsets* can be applied to the River Red Gum Riparian Woodland however assuming appropriate mitigation measures are implemented it is unlikely the Project will adversely affect the health or abundance of this community. It is unlikely that disturbance within the powerline corridor will significantly impact on the regional occurrence of the other five vegetation communities.

Two features of conservation significance inhabit the powerline corridor. These include:

- River Red Gum riparian community (1.3.7a); and
- Rocky outcrops containing Purple-necked Rock-wallaby (*Petrogale purpureicollis*) habitat.

Seven River Red Gum Riparian Woodland creek crossings were identified within the powerline corridor. The River Red Gum riparian community is listed as „Endangered" under the *Department of Environment and Resource Management Biodiversity Status*. This community is considered the most diverse within the local area of the Project site and helps maintain the environmental integrity of

watercourses in the region. The estimated area of vegetation disturbance from construction of the powerline within the River Red Gum riparian community, assuming a footprint width of 80 m, is approximately 23 ha.

Six rocky outcrops that could potentially provide Purple-necked Rock-wallaby (*Petrogale purpureicollis*) habitat were identified within the powerline corridor. The Purple-necked Rock-wallaby (*Petrogale purpureicollis*), listed as Vulnerable under Schedule 3 of the *Nature Conservation (Wildlife) Regulation 2006* but not listed under the *Environment Protection and Biodiversity Conservation Act 1999,* was observed during the powerline corridor survey at two rocky outcrops and potential habitat and/or foraging sites were observed at most other rocky outcrop locations.

Six introduced flora species were identified within two areas of the powerline corridor. Species identified included Mimosa Bush (*Acacia farnesiana*), Kapok Bush (*Aerva javanica*), Calotrope (*Calotropis procera*), Buffel Grass (*Pennisetum ciliare*), Colocynth (*Citrullus colocynthis*) and Downy Thornapple (*Datura inoxia*). Although none of these species are listed under the *Land Protection (Pest and Stock Route Management) Act 2002*, many of these species establish rapidly and out-compete existing native plants.

SURVEY RESULTS – WATER PIPELINE CORRIDOR

The water pipeline route commences at the T-intersection of the Ernest Henry / Lake Julius Pipeline and travels south and then west to the proposed process plant area within Project site. The corridor is approximately 10 kilometres long and a corridor width of 40 metres was surveyed.

Four vegetation communities are present along the water pipeline corridor. Communities are listed and described in the table below, each with their corresponding conservation status.

Vegetation Communities on the Water Pipeline Corridor

Vegetation Community / Regional Ecosystem	Environment Protection and Biodiversity Conservation Act 1999 Status	Queensland Vegetation Management Regulation 2000	Department of Environment and Resource Management Biodiversity Status
Snappy Gum Open Woodland / 1.11.2a	Not Listed	Least Concern	No Concern at Present
Cloncurry Box Open Woodland / 1.3.11x1	Not Listed	Least Concern	No Concern at Present
Snappy Gum / Cloncurry Box Open Woodland / 1.11.2e	Not Listed	Least Concern	No Concern at Present
Mixed Bloodwood Riparian Woodland / 1.3.6b	Not Listed	Least Concern	Of Concern

Based on proposed disturbance plans for the Project, clearing will be required within all vegetation communities.

The Mixed Bloodwood Riparian Woodland is listed as Of Concern" under the *Department of Environment and Resource Management Biodiversity Status.* Although minor clearing will be required within this community it is unlikely the Project will affect the health or abundance this community at a

regional scale, if appropriate control strategies are implemented. It is unlikely that disturbance within the water pipeline corridor will significantly impact on the regional occurrence of the other three vegetation communities.

One rocky outcrop is located within the water pipeline corridor. A few small crevices are present in this rock system however the site was considered of low rock-wallaby habitat value. Furthermore no marsupial scats were present at the outcrop indicating the Purple-necked Rock-wallaby (*Petrogale purpureicollis*) does not reside at the location.

SURVEY RESULTS – ACCESS ROUTE

The access route corridor is approximately 10 kilometres long and follows along an existing track for the majority of the length. An alternate access road and a temporary access road deviation were also surveyed. A 50 metre corridor was surveyed along all proposed access routes and deviations.

A total of five vegetation communities inhabit the access route corridor area. These communities and their corresponding conservation status are detailed in the table below.

Vegetation Communities on the Access Route Corridor

Vegetation Community / Regional Ecosystem	Environment Protection and Biodiversity Conservation Act 1999 Status	Queensland Vegetation Management Regulation 2000	Department of Environment and Resource Management Biodiversity Status
Snappy Gum Open Woodland / 1.5.3	Not Listed	Least Concern	No Concern at Present
Cloncurry Box Open Woodland / 1.3.11x1	Not Listed	Least Concern	No Concern at Present
River Red Gum Riparian Woodland / 1.3.7a / 1.3.7b	Not Listed	Least Concern	Endangered
Gidgee Open Woodland / 1.11.2x2	Not Listed	Least Concern	No Concern at Present
Mixed Bloodwood Riparian Woodland / 1.3.6b	Not Listed	Least Concern	Of Concern

Based on proposed disturbance plans for the Project, clearing will be required within the Snappy Gum Open Woodland, Cloncurry Box Open Woodland, Gidgee Open Woodland and Mixed Bloodwood Riparian Woodland communities. It is unlikely disturbance within the access route corridor will significantly impact on the regional occurrence of these communities.

Three major River Red Gum Riparian Woodland (RE 1.3.7) creek crossings exist within the access route corridor. Four minor creek crossings are present along the alternate access road and temporary access road deviation.

Although communities of conservation significance are present, no individual flora or fauna species of conservation significance occur. No weeds classified under the *Land Protection (Pest and Stock Route Management) Act 2002* inhabit the access route corridor.

POTENTIAL ENVIRONMENTAL IMPACTS

A range of potential impacts on nature conservation values may occur as a result of the Project. These include:

- Land clearing will reduce the current extent of vegetation communities and associated faunal habitats;
- Fauna injury or death may occur during the Project;
- Additional noise from mine operations may disturb fauna;
- Loss of vegetation may cause fragmentation or loss of individual species" local population;
- Loss of habitat may result in a loss of biological diversity;
- Land clearing and mineral processing activities associated with the Project may increase soil erosion, inadvertently causing silting, sedimentation or contamination of riverine habitats and waterholes downstream;
- An increase of pest fauna species identified as utilising the Project site may occur; and
- The introduction of additional weed species and spread of weeds on the Project site.

MANAGEMENT RECOMMENDATIONS

After assessment of terrestrial and aquatic flora and fauna desktop and field data, it has been determined that there is no significant impediment, in regards to terrestrial flora and fauna, to the development of the Dugald River Project. The following mitigation strategies are recommended to reduce the potential environmental impacts of the proposed activities.

Mitigation strategies for the Project site and associated corridors may include, but are not limited to:

- Avoid environmental impacts through appropriate design and planning of Project infrastructure and layout;
- In recognition of the intrinsic value of native vegetation, every effort should be made to keep proposed disturbance areas to a minimum;
- To maintain the integrity of vegetated land that is not cleared, appropriate erosion and sediment controls are recommended to prevent sediment deposition in remaining habitat.
- The River Red Gum Riparian Woodland community (1.3.7a and 1.3.7b) should be managed using relevant strategies suggested in the Queensland Government Environmental Offsets Policy and Policy for Vegetation Management Offsets;
- Rocky outcrops that could provide potential Purple-necked Rock-wallaby (*Petrogale purpureicollis*) should be avoided and a 150 m buffer should be implemented around these sites;
- Native vegetation removal should be conducted only after:

  - the areas to be cleared have been clearly delineated and identified to equipment operators and supervisors; and

  - Appropriate erosion and sediment control structures are in place.

- It is recommended that the methodologies for the rehabilitation/re-vegetation works for the Project use the most appropriate species for the landscape elements of the site. Such methodologies should include habitat matching of species to ensure rehabilitation success.

- It is recommended that recreated landforms are contoured to resemble the original local topography, and include hill slopes and rocky drainage lines;

- A segment of the Staff Induction Program should be allocated to informing staff of the conservation values on the Project site to increase staff awareness of the species present. This could include photographs, brief descriptions and management requirements of native species; and

- A rehabilitation strategy should be developed for the Project site. This strategy should embody the concepts and recommendations presented above and include provision for monitoring of rehabilitation progress over the life of the operation.

Additional specific mitigation strategies should be applied to features of conservation and management significance, including the River Red Gum Riparian Woodland (RE 1.3.7a and RE 1.3.7b) community, rocky outcrops that provide potential habitat for the Purple-necked Rock-wallaby (*Petrogale purpureicollis*), and introduced pest and weed species.

1.0 INTRODUCTION

AustralAsian Resource Consultants Pty Ltd (AARC) was commissioned by MMG Australia Limited (MMG) to conduct a Terrestrial Flora and Fauna Assessment for the proposed Dugald River Project (the Project site). The assessment also included an environmental assessment of three infrastructure corridors associated with the Project: the powerline, access road and water pipeline.

1.1 SCOPE OF STUDY

To assess the environmental values of flora and fauna communities on the Project site, AARC undertook the following scope of works:

- A literature and database review to identify species of conservation significance known from the region. This enabled these species to be targeted during the field survey components of the study;
- Standard field survey methodologies to determine the composition of dry season and wet season flora and fauna species inhabiting the Project site, particularly species of conservation significance[1]; and
- Preparation of a report describing significant ecological factors and outlining possible management strategies to reduce any foreseeable impacts associated with the proposed activities.

[1] References to "species of conservation significance" or "threatened species" refer to those species listed as extinct in the wild, endangered, vulnerable or near threatened under the *Nature Conservation (Wildlife) Regulation 2006* (Qld) or extinct, extinct in the wild, critically endangered, endangered, vulnerable or conservation dependent under the *Environment Protection and Biodiversity Conservation Act 1999* (Cth).

2.0 PROJECT AND SITE DESCRIPTION

2.1 PROJECT LOCATION

The Project is located approximately 85 kilometres (km) north-east of Mount Isa and 65 km north-west of Cloncurry (Figure 1), in north-western Queensland. The Project is located adjacent to the proposed Roseby Copper Project.

2.2 PROJECT LAYOUT

MMG is proposing to develop a zinc/lead and copper mining and processing operation at the Project site. The Project will process approximately 2 million tonnes (Mt) of zinc/lead ore per year, and an additional 1 Mt of copper ore per year. Mining will be conducted using underground techniques with portals near the proposed ore processing plant. The proposed Project infrastructure and pit layout is shown in Figure 2.

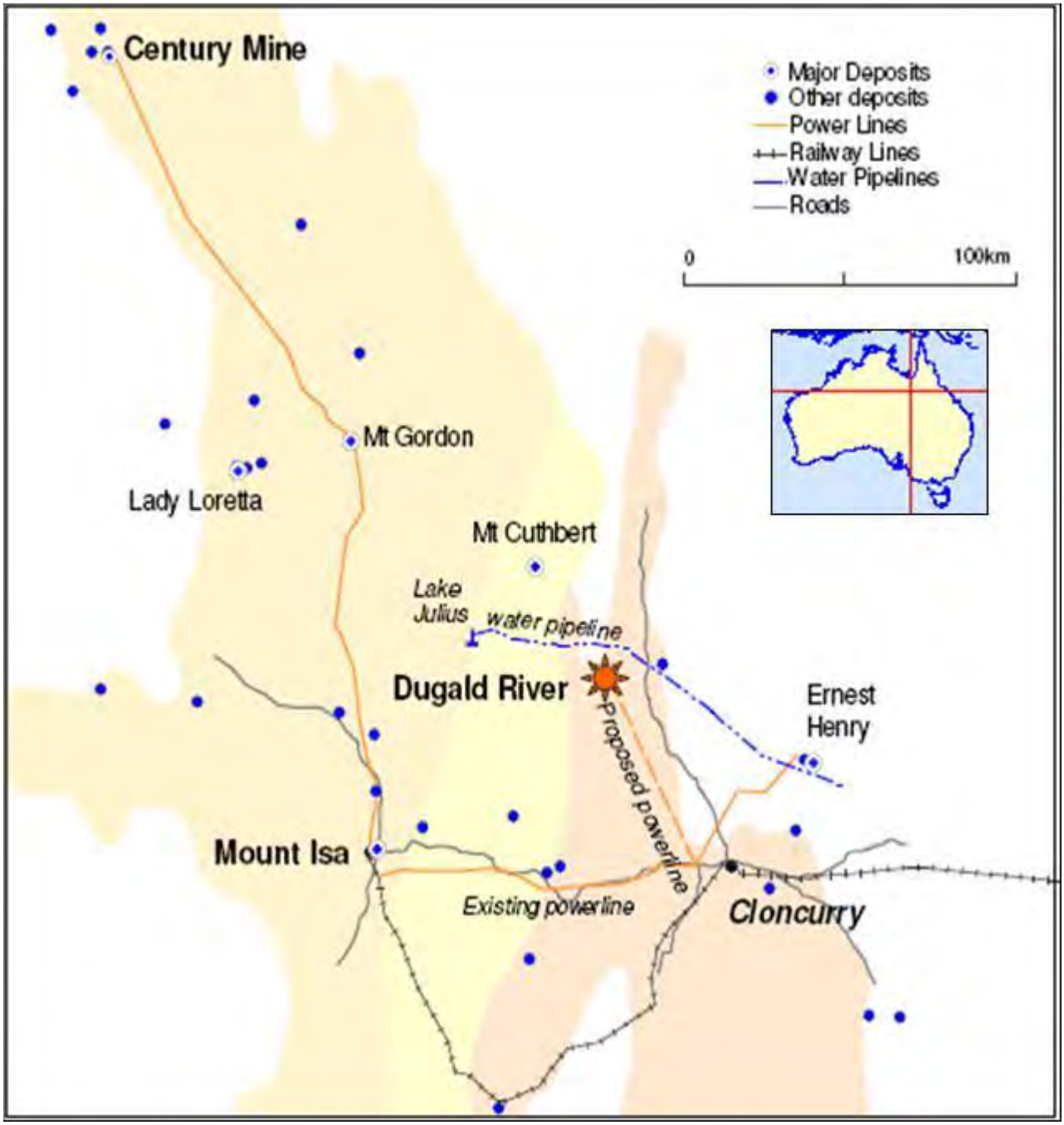


Figure 1 Project Location

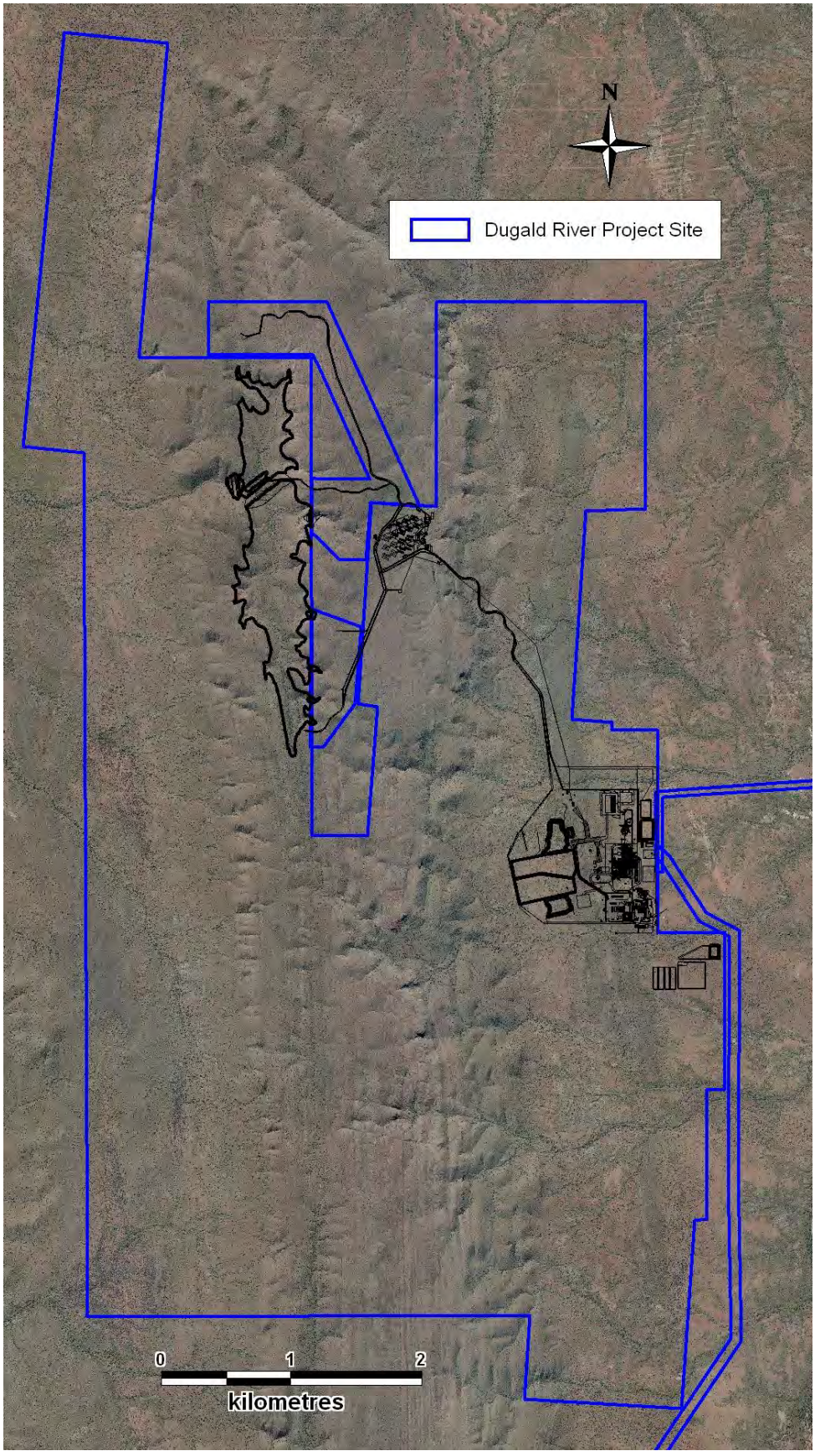


Figure 2 Dugald River Project site Infrastructure Layout

2.3 LOCAL WATERWAYS AND TOPOGRAPHY

There are no major watercourses on the Project site; however there are several minor, ephemeral tributaries which run through the site. Ephemeral watercourses on the eastern side of the site drain in an easterly direction to the Dugald River. On the western side of the Project, ephemeral creeks drain into Cabbage Tree Creek, which is a tributary of the Leichhardt River. Corella Creek is located south of the Project site, which traverses the proposed powerline corridor.

The Dugald River runs adjacent to the Project site and is a tributary of the Flinders River which flows 450 km north into the Gulf of Carpentaria. Water use downstream of the site primarily consists of stock watering.

The topography of the Project site is undulating with a dominant ridgeline (the Knapdale Range) running through the central portion of site in a north-south direction. The orebody is located on the east of this ridgeline; subsequently the proposed mining and processing activities are located to the east of this ridgeline, with only the proposed Tailings Storage Facility (TSF) located west of the ridgeline.

2.4 LOCAL GEOLOGY

The Project site is located in the transition zone between two major physiographic divisions, the Mount Isa highlands and the Carpentaria plains. Similarly, its bio-geographic location is near the boundary of the Gulf plains regions and the North West Highlands region.

The Dugald River deposit was discovered before 1881 and is an example of a stratabound base-metal deposit in a black shale environment. It forms part of a sedimentary basin within the Carpentarian Corella Formation (calc-silicate rocks). It strikes north-south and dips steeply to the west, with the grade of metamorphism low.

Two dominant and six minor ore types have been recognised. Oxidation is reported to be complete to 12 metres (m). The primary sulphides are pyrrhotite, pyrite, sphalerite, and galena, while at least four offshoots are thought to stem from the main lode. Sulphides are often seen as recrystallised bands and veins.

Sporadic copper mineralisation is observed and occurs as chalcopyrite mineralisation at the schist/calc-silicate - slate contact in the hanging wall of the Dugald zinc/lead/silver lode. Copper is also observed with mafic-intermediate porphyry dykes.

2.5 REGIONAL CLIMATE

Information from the Bureau of Meteorology website (www.bom.gov.au) was used to give mean annual maximum and minimum rainfall and temperatures for the Project region (based on data from the Cloncurry AERO weather station (in operation from 1939 – 1975) and the Cloncurry Airport weather station (operating since 1978).

The rainfall data shows that January and February exhibit the highest mean monthly rainfall, averaging 140.35 millimetres (mm) and 117.6 mm respectively. These months also experience the most rainy days, with more than eight rainy days per month. The driest month of the year is July, recording an average of just 3.45 mm with less than one day of rain for the month. A distinctive wet season (between November and April) is noted with very little rain falling in the remaining months of the year. The average annual rainfall for the region is 512.95 mm per year.

The mean annual maximum temperature is 32.8 degrees Celsius (ºC) with the hottest months November through to January (37 – 38.4 ºC). The mean annual minimum temperature is 18.6 ºC with the coolest months June through to August (10.4 – 12 ºC).

2.6 WEATHER CONDITIONS LEADING UP TO SURVEYS

Seasonal surveys are imperative for a methodical and scientifically valid ecological assessment. Complementing wet season and dry season surveys are conducted to ensure species which are migratory, transient or responsive to particular environmental conditions are captured, in addition to identifying seasonal variation in both species diversities and abundances. In AARC"s experience, survey timing is based on conceptual seasonal months. That is, they correspond to historic rainfall data and known weather patterns. Often however, the yearly weather cycle is more than wet and dry and includes the build-up period before the wet season that brings high humidity as moisture builds up in the air and post wet season as waterholes and creeks slowly dry up and dry winds strengthen. These transitional periods in combination with localised ecological response produce an environment that is continually adapting and adjusting. It is imperative that these periods be included, in combination with consideration to changing weather pattern behaviours when determining timing of wet and dry surveys as part of any seasonal flora and fauna assessment. The window of survey often needs to be adjusted to suit local conditions.

Survey timing for the Dugald River Project is considered to be scientifically sound and more than adequate to detect a comprehensive species list and highlight seasonal variation. Ecological variation is not strictly dictated by the black and white seasons suggested by textbook „wet" and „dry" labels. Survey timing falls within the Guidelines titled *Recommended Fauna Survey Methodology for Environmental Impact Assessments* (DERM, 2009) and *Guidelines for Flora Survey and Assessment in North Queensland (DERM*)

April 2008

Climate data abutting the (dry) 2008 survey describes average temperatures for January 2008 to be between 24.8^{o}C and 37.9^{o}C, with total rainfall equating 54 mm. February 2008 had higher temperatures accompanied with less rainfall, with the average temperature ranging between 25.4^{o}C to 38.5^{o}C and a total rainfall of 9.8 mm for the month.

The average rainfall in March 2008 was, however, substantially higher than previous months with 75.1mm of rain established beside average temperatures of 22.9^{o}C to 36.3^{o}C.

The recorded average rainfall in April 2008 was 22.1 mm with average temperatures ranging from 17.3^{o}C to 33.4^{o}C.

Average temperatures of 23.7^{o}C to 38.2^{o}C were recorded the week prior to the survey period (27th March to 4th of April) with data indicating total rainfall of 5.4 mm between the dates 20th of March through to 26th March 2008.

During the survey period (average) temperatures ranged from 19.1 ^{o}C to 32.8^{o}C and little rainfall was recorded between 27th March and 4th April 2008, with a total of 0.2 mm falling.

August 2008

The dry season survey of the Project site was conducted towards the end of the season (4th - 13th August 2008). Conditions were typical for the season, with a mean minimum temperature of 12.3 ºC

and a mean maximum of 28.7 ºC during the weeks leading up to the survey. No rain fell during the survey period, and a total of 19.4 mm fell during the 4 months prior to the survey.

March 2011

Climate data contiguous with the most recent (wet) survey, conducted between 21st to 31st March 2011, showed mean temperatures for January 2011 to be between 24.4°C to 36.6°C with total rainfall equating 71.2mm. Data pertaining to February 2011 showed average temperatures between 24.1°C to 34.5°C with rainfall reaching a total of 158.6 mm for the month.

Total rainfall again increased for the month of March 2011, when the survey was conducted, reaching a staggering 243 mm and returning average temperatures ranging from 22.5°C to 31.3°C.

A week prior to the survey period (14th to 20th March 2011) rainfall had subsided to a total of 6.6 mm with average temperatures ranging from 23.7°C to 33.4°C. During the survey period between 21st to 31st of March 2011, rainfall had decreased to 5 mm, allowing for the survey to proceed, and average temperatures ranged between 20.6°C to 31°C. Figure 3 indicates the intense rainfall that was experienced during February and March (2011) in comparison to previous years.

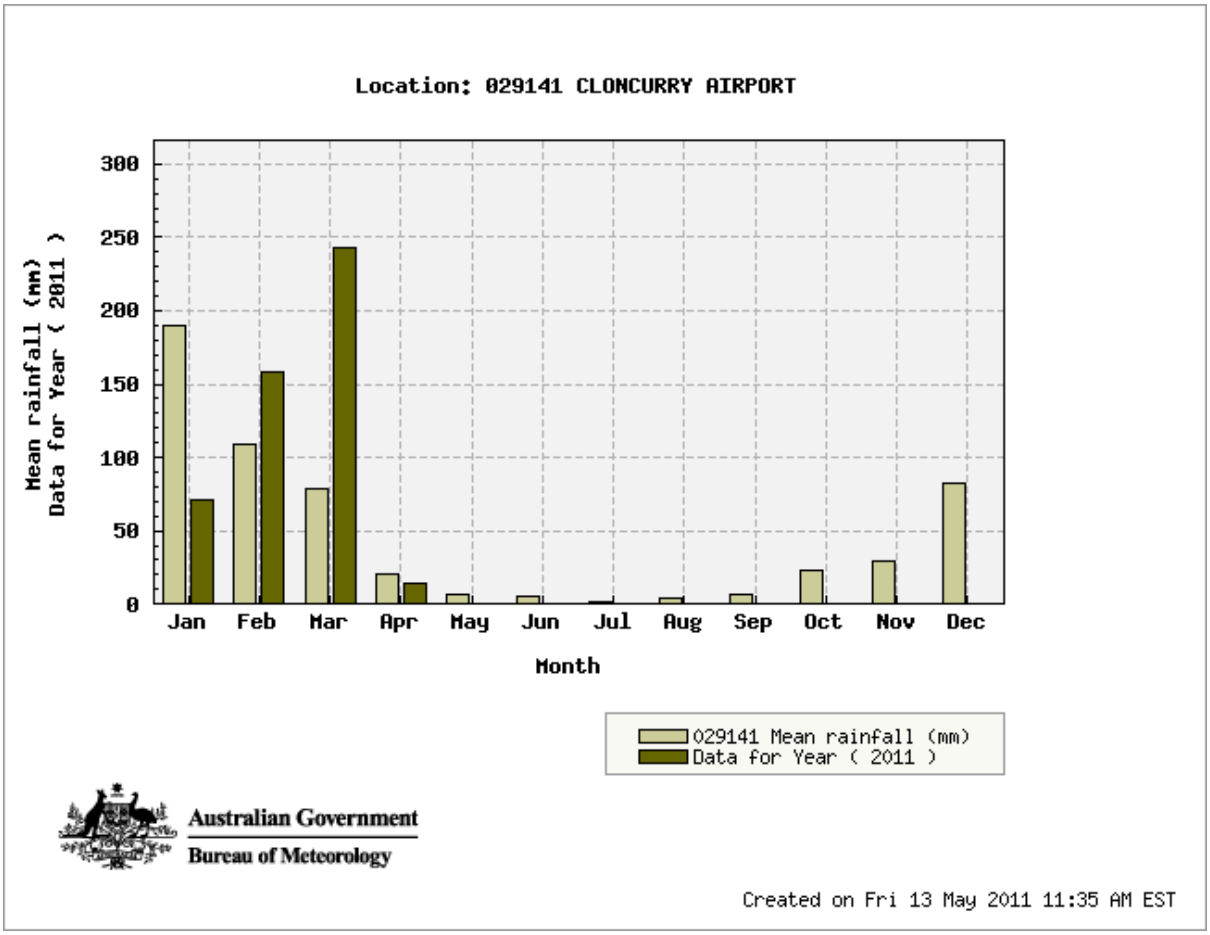


Figure 3 Comparison of long-term and recent (2011) rainfall data

2.7 CURRENT LAND USE

The predominant land use on the Project site is mineral exploration activities and low-intensity cattle grazing. Historically, mining activities and cattle grazing have dominated the land-use, evidence of

this is noted throughout the site, with cattle yards, feeding stations, muster assembly points and disused mine shafts obvious.

3.0 RELEVANT LEGISLATION AND POLICIES

Legislation relevant to the assessment of flora, fauna and biodiversity on the Project site and corridors is discussed below.

3.1 QUEENSLAND NATURE CONSERVATION ACT 1992

The most relevant portions of the *Nature Conservation Act 1992* (NC Act) to the Project are the sections which pertain to Wildlife and Habitat Conservation. The class of wildlife[2] to which the NC Act applies includes protected wildlife, which is defined as:

- Extinct wildlife;
- Endangered wildlife;
- Vulnerable wildlife;
- Near Threatened; and
- Least Concern wildlife.

Species listed under the above classes are published in the associated *Nature Conservation (Wildlife) Regulation 2006* (NCWR).

The NC Act defines „threatening processes" as:

a) Threatening the survival of any protected area, area of major interest, protected wildlife, community of native wildlife or native wildlife habitat; or

b) Affecting the capacity of any protected area, area of major interest, protected wildlife, community of native wildlife or native wildlife habitat to sustain natural processes.

The NC Act is relevant to the Project should any flora or fauna species of conservation significance (as detailed in the NCWR) be found on the Project.

3.2 COMMONWEALTH ENVIRONMENT PROTECTION AND BIODIVERSITY CONSERVATION ACT 1999

Under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act), an action will require approval from the Federal Environment Minister if the action has, will have, or is likely to have a significant impact on a Matter of National Environmental Significance, where Matters of National Environmental Significance are:

- World Heritage properties;
- National Heritage places;

[2] Under the *Nature Conservation Act 1992*, wildlife is defined to be any taxon of an animal, plant, protista, procaryote or virus.

- Wetlands of international importance (Ramsar wetlands);
- Nationally threatened species and ecological communities;
- Migratory species;
- The environment where nuclear actions are involved (including uranium mines);
- Great Barrier Marine Park; and
- Commonwealth marine areas.

Of the above Matters of National Environmental Significance, only two are applicable to the Project site:

- Nationally threatened species and ecological communities; and
- Migratory species.

Consequently, should any species/communities listed as Threatened or Migratory be found on the Project site, the Project will be assessed under guidelines provided in the EPBC Act.

In addition, the EPBC Act provides for the identification and listing of key threatening processes. Based on the information provided to AARC by MMG, key threatening processes are not associated with the Project.

3.3 QUEENSLAND VEGETATION MANAGEMENT ACT 1999

The *Vegetation Management Act 1999* (VM Act) was proclaimed on Thursday the 14th of September 2000 as part of a planning framework for the management of native vegetation across Queensland. The *Vegetation Management Regulation 2000* (VMR) prescribes the status of each of the Regional Ecosystems (RE) identified to occur within Queensland.

Although the VM Act does not apply to the clearing of vegetation on the Project, the scientific basis for biodiversity conservation is still valid and can be used to assess the conservation significance of the vegetation communities on the Project. This includes the conservation status categories of each RE under the VM Act, which are listed below as is the definition of Remnant Vegetation:

Endangered Regional Ecosystems:

- <10% of pre-clearing extent remaining; and
- 10-30% of pre-clearing extent remaining and remnant <10,000 hectares (ha).

Of Concern Regional Ecosystems:

- 10-30% of its pre-clearing distribution remains; and
- 30% of the pre-clearing extent remains and the remnant vegetation remaining is <10,000 ha.

Least Concern Regional Ecosystems:

- >30% of the pre-clearing distribution remains and remnant vegetation remaining is >10,000 ha.

Remnant Vegetation:

„Remnant Vegetation" for an area of Queensland for which there is no RE map or remnant vegetation map, means any vegetation where the predominant canopy:

- Covers more than 50% of the undisturbed predominant canopy;
- Averages more than 70% of the vegetation"s undisturbed height; and
- Is composed of species characteristic of the vegetation"s undisturbed predominant canopy.

3.4 QUEENSLAND LAND PROTECTION (PEST AND STOCK ROUTE MANAGEMENT) ACT 2002

The objectives of the *Land Protection (Pest and Stock Route Management) Act 2002* (LP Act) are to consolidate, amend and provide laws for the management, control, prohibition, and regulation of the introduction, spread and keeping of certain plants and animals declared under the Act. The LP Act is relevant to the Project with regard to the control and management of declared pest plant (weed) and animal species.

3.5 DEPARTMENT OF ENVIRONMENT AND RESOURCE MANAGEMENT BIODIVERSITY STATUS

The Queensland Department of Environment and Resource Management (DERM) Biodiversity Status is the status assigned by the DERM to REs to assist with biodiversity planning in Queensland. Unlike the status of REs under the VM Act, the DERM Biodiversity Status is based on an assessment of the condition of remnant vegetation in addition to the pre-clearing and extent of an RE. It takes into account other threatening processes in addition to land clearing. These other processes include:

- The reduction in biodiversity within the REs;
- Weed invasion;
- Grazing pressures;
- Inappropriate fire management;
- Fragmentation; and
- Infrastructure development.

3.6 QUEENSLAND GOVERNMENT ENVIRONMENTAL OFFSETS POLICY

The *Queensland Government Environmental Offsets Policy* (QGEOP) is a guide for appropriate use of environmental offsets across terrestrial and aquatic ecosystems in Queensland, based on the principles of ecologically sustainable development. It provides generic framework for environmental offsets and guidance on when specific-issue offsets (refer to Section 3.7) should and should not be considered.

An environmental offset is an action taken to counterbalance unavoidable, negative environmental impacts that result from an activity or development that supports a growing economy and population. Environmental offsets are only applicable when the impacts cannot be avoided or minimised, and if all other Government environmental standards have been met.

Environmental offsets should be considered (where there may be a remaining environmental impact) as part of an Environmental Impact Statement and in the development of an Environmental Management Plan. Consideration of specific-issue offsets policies, consistent with the QGEOP, should be included as one of the content requirements of an Environmental Management Plan for *Level 1 mining or petroleum activity* (excluding level 1 mining claims). If the activity will have a remaining environmental impact on an environmental value that is addressed by a specific-issue offsets policy, an environmental offset should be required as a condition of the Environmental Authority.

3.7 POLICY FOR VEGETATION MANAGEMENT OFFSETS

The *Policy for Vegetation Management Offsets* applies to an offset proposed to meet a performance requirement in an applicable VM Act code, and is administered by the Queensland DERM. This policy is applicable for any RE listed as „Endangered", „Of Concern", „Essential Habitat", „Natural Wetland" or „vegetation associated with watercourses" under the VM Act *Vegetation Management Status*.

A vegetation management offset is a legal arrangement or agreement that, over time, guarantees to maintain the extent, structure and function of:

- Regional ecosystems;
- Essential habitat; and
- Vegetation associated with:
    - Watercourses;
    - Natural wetlands; and
    - Natural significant wetlands.

Seven criterions apply to a vegetation management offset, which are listed in Table 1 below.

Table 1 Vegetation Management Offset Criterions and Descriptions

Offset Criteria	Criteria Description
Limitations on offset vegetation	The proposed offset must be mapped as non-remnant vegetation or is expected to fall below criteria for remnant vegetation
Selection and location of RE	The proposed offset must maintain ecological processes at a subregional level and ideally be within the same bioregion and subregion as area proposed to be cleared
Remnant mapping	The proposed offset must be an area which is large enough to be mapped as remnant vegetation
Obtaining ecological equivalence	The proposed offset must become ecologically equivalent to the proposed area for clearing
Ensuring ongoing management	The proposed offset must include a management plan that specifies how the offset will be managed to ensure it achieves or maintains remnant RE status and ecological equivalence
Ensuring offset is legally secured	The offset area and arrangements for securing the future protection of the offset area must be proposed as part of the development application
Other requirements	The offset is not required to be on land owned by the applicant. The offset must be protected and managed under agreement with the landholder
	The proposed offset cannot be a financial donation or contribution, although a contribution may be made to a third party for the management of an approved offset

4.0 DATABASE SEARCH AND LITERATURE REVIEW

Database searches collate information on flora and fauna species identified in the region from previous surveys, community records and other sources. A review of such databases facilitates the formulation of specific field survey techniques for flora and fauna species of special interest. The database searches revealed that several flora and fauna species of conservation significance have been identified in the Cloncurry region.

4.1 FLORA

Review of the EPBC Act Online Database, the Queensland Herbarium HERBREC Database and Wildlife Online indicated six species of conservation significance has been identified in the vicinity of the Project site (Appendix A).

The EPBC Act Online Database search contained a 25 km buffer surrounding a central point within the Project site and another along the powerline corridor. The Wildlife Online search contained a 20 km radius at a central point within the Project site and at a central point within the powerline corridor. No species of conservation significance were identified in either of these searches.

The HERBREC Database search was conducted in October 2008 with a radius of 20 km from a central location on the Project site and with a 10 km radius along the powerline corridor. An additional HERBREC database search was conducted for the Project site in March 2011, with a radius of 150 km.

Table 2 summarises all flora species and corresponding conservation significance identified from database searches.

Table 2 Threatened Flora Species known from the Region

Botanical Name	Habitat	Conservation Status	
		EPBC Act	NC Act
Brachychiton collinus	Inhabits rocky outcrops and granite country with little other understory present	Not Listed	Least Concern (current status) Rare (prior to May 2010)
Fimbristylis distincta	One record from Undilla homestead, Queensland. Occurred along a stream bank.	Not Listed	Near Threatened
Goodenia angustifolia	Occurs within *Corymbia terminalis* low woodland, on sandy loam soils with *Triodia pungens.* Records from Malbon and Duchess, northwest Queensland	Not Listed	Near Threatened

Botanical Name	Habitat	Conservation Status	
		EPBC Act	NC Act
Ipomoea antonschmidii	*Eucalyptus leucophloia, Corymbia capricornia, Corymbia aparrerinja* and *Eucalyptus camaldulensis* woodlands. Grows in a variety of habitats, including rocky, sandy and red clay substrates. Occurs along the Lake Julius pipeline, Gunpowder and north of Mount Isa	Not Listed	Near Threatened
Ptilotus maconochiei	*Eucalyptus leucophloia* and *Corymbia aspera* woodland, with *Triodia pungens* groundcover. On quartzite ridge tops, hillsides, slopes and shale	Not Listed	Near Threatened
Rhamphicarpa australiensis	Riparian Eucalypt open woodland, small creek channels, *Eucalyptus camaldulensis* woodland; occurs in clay soils and ferruginous/calcrete rock. Patchy distribution from Julia Creek, Gunpowder to Burk and Wills	Not Listed	Near Threatened

To ensure the survey team were familiar with these species of conservation significance, research into their growth form, ecology and appearance was undertaken prior to field surveys. The likelihood of these species of occurring on the Project site is discussed in Section 6.9.1.

Weeds of national significance (WoNS), along with other introduced plants considered by the State to pose a significant threat to biodiversity, were included in the EPBC database search. These species are summarised in Table 3 below.

Riverine areas are known to be an important dispersal corridor for weeds, as these areas create ideal conditions for many weeds to extend their range and invade new areas. Riverine areas are prone to weed invasion. Most common scenarios which contribute towards this are water transport of seeds downstream along watercourses, stock and other wildlife transport of seeds in their digestive system or coat or eroded or exposed areas of soil providing opportunities for new weed infestations by reducing competition from existing native plants.

The WoNS program coordinates the national effort against 20 of Australia"s worst invasive plants. A national strategy for each WoNS nominated weed specifies actions to better manage each weed. The Australian Government initiated program funding with commitments from state agencies and collaborative arrangements with other stakeholders. State legislation includes the LP Act, which classes weeds from class 1 – 3. Class 2 pests are established in Queensland and have, or could have, an adverse economic, environmental or social impact. Declaration under the LP Act imposes a legal responsibility for control by all landowners on land under their management.

Table 3 Weed Species Identified in Database Searches

Scientific Name	Common Name	Preferred Habitat	Conservation Status	
			Commonwealth	State
Acacia nilotica subsp. *indica*	Prickly Acacia	Mitchell grass plains most commonly infested, potential to invade Project region	WoNS	Class 2
Pennisetum ciliare	Buffel Grass	Grows on all types of soil, commonly on sandy and stony soils. Regarded as a weed of alluvial flats and riverine sites. Well established in north west Qld	Not Listed	Not Listed
Cryptostegia grandiflora	Rubber Vine	Initially invades waterways, expanding outward to hillsides and pastures. Rubber Vine is established throughout most of Queensland, including north west Qld	WoNS	Class 2
Hymenachne amplexicaulis	Hymenachne	Semi-aquatic grass which can thrive in waters up to 2 m deep. Potential to invade Project region	WoNS	Class 2
Parkinsonia aculeata	Parkinsonia	Adapted to a wide range of soil types, found along water courses in sub-humid and semi-arid areas of Qld	WoNS	Class 2
Parthenium hysterophorus	Parthenium	Invades pastures, disturbed areas along roadsides, watering points and cattle yards, grows in most soil types, most dominant in alkaline, clay and loam soils. Smaller outbreaks in north west Qld, with state level initiative to control	WoNS	Class 2
Prosopis spp.	Mesquite	Well adapted to hot climates and a wide range of soil types and annual rainfall of 150 – 1200 mm. Current distribution includes north west Qld	WoNS	Class 2

A review of the DERM Regional Ecosystems Descriptions Database (REDD) indicates the potential presence of twenty REs of conservation significance within the Bioregion 1, the Northwest Highlands, under the EPBC Act, Queensland VM Act and DERM Biodiversity Status (Table 4). The occurrence of these REs on the Project site is discussed in Section 6.9.2.

Table 4 Regional Ecosystems of Conservation Significance Potentially on the Project site

Regional Ecosystem	Description	Conservation Status		
		EPBC Act	Queensland VMR	DERM Biodiversity Status
1.3.2	*Eucalyptus microtheca* low open woodland to woodland on alluvial floodplains and channels	Not Listed	Least Concern	Of Concern
1.3.3	*Acacia georginae* low open woodland – low woodland on clay plains	Not Listed	Of Concern	Of Concern
1.3.4	*Acacia cambagei* low open woodland to woodland on earths in valleys	Not Listed	Least Concern	Of Concern
1.3.5	Mixed eucalypt open woodland on sandy alluvial terraces	Not Listed	Least Concern	Of Concern
1.3.6	*Corymbia aparrerinja* and *Corymbia terminalis* open woodland on sandy terraces	Not Listed	Least Concern	Of Concern
1.3.7	*Eucalyptus camaldulensis* woodland on channels and levees	Not Listed	Least Concern	Endangered
1.3.9	Perennial watercourses and associated alluvium	Not Listed	Of Concern	Of Concern
1.5.1	*Eucalyptus miniata* woodland on red earths on laterised plateaus	Not Listed	Of Concern	Of Concern
1.5.4	*Eucalyptus leucophylla* low open woodland on red earths in valleys	Not Listed	Least Concern	Of Concern
1.5.5	*Eucalyptus pruinosa* low open woodland on red earth plains	Not Listed	Least Concern	Of Concern
1.5.6	*Atalaya hemiglauca*, *Ventilago viminalis,* and *Grevillea striata* low open woodland on red earth plains	Not Listed	Least Concern	Of Concern
1.5.9	*Ventilago viminalis* low open woodland on loams on sand sheet margins	Not Listed	Least Concern	Of Concern
1.7.2	*Eucalyptus pruinosa* low open woodland on calcareous red/brown earths	Not Listed	Least Concern	Of Concern

Regional Ecosystem	Description	Conservation Status		
		EPBC Act	Queensland VMR	DERM Biodiversity Status
1.9.2	Mixed shrubby woodland on low rocky hills on Tertiary limestones	Not Listed	Of Concern	Of Concern
1.9.8	Spring wetlands on undeformed fine-grained sedimentary rock	Not Listed	Of Concern	Of Concern
1.10.6	Springs mostly associated with quartzose sandstone and fine-grained sedimentary rocks	Not Listed	Of Concern	Endangered
1.11.1	Mixed shrubby woodland of folded limestone	Not Listed	Of Concern	Of Concern
1.11.4	*Eucalyptus pruinosa* low open woodland on shallow soils in valleys below folded sediments	Not Listed	Least Concern	Of Concern
1.11.5	Springs associated with metamorphic rocks	Not Listed	Of Concern	Of Concern
1.12.2	*Eucalyptus melanophloia* low open woodland on low hills and torfields on biotite granites	Not Listed	Of Concern	Of Concern

4.2 FAUNA

The following databases were searched for historical records of fauna within the vicinity of the Project site:

- Wildlife Online Database (DERM): This database uses records collected from previous surveys, including the Queensland Museum surveys as well as records from the public. A 20 km search radius was used to cover the Project site (including corridor routes);
- EPBC Act Online Database: The search includes species if their distribution overlaps the broader Cloncurry region and it is likely that suitable habitat is nearby. The database only pertains to species listed under the EPBC Act. A 30 km search radius was used to cover the Project site (including corridor routes);
- Historic flora and fauna survey report conducted by Woodward-Clyde (Holmes 1991);
- Roseby Copper Project Terrestrial Flora and Fauna Assessment, prepared for Universal Resources Limited by AARC (2006b); and
- Roseby Copper Project Aquatic Flora and Fauna Assessment, prepared for Universal Resources Limited by AARC (2006a).

Search results indicate a number of species of conservation significance have been identified in the region of the Project site. These are listed in Table 5 below.

Search results from the DERM Wildlife Online Database and the EPBC Act Online Database are listed in Appendix A.

Table 5 Potential Threatened Fauna of the Project site

Species Identification		Conservation Status	
Scientific Name	**Common Name**	**EPBC Act**	**NCWR**
Heteromunia pectoralis	Pictorella Mannikin	Not Listed	Near Threatened
Ephippiorhynchus asiaticus	Black-Necked Stork	Not Listed	Near Threatened
Melithreptus gularis	Black Chinned Honeyeater	Not Listed	Near Threatened
Petrogale purpureicollis	Purple-Necked Rock-wallaby	Not Listed	Vulnerable
Rostratula australis	Australian Painted Snipe	Vulnerable/ Migratory/ Marine	Vulnerable
Sminthopsis douglasi	Julia Creek Dunnart	Endangered	Endangered
Pristis microdon	Freshwater Sawfish	Vulnerable	Not Listed
Haliaeetus leucogaster	White-bellied Sea-Eagle	Migratory/Marine	Not Listed
Merops ornatus	Rainbow Bee-eater	Migratory/Marine	Not Listed
Ardea alba	Great Egret, White Egret	Migratory/Marine	Not Listed
Ardea ibis	Cattle Egret	Migratory/Marine	Not Listed
Charadrius veredus	Oriental Plover, Oriental Dotterel	Migratory/Marine	Not Listed
Glareola maldivarum	Oriental Pratincole	Migratory/Marine	Not Listed
Numenius minutes	Little Curlew, Little Whimbrel	Migratory/Marine	Not Listed
Rostratula benghalensis s. lat	Painted Snipe	Migratory/Marine	Not Listed
Apus pacificus	Fork-tailed Swift	Migratory/Marine	Not Listed
Crocodylus johnstoni	Freshwater Crocodile	Marine	Not Listed

Note: The above table contains database search results from Wildlife Online Database (DERM) and EPBC Act Online Database where it was indicated that species of conservation significance may be known from the Project Region.

4.3 ENVIRONMENTALLY SENSITITVE AREAS

Environmentally Sensitive Area (ESA) mapping presents Category A, B, and C areas of conservation significance, National Parks, Conservation Parks, Forest Reserves, Nature Refuges, Resource Refuges, Endangered Regional Ecosystems (ERE) and areas listed under the Directory of Important Wetlands.

Figure 4 presents ESAs within and adjacent to the Project site. A Category B ESA, an ERE, is presented on the Figure. This ERE is classed as RE 1.3.7 – *Eucalyptus camaldulensis* watercourses. No other ESAs are present adjacent to the Project site.

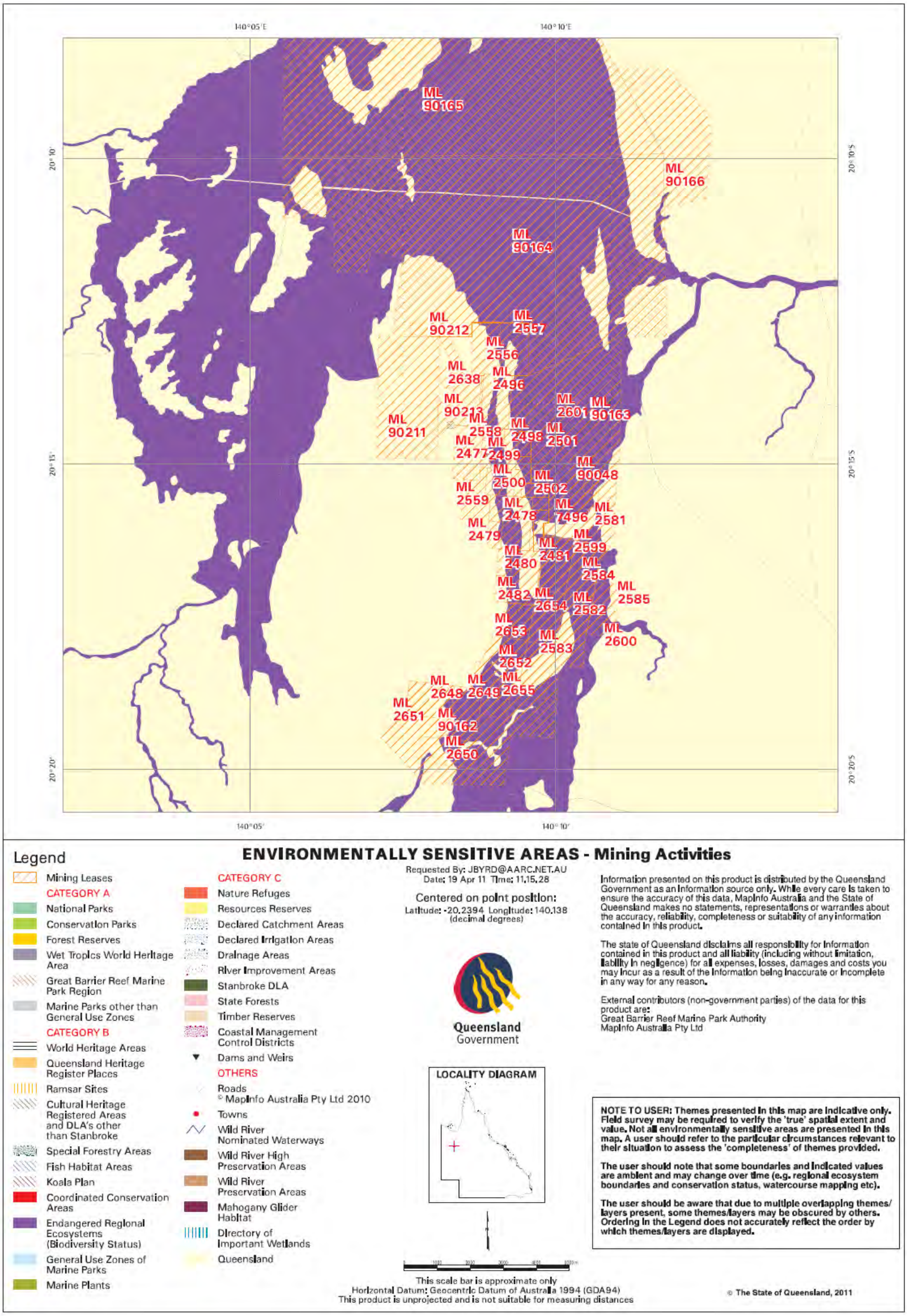


Figure 4 Environmentally Sensitive Areas for the Project site

5.0 FIELD SURVEY METHODOLOGY

The initial wet season survey on the Project site was undertaken over nine consecutive days between the 27th of March and the 4th of April 2008. The dry season survey on the Project site and an initial assessment of the corridors was undertaken over ten consecutive days between the 4th and 13th of August 2008. An additional three day assessment of the powerline corridor was conducted from the 1st to the 3rd of October 2008. A final three day assessment of modifications to the alignment of the access road and water pipeline was conducted between the 7th and 9th of April 2010. An additional wet season survey occurred between the 21st and 31st of March 2011, to capture ephemeral floral species and to supplement the existing fauna catalogue from previous surveys.

The methodology for assessing the flora and fauna on the Project site is described in Sections 5.1 to 5.3. The methodology for assessing the corridors is discussed separately in Section 5.4.

5.1 INITIAL SITE SCOPING

Site scoping was conducted using three methods. Firstly, aerial photography of the Project region was reviewed to gain an overall perspective of the vegetation distribution and landform variation.

Secondly, the Project site was broadly surveyed from vehicle. This enabled survey transects to be located in areas that maximised the sampling of representative vegetation types and fauna habitats. This also allowed for the targeting of habitats potentially occupied/utilised by species of conservation significance.

Thirdly, areas of potential sensitivity (for example, creek lines and rocky outcrops) were surveyed on foot. This allowed further ecological familiarisation and comprehensive survey coverage.

5.2 FLORA

5.2.1 Overall Approach

The field survey involved a baseline study of the Project using all standard floristic survey methods. Methods used were in accordance with the Queensland Herbarium"s *Methodology for survey and mapping of regional ecosystems and vegetation communities in Queensland* 1:25,000 Scale Vegetation Mapping.

The Queensland Herbarium Recommendations for mapping regional ecosystems 1:25,000 Scale Vegetation Mapping allows for four levels of sampling:

- *Primary* – Consists of permanently marked plots where individual tree and shrub species are marked to allow for individual monitoring. This technique is only used for monitoring or research;

- *Secondary* – Consists of 10 x 50 m plots. Data recorded at these sites includes a list of all species observed from all the major layers of vegetation. Species that fall outside the plot but are typical of the community are also listed. In addition, relative abundance for individual species in each strata is recorded, including density and foliage projection cover and height for the tree and shrub layers;

- *Tertiary* – Consists of 20 x 50 m plots in which all of the woody species in the plot are recorded. Data collected includes limited structural information (e.g. heights and basal area); and

- *Quaternary* or observation site – These plots include Global Positioning System (GPS) location, the dominant species in the characteristic layer with some landform and structural data. An intuitive classification of the vegetation is also recorded. These plots are commonly used in the ground truthing of mapping previously completed for the local area.

5.2.2 Regional Ecosystem Mapping

The flora survey employed a desktop assessment of floral taxa and vegetation communities of the Project site prior to the commencement of field work. Preliminary identification included vegetation community definition from aerial photography. This preliminary community identification was used to target locations for representative field survey sample plots to obtain floristic and structural data and ground truth communities.

A survey of all REs on the Project was conducted to supplement the Queensland Herbarium RE mapping. Consequently, the following methods were used:

- A total of 37 representative Secondary transects (50 x 10 m plot) in each vegetation type were selected and a detailed floristic inventory of the dominant and associated woody plants (i.e. trees and shrubs) was undertaken. Secondary plots were positioned in vegetation representative of the community as a whole;

- In addition to the Secondary transects, 245 Quaternary transects were also surveyed. Quaternary transects were conducted to capture any variation in species composition, community structure and to search for threatened species known to occur in the region;

- An assessment of the condition of the vegetation type with regard to quality and conservation value was undertaken at each transect; and

- The mapping of the REs was undertaken through the use of aerial photographs, geological maps, and the use of a GPS in association with the findings of the field survey. Vegetation transects were done until additional transects yielded no significant additional species or structural variation.

The RE mapping methodology recommends a minimum number of three s=Secondary sites per Regional Ecosystem type. It is noted in the methodology that sampling adequacy can be determined, when additional sites do not add substantial new species or show significant structural variation to the mapping process. .

5.2.3 Air Photo Interpretation

Aerial photo interpretation was conducted to delineate stands of potentially homogenous vegetation structure and composition, and to annotate those stands with data attributes that can be used to quantify and describe the current condition of vegetation. Aerial photography was interpreted and classed into visually identifiable patterns over the Project site as an initial, broad scale interpretation prior to the commencement of the initial field survey. The 1:25,000 scale of polygon definitions are consistent with the *Methodology for survey and mapping of regional ecosystems and vegetation*

communities in Queensland (Nelder et al., 2005) of 1.2 ha for a uniform occurrence and 1.7ha for an elongated occurrence.

The field assessment was then designed to sample the different classes identified in the aerial photograph interpretation. Secondary and Quaternary transects were surveyed within these polygons to sample the variation within and between aerial photo classes and to interpret the relationship between variation in the aerial photo and floristic variation

5.2.4 Survey for Species of Conservation Significance

When a habitat suitable for a species of conservation significance was located, a specific survey for that species was undertaken. This specific search involved the use of methods discussed in the draft New South Wales (NSW) *Threatened Species Survey and Assessment Guidelines* (NSW National Parks and Wildlife Service 2001).

The method that was used in this survey was the random meander technique. As its name suggests, this technique involves traversing areas of suitable habitat in no set pattern whilst searching for the particular plant species. If there was any uncertainty in identifying the species, a specimen is collected for confirmation by the Queensland Herbarium. Random meanders were conducted in all ecological communities found on the Project site, as well disturbed areas such as roadsides and old mining works.

5.2.5 Plant and Regional Ecosystem Identification

All dominant plants representative of each vegetation community were identified using a number of taxonomic keys and other reference materials. All REs were described in accordance with the REDD and Sattler and Williams (1999). The use of the terms „Remnant" and „Non-remnant" vegetation" are used as per the VM Act. For any plant species that could not be identified in the field, a sample was collected and sent to the Queensland Herbarium for identification.

5.2.6 Mixed Polygons

On vegetation and RE maps, a polygon usually denotes a discrete area of one type of vegetation community. The scale at which an RE map is produced dictates the minimum area of continuous vegetation type that can be represented by one polygon. This is known as the "minimum mappable area". If distinct vegetation communities are smaller than this minimum area, then vegetation communities are put together in "mixed polygons". This has the consequence that when Land zone maps are combined with vegetation maps to produce REs, mixed polygons containing more than one RE can be produced. Where mixed polygons are represented on an RE map, all REs represented within the polygon are denoted.

5.2.7 Flora Transects Locations

Flora transects were conducted in each community found within the Project site. The locations of these transects are shown in Figure 5. In addition to the transect study locations, incidental observations of flora species were recorded with notes on the vegetation community as they were encountered. Areas of disturbance such as roadsides and creek crossings were also investigated as they often provide a foothold for a number of different species, particularly invasive weeds. In total, 37 Secondary vegetation transects were conducted, with a minimum of 3 transects within each RE. Thirteen of the 37 transects were conducted within the two riverine communities (RE 1.3.6b and RE 1.3.7b), as these communities are most diverse in species.

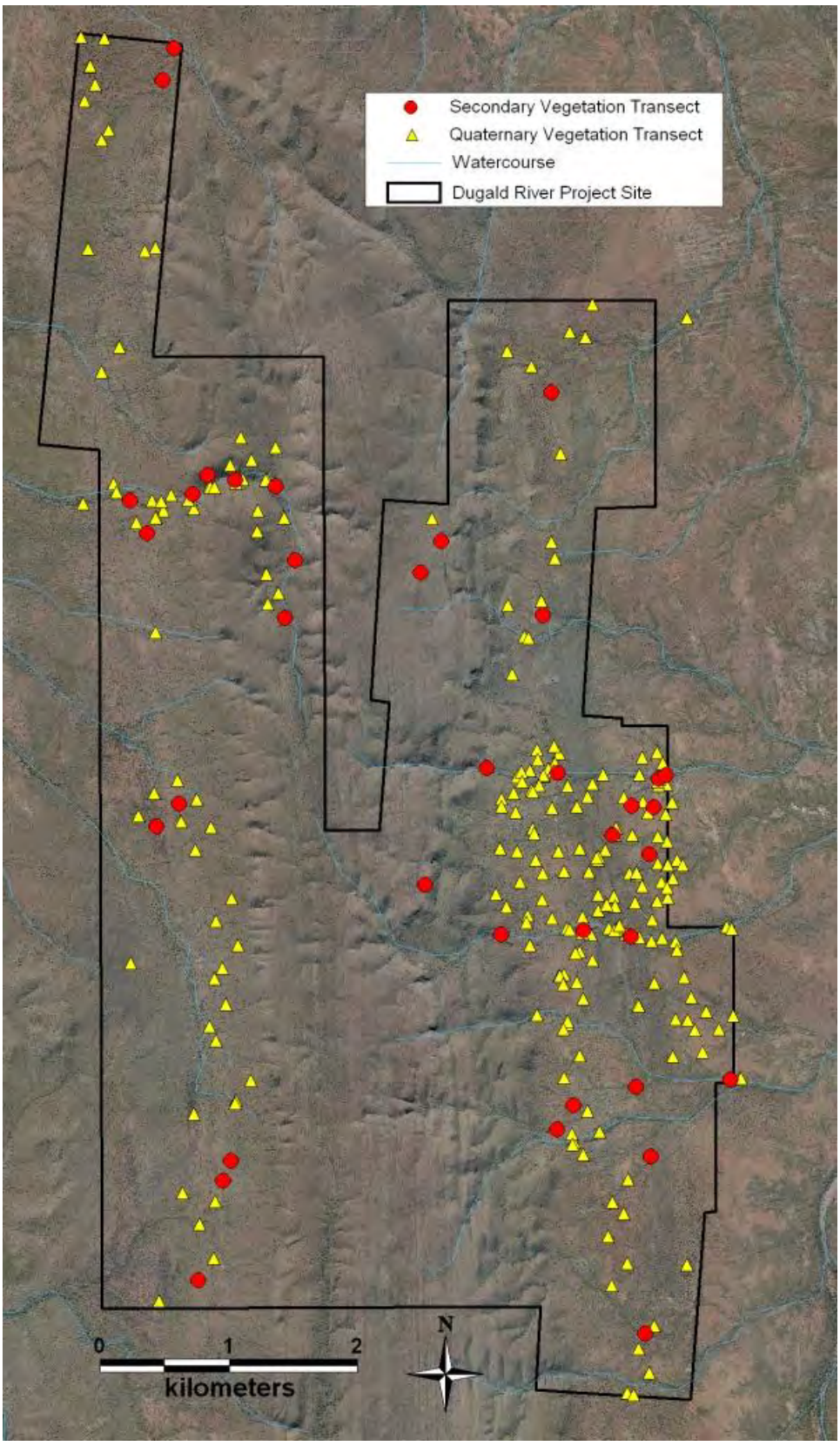


Figure 5 Flora Transect Locations on the Project site

5.3 FAUNA

The fauna sampling methodology for the Project site was based on survey techniques provided by DERM (2009), titled *Recommended Fauna Survey Methodology for Environmental Impact Assessments*. Sampling of vertebrate fauna was conducted primarily along transects established in each of the major fauna habitat types and at changes in vegetation community groups. Secondary sites were established to provide important information on fauna species associated with preferred habitat, as well as increasing the chances of finding species of conservation significance. Their inclusion in the assessment provides a more robust survey methodology and greater survey coverage. Study locations were replicated throughout the dry and wet season surveys where possible, to aid the identification of seasonal variation in species diversities and abundances. Sampling locations are described and shown in Section 5.3.3.

Observations of species outside the specific study locations were noted as incidental observations.

5.3.1 Nomenclature

Many fauna species, particularly frogs and reptiles, do not have widely accepted common names. Where possible, the accepted common names of wildlife are used preferentially in this report, with scientific names stated on all other occasions.

Taxonomy within this report follows the following references:

- DERM Wildlife Online database (2010) for reptile and amphibian species;
- Tyler and Knight (2009) for amphibians (as secondary reference);
- Wilson (2005) for reptiles (as secondary reference);
- Simpson and Day (2010) for birds; and
- Menkhorst and Knight (2011) for mammals.

5.3.2 Detection Methods

A description of the techniques employed to survey the fauna occurring on the Project site is provided below. Trapping was conducted over four consecutive nights plus two additional nights during the sampling efforts, unless otherwise stated. Appropriate combinations of the listed trapping methods were used to maximise chances of surveying all fauna.

Elliottt trapping

Type A Elliottt traps were used to target small ground-dwelling mammals inhabiting the Project region. Traps were baited with a mixture of honey-soaked oats, peanut butter and vanilla essence. A small portion of bait was placed at the entrance of each trap to entice target species and improve capture rates.

During the wet season survey, 5 Elliottt traps were positioned either side of the central transect line, for two transects, resulting in a total of 10 Elliottt traps per transect. At the remaining four transects, 15 Elliott traps were placed either side of the central transect line (7 on one side and 8 on the other). At the secondary site 15 Elliottt traps were placed in positions thought to be representative of habitat

diversity. Additional Elliottt traps were placed along creek lines during the wet season of 2011. Six trap sites were established, with 16 traps at each site. This yields a wet season survey effort of 762 Elliottt trap nights.

During the dry season survey, 16 Elliottt traps were positioned at each study location in areas considered to be of increased habitat value. As each study site was operational for six nights during the survey, the dry season effort was 672 Elliottt trap nights.

The overall Elliottt trap survey effort for the Flora and Fauna Assessment was 1,434 Elliottt trap nights.

Pitfall trapping

A pitfall trap-line was established at each transect to target small ground-dwelling fauna (reptiles, mammals and amphibians). Each line consisted of a 20 centimetre (cm) tall wire-mesh drift fence running along the ground and crossing the middle of five 10-litre buckets buried flush with the soil surface. The bottoms of the drift fences were buried slightly to guide target species towards a bucket. A small amount of soil, vegetation litter, polystyrene block and a damp sponge were placed in the bottom of each bucket to provide a floating device in case of significant rain, shelter and moisture for captured wildlife. Trap-lines were checked each morning and evening. Each pitfall-line was operational for four consecutive nights plus two additional nights during both surveys, yielding an overall survey effort of 84 trap nights.

Funnel trapping

Funnel traps were placed along fallen logs or at the end of rock crevices and fallen tree hollows to capture small vertebrates. Eight funnel traps were used at each fauna site during the 2011 wet season, giving a total survey effort of 96 trap nights.

Micro-bat surveying

Micro-bats (Microchiropterans) form an extremely diverse group of wildlife and the identification of individual species requires the use of specialised survey methods due to the superficial similarity of many species, their small size, and largely inaudible calls. The following technique was adopted to survey the diversity of micro-bats occurring on the Project site:

ANABAT recordings: In order to navigate and hunt at night, micro-bats use high frequency echolocation calls, most of which are above the frequency range audible to humans (i.e. ultrasound). These echolocation calls provide an opportunity to unobtrusively survey and identify micro-bats through the use of a specialised electronic bat call recorder called ANABAT. The ANABAT recorder was used to record micro-bat calls at specific sites determined to be potential bat habitat. Recordings were sent to an expert ANABAT call analyst (Mr Greg Ford – Toowoomba, Queensland) for species identification.

A total of six ANABAT sites, selected primarily on an assessment of bat habitat value, were used to position the ANABAT unit during the wet season survey in 2008. Two sites yielded bat echolocation calls and were analysed to provide a species list.

While an additional six ANABAT sites were used during the dry season survey, a faulty ANABAT unit corrupted the stored files and no readable data was recorded.

An additional ANABAT survey was conducted during the wet season of 2011. Two ANABATS were placed in various locations over a week, equating to a total of 14 recording nights.

Harp trapping was also conducted along riparian areas during the wet season 2011 survey. This method of trapping aimed to complement the data from ANABAT recordings, as well as increase the potential to identify more cryptic species with lower frequency vocalisation. The harp trap was in operation for 9 evenings along riparian areas

Bird surveying

A dedicated search for diurnal birds was conducted visually and aurally on each morning of the surveys in the immediate vicinity of each study site. In addition, opportunistic diurnal searches were also conducted on foot in areas considered likely to have high avian diversity (e.g. vegetated watercourses), or to contain cryptic or threatened bird species.

Spotlighting

Spotlighting was carried out at night in various sections of the Project site in an attempt to observe nocturnal wildlife, such as owls and arboreal mammals, not likely to be detected by other survey methods. Two spotlighting techniques were employed:

Walk searches: Various habitats within the Project site were selected for spotlighting on foot, especially those considered likely to have high wildlife diversity or to contain cryptic or threatened species. These areas were randomly traversed by two ecologists wearing headlamps and hand held spotlights, and where possible, rock fissures, bark crevices and tree hollows were investigated. A slow walking speed (approximately 1 km/hr) was maintained to facilitate intensive listening and thorough visual searching. While this technique improves the likelihood of detecting small cryptic species, it is a time consuming activity that does not permit the coverage of large areas. A total of 19 spotlight hours were undertaken on foot within the Project site during the dry and wet surveys.

Vehicle searches: Spotlighting was also conducted from a slow-moving vehicle where established roads/tracks permitted driving through areas considered likely to have high wildlife diversity or to contain cryptic or threatened species. A 55-watt 12-volt spotlight was used to scan vegetation for arboreal and ground-dwelling wildlife. An advantage of this survey technique is the efficiency with which large areas can be covered. A total of 14 hours of vehicle spotlighting were undertaken on the Project site during the dry and wet surveys.

Habitat searching

To further enhance the likelihood of detecting small cryptic species, opportunistic diurnal searches of likely micro-habitats were conducted at each transect, secondary site and in other selected areas of the Project site. Searches involved the rolling of rocks and logs, rustling through leaf litter and the peeling of exfoliating bark from standing trees. Observed animals were caught where possible to aid positive species identification.

Scat/Track searching

At each transect and secondary site a search of the immediate area was conducted for evidence of the presence of cryptic wildlife species through the identification of obvious tracks, scats and other signs of occupation (e.g. tree trunk scratchings).

Incidental recordings

Throughout survey periods numerous wildlife species were observed or heard on the Project site during the course of routine activities, such as setting and checking trap-lines, or driving between study locations. Where required, a closer inspection of detected wildlife was carried out to ensure

positive species identification. All incidental observations were recorded and appropriate notes made on the surrounding habitat.

5.3.3 Fauna Transect Locations

In total, six primary transects and eight secondary transects (one secondary transect was used during each survey in 2008, with an additional six sites established in 2011) were established for terrestrial fauna monitoring on the Project site. Transects were positioned to maximise the potential for sampling all wildlife present by targeting the full range of habitat types present on Site.

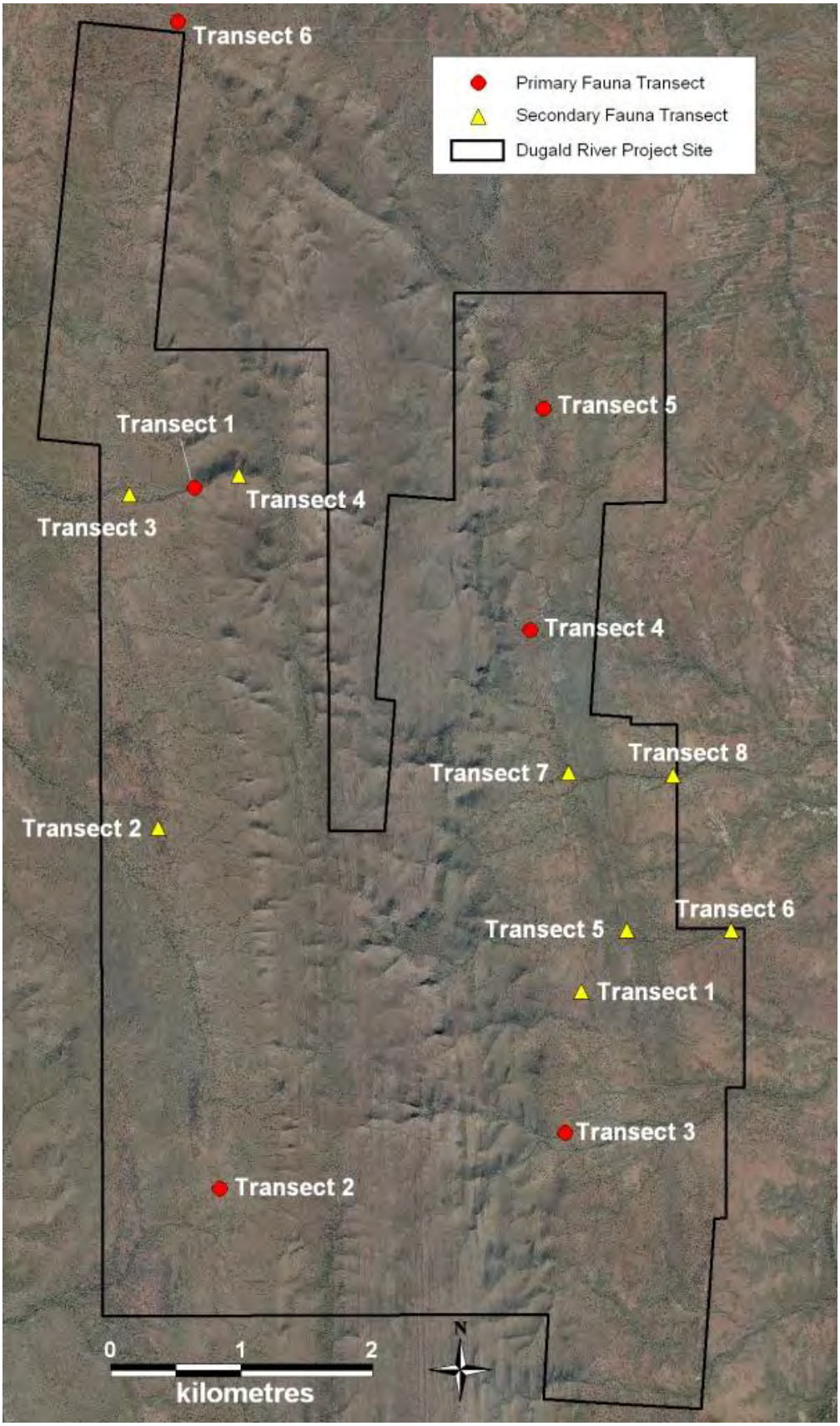


Figure 6 Terrestrial Fauna Study Locations on the Project site

5.4 CORRIDORS

Three infrastructure corridors were assessed by AARC: the access route, water pipeline and powerline corridor. Each corridor was fully traversed, with specific widths listed below. Features of conservation significance were noted at each site in particular:

- Purple-necked Rock-wallaby (*Petrogale purpureicollis*) habitat; and
- River Red Gum crossings (RE 1.3.7 a).

5.4.1 Powerline

The Proponent proposes to construct a powerline from the Project site to Chumvale Substation, which is located approximately 10 km west of Cloncurry on the Barkly Highway. The powerline corridor will be approximately 60 km in length.

AARC"s survey scope included a 400 m wide assessment of vegetation condition with regard to features of conservation significance, in particular Purple-necked Rock-wallaby (*Petrogale purpureicollis*) habitat and River Red Gum (*Eucalyptus camaldulensis*) creek crossings. Any areas of conservation significance were surveyed on foot along the 400 m wide corridor, while areas not of conservation significance were surveyed from a vehicle. In addition, a weed survey was conducted, which entailed identifying any LP Act listed weeds or introduced flora species found along the corridor.

5.4.2 Access Route

The primary proposed Access Route follows an existing track for approximately 9 km from the Project site. At the eastern end of the primary access route it diverts from the existing track from 1 km along a straight route across open terrain to join up with the Burke Developmental Road. The proposed primary route crosses the Dugald River and Silvermine Creek.

An alternate access road route is being proposed and may be used in the foreseeable future. This route follows the primary access road route from the Project site for 4 km, and then diverts directly east for 5 km, ultimately joining the Burke Developmental Road.

It may also be necessary to use a temporary access road deviation (called the Longamundi Deviation), if mining activity occurs on adjacent tenures. This deviation will divert the access road from the Project site around the Longamundi mineral deposit. The deviation will commence at the Project site approximately 850 m north of the primary access route. The deviation is approximately 2 km in length and connects with the primary access track before the alternate access road diversion.

The scope of the Access Route was to survey a 50 m wide corridor, assessing of the condition of the vegetation type with regard to quality and conservation value. Mapping of the REs was undertaken through the use of aerial photographs, geological maps, and the use of a Geographic Positioning System in association with the findings of the field survey.

5.4.3 Water Pipeline

The water pipeline route commences at the T-intersection of the Ernest Henry / Lake Julius Pipeline and travels south and then west to the proposed process plant area within the Dugald River Project site. The corridor is approximately 10 km long.

AARC"s scope of works for the water pipeline corridor included a 40 m wide assessment of the condition of the vegetation type with regard to quality and conservation value and the mapping of the REs through the use of aerial photographs, geological maps, and the use of a GPS in association with the findings of the field survey. As the water pipeline corridor travels close to the base of Mount Rose Bee, potential Purple-necked Rock-wallaby (*Petrogale purpureicollis*) habitat, scats were collected for analysis and outcrops were walked to determine extent of habitat.

6.0 PROJECT SITE FLORA RESULTS AND DISCUSSION

In summary, eight vegetation communities inhabited the Project site with a total of 222 flora species. No flora species identified are of conservation significance and 17 species are introduced.

The following sections describe the vegetation communities occurring on the Project site. This includes a description of the vegetation structure and the dominant species of the canopy, mid-storey and ground layer. Section 8.0 discusses the vegetation communities and species of significance found on the corridors.

Eight distinct vegetation communities were identified on the Project site. All of these communities were classed as Remnant Vegetation as defined in the VM Act. Associations within the communities reflect different vegetation structures and compositions, which occur on different geophysical locations. The corresponding Queensland Herbarium RE classifications are noted for each of the described remnant vegetation communities.

The eight vegetation communities include:

- Community 1 – Snappy Gum Open Woodland on steep hills and strike ridges (RE 1.11.2a);
- Community 2 – Snappy Gum Open Woodland on foothills (RE 1.11.2e);
- Community 3 – Cloncurry Box Open Woodland on low broad hills (RE 1.11.3a);
- Community 4 – Cloncurry Box Open Woodland on hills (RE 1.11.3x1);
- Community 3 – Mixed Bloodwood Riparian Woodland (RE 1.3.6);
- Community 4 – River Red Gum Riparian Woodland (RE 1.3.7b);
- Community 5 – Gidgee Open Woodland (re 1.11.2x2); and
- Community 6 – Silver Box / Cloncurry Box Open Woodland on red earths (RE 1.5.4x3).

Figure 7 maps the location of vegetation communities on the Project site.

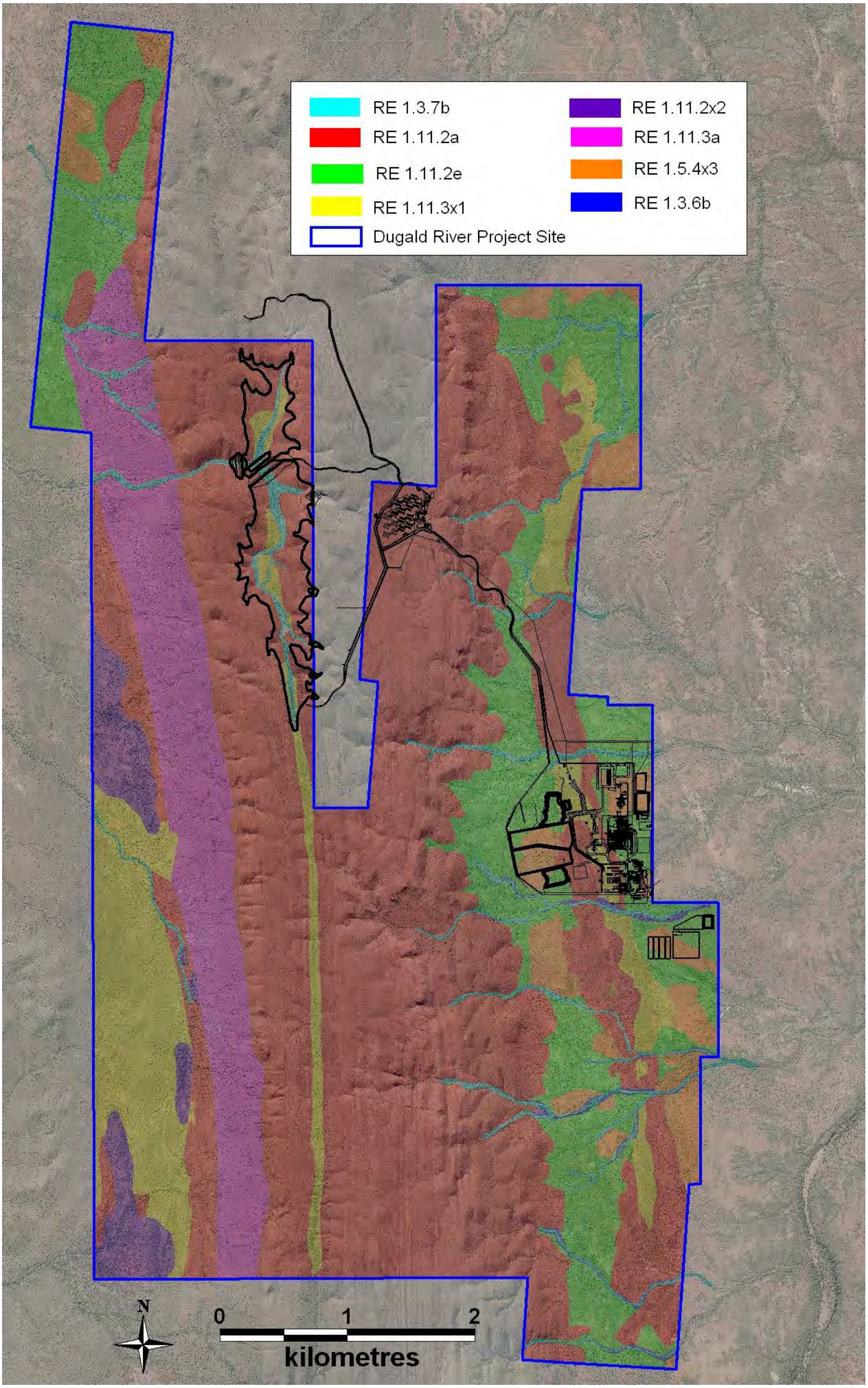


Figure 7 Vegetation Communities on the Project site

6.1 COMMUNITY 1 – SNAPPY GUM OPEN WOODLAND ON STEEP HILLS AND STRIKE RIDGES (RE 1.11.2A)

6.1.1 Location

The Snappy Gum woodland on steep hills and strike ridges (RE 1.11.2a) community is located on skeletal soils forming the Knapdale Range and smaller hillocks on the Project site (refer to Figure 7). Snappy Gum was the dominant community on the Project site, spanning over approximately 52.9% (1,816 ha).

6.1.2 Community Description

The Snappy Gum Open Woodland (RE 1.11.2a) is dominated by a Snappy Gum (*Eucalyptus leucophloia*) open canopy, a moderate to dense shrub layer of Turpentine (*Acacia chisholmii*) and a grassy layer of Soft Spinifex (*Triodia pungens)* (Photo Plate 1 and Photo Plate 2). Other canopy trees include the Western Bloodwood (*Corymbia terminalis*), *Eucalyptus herbertiana* and Cloncurry Box (*Eucalyptus leucophylla*), with an occasional sparse understory of Arid Peach (*Terminalia aridicola*). Groundcover consists of 45% grass and forbs, 4% bare ground, 1% leaf litter and 50% rock. Canopy cover is approximately 3% with an average height of 4 m. Average species recorded along a Secondary transect in the Snappy Gum Open Woodland is 9 in the dry season and 44 in the wet season.



Photo Plate 1 Snappy Gum Open Woodland – RE 1.11.2a



Photo Plate 2 Snappy Gum Open Woodland – RE 1.11.2a

Species presented within Table 6 are indicative of the dominant species recorded within this community. A full list of species is presented in Appendix B. RE 1.11.2a occurs on strongly folded metamorphic pre-Cambrian rock, along the Knapdale Quartzite geological sequence, with associated mudstone, sandstone, siltstone and shale.

Table 6 Community 1 (RE 1.11.2a)- Vegetation Community Description

Community	Snappy Gum Open Woodland on steep hills and strike ridges
Regional Ecosystem	1.11.2a : Low open-woodland of *Eucalyptus leucophloia* often with *Corymbia spp., Terminalia aridicola* and *Eucalyptus leucophylla* with shrub layer of *Acacia spp.* and ground layer of *Triodia spp*. Occurs on steep hills and strike ridges (BVG1M: 19a)
Biodiversity Status	No concern at present
VM Act Status	Least concern
EPBC Act	Not listed
Tree Layer	3 – 6 metres *Eucalyptus leucophloia, Eucalyptus herbertiana, Corymbia terminalis, Terminalia aridicola, Corymbia aspera*

Shrub Layer	1 – 3 metres *Acacia monicola, Acacia chisholmii, Acacia elachantha, Acacia chippendalei, Grevillea dryandri, Euphorbia tannensis*
Groundcover	0 – 0.6 metre *Triodia pungens, Fimbristylis tetragona, Fimbristylis dichotoma, Cymbopogon bombycinus, Indigofera linnaei, Hybanthus enneaspermus, Stackhousia intermedia, Cheilanthes brownii, Chamaecrista symonii, Bonamia media, Polycarpaea corymbosa*
Structure Category	Very sparse

6.1.3 Conservation Value

6.1.3.1 Species

Targeted searches for species of conservation significance were conducted. Ground-truthing identified no species of conservational significance within RE 1.11.2a. The potential on site occurrence of threatened species identified in database searches is described in Table 14

Introduced flora species within RE 1.11.2a include Kapok Bush (*Aerva javanica*), Tickweed (*Cleome viscosa*) and Buffel Grass (*Pennisetum ciliare*). Weed diversity and abundance is relatively low within this RE, as seed dispersal would be limited to wind transport and bird droppings. No weeds of national significance were found within RE 1.11.2a.

6.1.3.2 Community

Snappy Gum Open Woodland on steep hills and strike ridges (RE 1.11.2a), is listed as „Least Concern" under the VMR, „No Concern at Present" under the DERM Biodiversity Status. This ecological community is not listed under the EPBC Act. Areas in which RE 1.11.2 is under reserve include Lawn Hill (Gregory) Resources Reserve and the Boodjamulla (Lawn Hill) National Park.

Overall, the condition of Snappy Gum Open Woodland (RE 1.11.2a) on the Project site is healthy. Intact stands of this community are abundant in the region and it is unlikely disturbance within the Project site will significantly impact on the regional occurrence of this community.

6.2 COMMUNITY 2 – SNAPPY GUM OPEN WOODLAND ON FOOTHILLS (RE 1.11.2E)

6.2.1 Location

The Snappy Gum Open Woodland on foothills (RE 1.11.2e) occurs on lower slopes of the Knapdale Range. This community covers approximately 16.2% (555.5 ha) of the Project site. Refer to Figure 7 for community distribution.

6.2.2 Community Description

The Snappy Gum Open Woodland (RE 1.11.2e) is dominated by a Snappy Gum (*Eucalyptus leucophloia*) open canopy, with associated Western Bloodwood (*Corymbia terminalis*) and Cloncurry Box (*Eucalyptus leucophylla*), a sparse shrub layer of Turpentine (*Acacia lysiphloia*) and a grassy layer of Soft Spinifex (*Triodia pungens)* (Photo Plate 3). Groundcover consists of 45% grass and forbs, 34% bare ground, 6% leaf litter and 15% ironstone cover. Canopy cover is approximately 3% with an average height of 5.5 m. Average species recorded along a Secondary transect in the Snappy Gum Open Woodland (RE 1.11.2e) is 12 in the dry season and 38 in the wet season.



Photo Plate 3 Snappy Gum Open Woodland – RE 1.11.2e

Species presented within Table 7 are indicative of the dominant species recorded within this community. A full list of species is presented in Appendix B. RE 1.11.2e occurs on strongly folded metamorphic Middle Proterozoic rock, along the Corella Formation and Knapdale Quartzite geological sequences, with associated laminated calcareous siltstone, limestone, scapolitic granofels and minor metabasalts at the top.

Table 7 Community 2 (RE 1.11.2e) - Vegetation Community Description

Community	Snappy Gum Open Woodland on foothills
Regional Ecosystem	1.11.2e : Low open-woodland of *Eucalyptus leucophylla* and *E. leucophloia* often with *Acacia cambagei* and *Corymbia terminalis* with a sparse ground layer of *Triodia pungens* and/or *Triodia longiceps*. Occurs on footslopes and lower slopes, broken by creeks and drainages (BVG1M: 19b)

Biodiversity Status	No concern at present
VMR Status	Least concern
EPBC Act	Not listed
Tree Layer	4 – 7 m *Eucalyptus leucophloia, Eucalyptus leucophylla, Corymbia terminalis*
Shrub Layer	1 – 3 metres *Acacia lysiphloia, Acacia monicola, Acacia bidwillii, Acacia holosericea, Acacia retivenea, Carissa lanceolata, Gossypium australe, Hakea cordophylla, Paratephrosia lantana, Tephrosia rosea var rosea, Tephrosia varians, Triumfetta rupestris*
Groundcover	0 – 1 metre *Triodia pungens, Pennisetum ciliare, Aristida contorta, Cymbopogon bombycinus, Enneapogon polyphyllus, Eriachne mucronata, Bulbostylis barbata, Cyperus vaginatus, Fimbristylis signata, Fimbristylis dichotoma, Crotalaria novae-hollandiae, Crotalaria dissitiflora,*
Structure Category	Very sparse

6.2.3 Conservation Value

6.2.3.1 Species

Targeted searches for species of conservation significance were conducted. Ground-truthing identified no species of conservational significance within RE 1.11.2e at the time of surveys. The potential on site occurrence of threatened species identified in database searches is described in Table 14.

Introduced flora species within RE 1.11.2e include Kapok Bush (*Aerva javanica*), Tickweed (*Cleome viscosa*), Tarvine (*Boerhavia paludosa*), Colocynth (*Citrullus colocynthis*), Buffel Grass (*Pennisetum ciliare*) and Cloncurry Buffel Grass (*Pennisetum pennisetiforme*). The Buffel Grass (*Pennisetum ciliare*) was co-dominant with Soft Spinifex (*Triodia pungens*) in areas adjacent to ephemeral watercourses. No weeds of national significance were found.

6.2.3.2 Community

Snappy Gum Open Woodland on foothills (RE 1.11.2e), is listed as „Least Concern" under the VMR, „No Concern at Present" under the DERM Biodiversity Status and is not classed as a listed ecological community under the EPBC Act. Areas in which RE 1.11.2 is under reserve include Lawn Hill (Gregory) Resources Reserve and the Boodjamulla (Lawn Hill) National Park.

Intact stands of this community are abundant in the region, with greater than 10,000 ha of the state-wide extent of this RE remaining. It is unlikely disturbance within the Project site will significantly impact on the regional occurrence or integrity of this community

6.3 COMMUNITY 3 – CLONCURRY BOX OPEN WOODLAND ON LOW BROAD HILLS (RE 1.11.3A)

6.3.1 Location

Cloncurry Box Open Woodland on low broad hills (RE 1.11.3a) occurred along the western foothills of the Knapdale Range. This community covers approximately 10.6% (365.5 ha) of the Project site (refer to Figure 7).

6.3.2 Community Description

The Cloncurry Box Open Woodland on low broad hills (RE 1.11.3a) is dominated by a low canopy of Cloncurry Box (*Eucalyptus leucophylla*), with associated Western Bloodwood (*Corymbia terminalis*), Ghost Gum (*Corymbia aparrerinjia*) and an infrequent understory of Whitewood (*Atalaya hemiglauca*) (Photo Plate 4). The shrub layer is sparsely dominated by Turpentine. Groundcover consists of 70% Soft Spinifex, 10% rock, 15% bare ground and 5% leaf litter. Canopy cover averages 11% with a height of 4 m. Floristic diversity was relatively lower than other communities, with an average of 6 species during the dry season and 32 species during the wet season were recorded along each Secondary transect.



Photo Plate 4 Cloncurry Box Open Woodland – RE 1.11.3a

Species presented within Table 8 are indicative of the dominant species recorded within this community. A full list of species is presented in Appendix B. This community occurs on the Knapdale Quartzite geological sequence on siltstone, shale, metabasalts and dolerites.

Table 8 Community 3 (RE 1.11.3a) - Vegetation Community Description

Community	Cloncurry Box Open Woodland on low broad hills
Regional Ecosystem	1.11.3a: Low open-woodland *Eucalyptus leucophylla* often with *Corymbia terminalis*, *Corymbia aparrerinja* and *Atalaya hemiglauca* with scattered shrubs of *Acacia chisholmii* and a sparse ground layer of *Triodia pungens*. Occurs on broad low hills; metamorphosed igneous rocks (BVG1M: 19b)
Biodiversity Status	No concern at present
VMR Status	Least concern
EPBC Act	Not listed
Tree Layer	3 – 5 metres *Eucalyptus leucophylla, Corymbia terminalis, Corymbia aparrerinja, Atalaya hemiglauca*
Shrub Layer	1 – 3 metres *Acacia chisholmii, Acacia retivena, Acacia monitcola, Grevillea striata, Acacia holosericea, Carissa lanceolata, Eremophila latrobei, Eremophila longifolia, Sesbania campylocarpa, Tephrosia flagellaris*
Groundcover	0 – 0.7 metre *Triodia pungens, Pennisetum ciliare, Aristida inaequiglumis, Enneapogon polyphyllus, Eragrostis fallax, Eulalia aurea, Heteropogon contortus, Fimbristylis microcarya, Crotalaria aridicola, Sida cordifolia, Hybanthus enneaspermus, Vigna radiata var subobata, Indigofera colutea, Pterocaulon sphacelatum, Boerhavia schomburgkiana, Chamaesyce coghlanii, Zornia muriculata*
Structure Category	Very sparse

6.3.3 Conservation Value

6.3.3.1 Species

Targeted searches for species of conservation significance determined that no species of conservation significance inhabit the Cloncurry Box Open Woodland.

No weed species, listed under the LP Act or listed as of national significance, were observed within Cloncurry Box Open Woodland on low broad hills (RE 1.11.3a). Introduced species identified within this community include Mimosa (*Acacia* farnesiana), Kapok Bush (*Aerva javanica*), Cockroach Bush (*Senna notabilis*), Buffel Grass (*Pennisetum ciliare*), Cloncurry Buffel (*Pennisetum pennisetiforme*) and Flannel Weed (*Sida cordifolia*).

6.3.3.2 Community

As detailed in Table 7, Cloncurry Box Open Woodland (RE 1.11.3a) is listed as „Least Concern" under the VMR, „No Concern at Present" under the DERM Biodiversity Status and is not listed under the EPBC Act.

Although RE 1.11.3 is not protected within the Northwest Highlands bioregion, intact stands are abundant throughout this Queensland bioregion. The Cloncurry Box Open Woodland on low broad hills (RE 1.11.3a) is not under threat from clearing and is considered abundant within the region, with the state-wide remnant extent greater than 10,000 ha.

6.4 COMMUNITY 4 – CLONCURRY BOX OPEN WOODLAND ON HILLS (RE 1.11.3X1)

6.4.1 Location

The Cloncurry Box Open Woodland on hills (RE 1.11.3x1) occurred within the valley of the Knapdale Range and along the eastern sections of the Project site (refer to Figure 7). This community covered approximately 9.7% (331.6 ha) of the entire site.

6.4.2 Community Description

This community consists of an open canopy of Cloncurry Box (*Eucalyptus leucophylla*), with associated Western Bloodwood (*Corymbia terminalis*) (Photo Plate 5). Ground cover consisted of 30% bare ground, 20% rock, 10% leaf litter and 35% tussock grass. Trees and shrubs cover approximately 5%, with an average crown cover of 8%. The average number of flora species identified along a Secondary transect within this community is 8 in the dry season and 29 in the wet season.



Photo Plate 5 Cloncurry Box Open Woodland on hills – RE 1.11.3x1

Species presented within Table 9 are indicative of the dominant species recorded within this community. A full list of species is presented in Appendix B. This RE is located along the Corella Formation geological sequence, with associated calcareous siltstone, limestone and minor metabasalts at the top.

Table 9 Community 4 (RE 1.11.3x1) – Vegetation Community Description

Community	Cloncurry Box Open Woodland on hills
Regional Ecosystem	RE 1.11.3x1: Low open-woodland of *Eucalyptus leucophylla* often with *Corymbia terminalis* and Eucalyptus *leucophloia* with *Acacia spp.* dominated shrub layer and ground layer of *Triodia spp.* and/or tussock grasses. Includes areas of *Acacia spp.* shrubland and *Triodia spp. grassland*. Occurs on hills on strongly folded pre-Cambrian rocks; skeletal soils, some shallow loams. (BVG1M: 19b)
Biodiversity Status	No concern at present
VMR Status	Least concern
EPBC Act	Not listed
Tree Layer	5 – 7 metres *Eucalyptus leucophylla, Corymbia terminalis, Eucalyptus leucophloia*
Shrub Layer	0.5 – 2.5 metres *Acacia chisholmii, Acacia monitcola, Acacia lysiphloia, Grevillea striata, Carissa lanceolata, Acacia torulosa*
Groundcover	0 – 0.5 metre *Triodia pungens, Enneapogon polyphyllus Aristida contorta, Fimbristylis dichotoma, Fimbristylis microcarya, Crotalaria novae-hollandiae,*
Structure Category	Very sparse

6.4.3 Conservation Status

6.4.3.1 Species

Targeted searches for species of conservation significance determined that no species of conservation significance inhabit the Cloncurry Box Open Woodland on hills (RE 1.11.3x1) during survey periods.

Non-native species identified within RE 1.11.3x1 include the Kapok Bush (*Aerva javanica*), Cockroach Bush (*Senna notabilis*), Buffel Grass (*Pennisetum ciliare*), Cloncurry Buffel (*Pennisetum pennisetiforme*) and Flannel Weed (*Sida cordifolia*). No weed species, listed under the LP Act or listed as of national significance, were observed within RE 1.11.3x1.

6.4.3.2 Community

As detailed in Table 7, Cloncurry Box Open Woodland (RE 1.11.3x1) is listed as „Least Concern‟ under the VMR, „No Concern at Present‟ under the DERM Biodiversity Status and is not listed under the EPBC Act.

Although RE 1.11.3 is not protected within the Northwest Highlands bioregion, intact stands are abundant throughout this Queensland bioregion. The Cloncurry Box Open Woodland on low broad hills (RE 1.11.3e) is not under current threat from clearing or non-native species encroachment. RE 1.11.3 is considered abundant within the region, with the state-wide remnant extent greater than 10,000 ha.

6.5 COMMUNITY 5 - MIXED BLOODWOOD RIPARIAN WOODLAND (RE 1.3.6B)

6.5.1 Location

The Mixed Bloodwood Riparian Woodland community occurred on all watercourses within the Project site (refer to Figure 7), covering approximately 0.3% (11.2 ha) of the entire site.

6.5.2 Community Description

This community is dominated by the Western Bloodwood (*Corymbia terminalis*) and North-west Ghost Gum (*Corymbia aparrerinjia*), with associated Cloncurry Box (*Eucalyptus leucophylla*) (Photo Plate 6). Ground cover consisted of 10% bare ground, 20% rock, 5% leaf litter and 55% groundcover. Trees and shrubs cover approximately 10%, with an average crown cover of 24%. The average number of flora species identified along a Secondary transect within this community is 11 in the dry season and 41 in the wet season.



Photo Plate 6 Mixed Bloodwood Riparian Woodland – RE 1.3.6b

Species presented within Table 10 are indicative of the dominant species recorded within this community. A full list of species is presented in Appendix B. This community occurs along the Corella formation geological sequence. It occurs on terraces and floodplains on Quaternary alluviums. Soils consist of rock, gravel and shallow loams.

Table 10 Community 5 (RE 1.3.6b) – Vegetation Community Description

Community	Mixed Bloodwood Riparian Woodland
Regional Ecosystem	RE 1.3.6b: Floodplain (other than floodplain wetlands). Woodland of *Corymbia aparrerinja* often with *Corymbia terminalis, Eucalyptus leucophylla, Eucalyptus camaldulensis, Lysiphyllum cunninghamii* and/or *Acacia cambagei* with a sparse ground layer of tussock grasses with *Triodia longiceps* in some places. Occurs on river terraces. (BVG1M: 16c)
Biodiversity Status	Of Concern
VMR Status	Least concern
EPBC Act	Not listed
Tree Layer	*Corymbia terminalis, Corymbia aparrerinjia, Eucalyptus leucophylla, Eucalyptus camaldulensis*
Shrub Layer	1 – 3 metres *Acacia holosericea, Acacia monticola, Acacia retivena, Sesbania javanicea, Ocimum tenuiflorum*
Groundcover	0 – 0.7 metre *Pennisetum ciliare, Indigofera colutea, Heteropogon contortus, Eragrostis elongata, Eragrostis basedowii, Themeda triandra, Cyperus difformis, Cyperus pulchellus, Fimbristylis microcarya, Alternanthera denticulata, Bonamia media, Crotalaria novae-hollindiae, Evolvulus alsinoides, Vigna radiate var sublobata*
Structure Category	Very sparse

6.5.3 Conservation Status

6.5.3.1 Species

Targeted searches for species of conservation significance determined that no species of conservation significance inhabit the Mixed Bloodwood Riparian Woodland (RE 1.3.6b) at the time of surveys.

No weed species, listed as a weed of national significance or listed under the LP Act, were observed within Mixed Bloodwood Riparian Woodland (RE 1.3.6b). However non-native species which inhabit this community include Mimosa (*Acacia farnesiana*), Kapok Bush (*Aerva javanica*), Khaki Weed (*Alternanthera pungens*), Spiked Malvastrum (*Malvastrum americanum var americanum*), Buffel

Grass (*Pennisetum ciliare*), Cloncurry Buffel (*Pennisetum pennisetiforme*), Cockroach Bush (*Senna notabilis*) and Flannel Weed (*Sida cordifolia*).

6.5.3.2 Community

As detailed in Table 10, Mixed Bloodwood Riparian Woodland (RE 1.3.6b) has been given an „Of Concern" DERM Biodiversity status due to a high grazing pressure, changed fire regimes and subjection to Buffel Grass (*Pennisetum ciliare*) invasion. It is listed as being „Least Concern" under the VMR and is not classed as a threatened ecological community under the EPBC Act. Areas within the Northwest Highlands bioregion where RE 1.3.6 is protected include the Boodjamulla (Lawn Hill) National Park, Lawn Hill (Gregory) Resources Reserve, Camooweal Caves National Park and Lawn Hill (Gregory River Base) Resources Reserve.

Overall, the condition of Mixed Bloodwood Riparian Woodland on the Project site is healthy, with a relatively diversity of species comprising the community. Intact stands of this community are abundant within this Queensland bioregion, with the total regional mapped extent of this RE compromising of greater than 10,000 ha. Assuming mitigation strategies are in place, it is unlikely the Project will have impact on the regional extent and health of this community.

6.6 COMMUNITY 6 – RIVER RED GUM RIPARIAN WOODLAND (RE 1.3.7B)

6.6.1 Location

The River Red Gum Riparian Woodland (RE 1.3.7b) fringes most watercourses on the Project site. This community comprises 2.9% (98.4 ha) of the Project site (refer to Figure 7).

6.6.2 Community Description

The River Red Gum Riparian Woodland (RE 1.3.7b) is dominated by the River Red Gum (*Eucalyptus camaldulensis*), with associated Northern Swamp Box (*Lophostomon grandiflorus subsp. riaparius*), and North-west Ghost Gum (*Corymbia aparrerinjia*) (Photo Plate 7 and Photo Plate 8). Unlike the RE description for 1.3.7b, no *Melaleuca spp.* are established within this community on the Project site. Larger watercourses with more frequent surface water inundation, such as the Dugald River, contained *Melaleuca spp.*. A shrubby understory was present. Groundcover averages 60% grasses and vines, 20% leaf litter and 10% gravel and sand. Trees and shrubs comprise 10% of the community coverage, with approximate canopy coverage of 19%. The average number of species recorded in a Secondary transect is 12 during the dry season and 50 during the wet season.



Photo Plate 7 River Red Gum Riparian Woodland - RE 1.3.7b – Swamp Box dominant along upper reaches of watercourse



Photo Plate 8 River Red Gum Riparian Woodland - RE 1.3.7b

Species presented within Table 11 are indicative of the dominant species recorded within this community. A full list of species is presented in Appendix B. This community is located along the

Knapdale Quartzite and Corella Formation geological sequence, within small eroded sections of sand, gravel and colluviums.

Table 11 Community 6 (RE 1.3.7b) – Vegetation Community Description

Community	River Red Gum Riparian Woodland
Regional Ecosystem	RE 1.3.7b: Riverine wetland or fringing riverine wetland. Fringing woodland of *Eucalyptus camaldulensis*, usually with *Lophostomon grandiflorus* and *Melaleuca bracteata* and/or *Melaueca dissitiflora*. Occurs on recent levees and channel deposits of medium and smaller tributaries which are dry for most of the year; alluvial soils. (BVG1M: 16a)
Biodiversity Status	Endangered
VMR Status	Least concern
EPBC Act	Not listed
Tree Layer	12 – 18 metres *Eucalyptus camaldulensis, Lophostomon grandiflorus subsp. riparius, Corymbia aparrerinjia, Corymbia terminalis, Terminalia aridicola, Lysiphyllum cunninghamii, Eucalyptus leucophylla*
Shrub Layer	1 – 3 metres *Acacia holosericea, Flueggea virosa subsp melanthesoides Vitex trifolia var trifolia Acacia monticola, Acacia retivenea, Acacia torulosa,Carissa lanceolata, Sesbania javacina, Ficus aculeata, Hakea aborescens,*
Groundcover	0 – 1 metre *Pennisetum ciliare, Aristida latifolia, Cymbopogon bombycinus, Dicanthium sericeum, Eragrostis basedowii, Triodia pungens, Cyperus conicus car conicus, Cyperus difformis, Cyperus pulchellus, Cyperus microcephalus, Fimbristylis littoralis, Frimbristylis microcarya, Alternanthera denticulata, Anisomeles malabartica, Bonamia media, Corchorus pascuorum, Crotalaria dissitiflora, Cyanotis axillaris,Evolvulus alsinoides, Indigofera colutea, Iphigenia indica,*
Structure Category	Sparse

6.6.3 Conservation Value

6.6.3.1 Species

Targeted searches for species of conservation significance identified no species of conservation significance present at the time of surveys within River Red Gum Riparian Woodland (RE 1.3.7b).

No weed species, listed under the LP Act or listed as of national significance, were observed within the River Red Gum Riparian Woodland (RE 1.3.7b). However 14 non-native species, including Buffel Grass (*Pennisetum cilare*), Cabbage Tree (*Calotropis procera*), Mimosa (*Acacia farnesiana*),Kapok Bush (*Aerva javanica*), Khaki Weed (*Alternanthera pungens*), Awnless Barnyard Grass (*Echinochloa crebra*), Small Stinkgrass (*Eragrostis minor*), Tickweed (*Cleome viscosa*), Spiked Malvastrum

(*Malvastrum americanum var. americanum*), Cloncurry Buffel (*Pennisetum pennisetiforme*), Cockroach Bush (*Senna notabilis*), Flannel Weed (*Sida cordifolia*), Spiny Sida (*Sida spinosa*) and Noogoora Burr (*Xanthium strumianum*) were noted to inhabit this community. In most cases, the larger the watercourse, the more dominant Buffel Grass (*Pennisetum ciliare*) occurred. Transects within creeklines would comprise of 100% groundcover composition of Buffel Grass (*Pennisetum cilare*) in the wet season.

6.6.3.2 Community

As detailed in Table 11, River Red Gum Riparian Woodland (RE 1.3.7b) is listed as „Least Concern" under the VMR and is not listed as a threatened ecological community under the EPBC Act. The DERM Biodiversity Status lists this RE as being „Endangered". The Endangered listing is due to severe degradation from high grazing pressure and invasion of Buffel Grass (*Pennisetum ciliare*). Protected areas within Queensland for this community occurs include the Boodjamulla (Lawn Hill) National Park, Lawn Hill (Gregory) Resource Reserve and Lawn Hill (Gregory River Base) Resource Reserve. These protected areas assist in preserving the diversity and health of floral and faunal species which thrive in this riverine community.

Overall the condition of River Red Gum Riparian Woodland (RE 1.3.7b) is reduced by grazing and weed invasion. The River Red Gum Riparian Woodland, and much of the surrounding vegetation, is subject to low intensity cattle grazing. The impact of disturbance is obvious in the ground flora that inhabits the community, which was heavily grazed during the dry season survey. Based on proposed disturbance plans for the Project and current infrastructure, some additional clearing of this community will be required for the proposed access tracks and TSF. Assuming appropriate sediment and erosion control measures are in place, it is unlikely the community"s diversity or abundance would be impacted at a regional scale.

6.7 COMMUNITY 7 – GIDGEE OPEN WOODLAND (RE 1.11.2X2)

6.7.1 Location

The Gidgee Open Woodland (RE 1.11.2x2) is found in isolated patches, predominantly on the western side of the Project site (refer to Figure 7), covering approximately 2.9% (97.1 ha).

6.7.2 Community Description

The open canopy is comprised of Gidgee (*Acacia cambagei*) trees, with an understory consisting of the Limestone Cassia (*Senna artemisioides subsp. oligophylla*) and Crimson Turkey Bush (*Eremophila latrobei*) and seasonal grass layer of predominantly Buffel Grass (*Pennisetum ciliare*) (Photo Plate 9). Groundcover consists of 16% grass and forbs, 35% leaf litter, 25% rock and 21% bare ground. The remaining 6% is comprised of trees and shrubs. Canopy cover averages 22%. The community has a relatively low diversity of flora, averaging 5 species per Secondary transect in the dry season and 17 species in the wet season.



Photo Plate 9 Gidgee Open Woodland – RE 1.11.2x2

Species presented within Table 12 are indicative of the dominant species recorded within this community. A full list of species is presented in Appendix B This community is located on the Knapdale Quartzite geological sequence, along folded metamorphic sediments on skeletal soils. A layer of ironstone pebbles is prevalent on the surface soils.

Table 12 Community 7 (RE 1.11.2x2) – Vegetation Community Description

Community	Gidgee Open Woodland
Regional Ecosystem	RE 1.11.2x2: *Acacia cambagei* low woodland. Occurs on hills and ranges of fine grained metamorphic sediments. (BVG1M: 26a)
Biodiversity Status	No concern at present
VMR Status	Least concern
EPBC Act	Not listed
Tree Layer	5 – 8 metres *Acacia cambagei*
Shrub Layer	0.5 – 2 metres *Carissa lanceolata Acacia hemignosta, Salsola kali, Senna arteisioides subsp. oligophylla, Capparis lasiantha, Eremophila latrobei*

Groundcover	0 – 0.5 metre *Pennisetum cilare, Aristida contorta, Enneapogon oblongus, Triodia pungens, Enneapogon poilphyllus, Paspalidium rarum, Panicum decompositum, Pennisetum ciliare, Achyranthes aspera, Evolvulus alsinoides, Indigofera linifolia, Indigofera linnaei, Polycarpaea corymbosa, Sclerolaena bicornis, Solanum ellipticum*
Structure Category	Very sparse

6.7.3 Conservation Value

6.7.3.1 Species

Targeted searches for species of conservation significance determined that no listed species were present at the time of surveys within Gidgee Open Woodland (RE 1.11.2x2).

No weed species, listed under the LP Act or identified of national significance, were observed within this community. Non-native species identified within this community include Buffel Grass (*Pennisetum cilare*), Cloncurry Buffel (*Pennisetum pennisetiforme*), Mimosa (*Acacia farnesiana*), Kapok Bush (*Aerva javanica*), Downy Thornapple (*Datura inoxia*) and Spiked Malvastrum (*Malvastrum americanum var americanum*).

6.7.3.2 Community

The Gidgee Open Woodland (RE 1.11.2x2) is listed as „Least Concern" under the VMR and „No Concern at Present" under the DERM Biodiversity Status. This community is not classed as a threatened ecological community under the EPBC Act. RE 1.11.2 is represented within Lawn Hill (Gregory) Resource Reserve and Boodjamulla (Lawn Hill) National Park.

This community is subject to low intensity cattle grazing, as Gidgee (*Acacia cambagei*) is known to grow on fertile soils. The surface clay layer enables moisture to hold in the soils for a prolonged period of time following a rain event. The impact of disturbance is obvious in the ground flora that inhabits the community, as well as the evidence of recent cattle presence.

No infrastructure is proposed within or near, the Gidgee Open Woodland community (refer to Figure 7), therefore it is unlikely the Project will affect the regional occurrence or health of this community.

6.8 COMMUNITY 8 - SILVER BOX / CLONCURRY BOX OPEN WOODLAND ON RED EARTHS (RE 1.5.4X3)

6.8.1 Location

The Silver Box / Cloncurry Box Open Woodland on red earths (RE 1.5.4x3) occurs along the eastern portion of the Project site, as well as in the northwest portion of site (refer to Figure 7). Approximately 4.5% (155.1 ha) of the Project site are covered by this community.

6.8.2 Community Description

The Silver Box / Cloncurry Box Open Woodland on red earths (RE 1.5.4x3) consists of a dominant canopy of the Cloncurry Box (*Eucalyptus leucophylla*), with a patchy yet sometimes dominant layer of Silver Box (*Eucalyptus pruinosa*). Occasional Small-fruited Bloodwood (*Eucalyptus dichromophloia)* and North-west Ghost Gum (*Corymbia aparrerinjia*) are present (Photo Plate 10 and Photo Plate 11). The scattered shrub layer consists of Bootlace Oak (*Hakea cordophylla*), Conkerberry (*Carissa lanceolata)* and Turpentine (*Acacia lysiphloia*). Groundcover consists of 20% surface pebbles, 10% leaf litter, 20% bare ground and 40% tussock grasses. Trees and shrubs make up the remaining 10% and have an average canopy cover of 5%. The average number of flora species identified within a Secondary transect is 8 during the dry season and 37 during the wet season.



Photo Plate 10 Silver Box / Cloncurry Box Open Woodland on red earths



Photo Plate 11 RE 1.5.4x3 - Cloncurry Box dominant on red earths

Species presented within Table 13 are indicative of the dominant species recorded within this community. A full species list can be found in Appendix B. This community occurs within the Knapdale Quartzite and Corella Formation geological sequence. This community occurs on plains and valley bottoms with red earths, shallow loams, clays and skeletal soils.

Table 13 Community 8 (RE 1.5.4x3) – Vegetation Community Description

Community	Silver Box / Cloncurry Box Open Woodland on red earths
Regional Ecosystem	1.5.4x3: Open tussock grassland *of Aristida contorta, Aristida ingrata, Aristida inaequiglumis, Enneapogon spp., Eulalia aurea* often with *Triodia pungens* wooded with low trees including *Atalaya hemiglauca, Eucalyptus pruinosa, Lysiphyllum spp., Acacia cambagei, Eucalyptus leucophylla* and *Corymbia aparrerinja*. Includes substantial areas of bare ground. Occurs on gravelly red plains. (BVG1M: 31b)
Biodiversity Status	Of Concern
VMR Status	Least concern
EPBC Act	Not listed
Tree Layer	4 – 7 metres *Eucalyptus leucophylla, Eucalyptus pruinosa, Corymbia aparrerinjia, Corymbia terminalis, Atalaya hemiglauca, Corymbia capricornia*

Shrub Layer	0.5 – 2.5 metres *Carissa lanceolata, Salsola kali, Acacia monicola, Acacia lysiphlia Santalum lanceolatum, Acacia holosericea, Capparis lasiantha, Gossypium australe, Grevillea striata, Trema tomentosa var aspera, Hakea cordophylla*
Groundcover	0 – 0.6 metre *Aristida holathera,* Enneapogon polyphyllus*, Triodia pungens, Pennisetum pennisetiforme, Cymbopogon bombycinus, Dicanthium sericeum, Enneapogon oblongus, Eragrostis leptocarpa, Eulalia aurea, Aristida inaequiglumis, Chloris virgata, Setaria surgens, Sporobolus caroli, Crotalaria aridicola, Crotalaria novae-hollindiae, Evolvulus alsinoides, Neptunia gracilis, Fimbrostylis dichotoma, Fimbristylis microcarya, Phyllanthis maderaspatensis, Solanum echinatum, Solanum ellipticum*
Structure Category	Very sparse

6.8.3 Conservation Value

6.8.3.1 Species

Despite targeted searches, no flora species of conservation significance were identified within this community at the time of surveys.

The non-native species of Mimosa (*Acacia farnesiana*), Awnless Barnyard Grass (*Echinochloa colona*), Spiked Malvastrum (*Malvastrum americanum var americanum*), Flannel Weed (*Sida cordifolia*) and Cloncurry Buffel (*Pennisetum pennisetiforme*) inhabit the Silver Box / Cloncurry Box Open Woodland on red earths (Re 1.5.4x3) community. No weeds of national significance were identified.

6.8.3.2 Community

As detailed in Table 13, Silver Box / Cloncurry Box Open Woodland on red earths (Re 1.5.4x3) community is listed as „Least Concern" under the VMR and „Of Concern" under the DERM Biodiversity Status. The „Of Concern" listing is due to Cloncurry Buffel (*Pennisetum pennisetiforme*) invading the ecosystem and changing its floristics and structure. Protected areas within the Northwest Highlands bioregion in which this regional ecosystem occurs includes the Camooweal Caves National Park, Boodjamulla (Lawn Hill) National Park and Lawn Hill (Gregory) Resources Reserve.

The Silver Box / Cloncurry Box community is in a relatively healthy condition, with low density of non-native species. Intact stands of this community are abundant in the region, with the state wide remnant extent being greater than 10,000 ha. It is unlikely the Project will impact on the regional occurrence of this community.

6.9 SUMMARY OF SPECIES OF CONSERVATION SIGNIFICANCE AND PROJECT SITE VEGETATION COMMUNITIES

6.9.1 Species of Conservation Significance

Targeted searches revealed no species of conservation significance to be present within the Project site.

This section discusses species of conservation significance known from the broader region and the potential to occur on the Project site. These species have been identified from a literature review (refer to Section 4.0). Table 14 provides an assessment of the likelihood of these species utilising the Project site. The assessment is based on the knowledge and opinion of AARC staff, information obtained from current field surveys, scientific literature and communications with relevant experts or interest groups.

Table 14 Flora of Conservation Significance Known from the Region Not Identified on the Project site

Botanical Name	Habitat Description	Potential Presence on Site
Brachychiton collinus	Inhabits rocky outcrops and granite country with little other understory present	Habitat for this species is present on the Project site. Despite extensive searches, this conspicuous species was not identified on the Project site. Low potential for presence on site
Fimbristylis distincta	One record from Undilla Homestead, Queensland. Occurred along a stream bank	Habitat for this species is present on the Project site. This species is ephemeral and presence is reliant on water availability. Low Potential for presence on site
Goodenia angustifolia	Occurs within *Corymbia terminalis* low woodland, on sandy loam soils with *Triodia pungens.* Records from Malbon and Duchess, northwest Queensland	Habitat for this species is present on the Project site. Moderate potential for presence on site
Ipomoea antonschmidii	*Eucalyptus leucophloia, Corymbia capricornia, Corymbia aparrerinja* and *Eucalyptus camaldulensis* woodlands. Grows in a variety of habitats, including rocky, sandy and red clay substrates. Occurs along the Lake Julius pipeline, Gunpowder and north of Mount Isa	Habitat for this species is present on the Project site. Extensive searches for any species in the Convolvulaceae family were conducted; however this species was not identified. Moderate potential for presence on site
Ptilotus maconochiei	*Eucalyptus leucophloia* and C*orymbia aspera* woodland, with *Triodia pungens* groundcover. On quartzite ridge tops, hillsides, slopes and shale	Habitat for this species is available on the Project site; however it was not identified despite extensive field surveys for any species in the family Asteraceae. Moderate potential for presence on site

Botanical Name	Habitat Description	Potential Presence on Site
Rhamphicarpa australiensis	Riparian Eucalypt open woodland, small creek channels, *Eucalyptus camaldulensis* woodland; occurs in clay soils and ferruginous/calcrete rock. Patchy distribution from Julia Creek, Gunpowder to Burke and Wills	Some habitat for this species is located on the Project site. Low potential for presence on site

6.9.2 Communities of Conservation Significance

A summary all REs occurring on the Project site is provided below in Table 15.

Table 15 Summary of the Conservation Significance of Regional Ecosystems

Vegetation Community	Regional Ecosystem Equivalents	EPBC Status	Queensland VMR	DERM Biodiversity Status
Snappy Gum Open Woodland on steep hills and strike ridges	1.11.2a	Not Listed	Least Concern	No Concern at Present
Snappy Gum Open Woodland on foothills	1.11.2e	Not Listed	Least Concern	No Concern at Present
Cloncurry Box Open Woodland on low broad hills	1.11.3a	Not Listed	Least Concern	No Concern at Present
Cloncurry Box Open Woodland on hills	1.11.3x1	Not Listed	Least Concern	No Concern at Present
Mixed Bloodwood Riparian Woodland	1.3.6b	Not Listed	Least Concern	Of Concern
River Red Gum Riparian Woodland	1.3.7b	Not Listed	Least Concern	Endangered
Gidgee Open Woodland	1.3.4	Not Listed	Least Concern	Of Concern
Silver Box/ Cloncurry Box Open Woodland on red earths	1.5.4x3	Not Listed	Least Concern	Of Concern

One community (RE 1.3.7b – River Red Gum Riparian Woodland) is listed as „Endangered" under the DERM Biodiversity Status due to severe degradation from high grazing pressure. The overall condition of this community on the Project site is reduced by cattle grazing and weed invasion. Based on proposed disturbance plans and existing tracks within the Project, additional clearing of this

community will be required for Project corridors and TSF. The total area of clearing within this community for the TSF will be 16.72 ha.

The Silver Box/Cloncurry Box Open Woodland (RE 1.5.4x3) is listed as „Of Concern" under the DERM Biodiversity Status due to invasion by Cloncurry Buffel Grass (*Pennisetum pennisforme*). On the Project site the overall condition of this community is relatively healthy with little invasion of introduced species. Based on proposed disturbance plans for the Project, 23.57 ha of clearing will be required in this community.

The Mixed Bloodwood Riparian Woodland (RE 1.3.6b) is listed as „Of Concern" under the DERM Biodiversity Status due to high grazing pressure, changing fire regimes and weed invasion. Based on the proposed plans for the Project, no clearing of this community will be required. Assuming mitigation strategies are implemented, the community is unlikely to be significantly impacted at a regional scale.

7.0 PROJECT SITE FAUNA RESULTS AND DISCUSSION

A combined total of 113 vertebrate fauna species were identified on the Project site (or immediately downstream) during the dry and wet season surveys, comprising 16 reptiles, 65 birds, 26 mammals and 6 amphibians. One mammal species of listed under the NC Act was identified on the Project site. A complete list of all observed fauna species is provided in Appendix C.

Each of the major vertebrate groups observed on the Project site is discussed below in Sections 7.1 to 7.4.

Fauna species of conservation significance along the corridor routes are discussed in Section 8.0.

7.1 AMPHIBIANS

7.1.1 Habitat Values

Many amphibian species that occur in Australia"s drier regions are burrowing species capable of spending extensive periods underground awaiting heavy rain, after which they come to the soil surface to feed and breed. This behaviour is referred to as aestivation and assists in water preservation and survival during prolonged drought (Withers 1995). Consequently, the vast majority of amphibians from seasonally dry regions occur in areas where the ground is soft enough to allow digging during wet periods.

Non-burrowing frog species also inhabit Australia"s drier regions where they adopt different survival strategies, such as sheltering deep in tree hollows or cool rock crevices. These species are typically associated with permanent water sources.

Amphibian habitat on the Project site varies seasonally due to the ephemeral nature of creeks and associated drainage lines. During the dry season (May-October), sandy drainage lines offer the only potential habitat. During the wet season (November-April), habitat variation and suitability increases in response to increased rainfall.

7.1.2 Observed Species

Most common amphibian species identified on the Project site included the Green Tree Frog (*Litoria caerula*), Ornate Burrowing Frog (*Platyplectrum ornatum*) and the non-native Cane Toad (*Rhinella marina*). The Red Tree Frog (*Litoria rubella*) (Photo Plate 12) was frequently observed near current exploration camp facilities. Less commonly observed species included the Giant Frog (*Cyclorana australis*) and Pale Tree Frog (*Litoria pallida*).



Photo Plate 12 Red Tree Frog seeking refuge in an *Acacia holosericea* phyllode

7.1.3 Amphibians of Conservation Significance

No amphibians of conservation significance have been previously recorded within the region (Appendix A). It is considered unlikely that any amphibian species of conservation significance occur on the Project site.

7.2 REPTILES

7.2.1 Habitat Values

Australia"s environment supports an extremely diverse assemblage of reptile species which exploit a wide array of micro-habitats (e.g. tree hollows, soil cracks) and food sources (e.g. succulent leaves, termites, grasshoppers, birds, and other reptiles) (Pianka 1969a; 1969b). This diversity encompasses species of widely different body sizes (skinks v. monitors), and life history strategies (burrowing blind snakes v. arboreal geckos).

The Project site provides a variety of habitat types thought to be suitable for reptile species occurring in the region. Micro-habitats such as those associated with tree hollows, vegetated watercourses, open woodlands scattered with fallen timber and rocky outcrops may suit a variety of reptile species.

7.2.2 Observed Species

A total of 16 reptile species were observed on the Project site. All reptile species recorded on the Project site are listed in Appendix C.

Skinks were the most diverse reptile group encountered and was represented by six species, comprising *Cryptoblepharus plagiocephalus sensu lato*, Stout Ctenotus (*Ctenotus herbetior*), Gravelly-soil Ctenotus (*Ctenotus lateralis*), Leopard Ctenotus (*Ctenotus pantherinus*), Northern Soil-crevice Skink (*Proablepharus tenuis*) and the Centralian Blue-tongue (*Tiliqua multifasciata*).

Four gecko species were identified, predominantly whilst spotlighting in watercourses. These included the Fat-tailed Gecko (*Diplodactylus conspiculatus*), Spotted Gecko (*Gehyra nana*), Tree Dtella (*Gehyra variegata*) and Bynoe"s Gecko (*Heteronotia binoei*).

The remaining six reptile species observed on the Project site were the Gilbert"s Dragon (*Amphibolurus gilberti*), Two-lined Dragon (*Diporiphora australis*) (Photo Plate 13), Yellow-sided Two-lined Dragon (*Diporiphora magna*), Black-headed Python (*Aspidites melanocephalus*), Stimpson"s Python (*Antaresia stimsoni*) and Orange-naped Snake (*Furnia ornatus*).



Photo Plate 13 Two-lined Dragon observed on the Project site during the Wet Season Survey

7.2.3 Reptiles of Conservation Significance

No reptiles of conservation significance were observed on the Project site during the wet or dry season surveys and none have been previously recorded within the region (Appendix A). Therefore, it is considered unlikely that any reptile species of conservation significance occur on the Project site.

7.3 BIRDS

7.3.1 Habitat Values

Avian assemblages are generally determined by factors such as food sources (e.g. fruit, nectar, seeds, and insects), as well as a mosaic of habitat structures such as grasses, thick understorey, midstorey and canopy vegetation (i.e. vertical habitat complexity). Generally, the more food sources available and the more complex the structure of the vegetation, the more diverse the avifauna.

Food sources on the Project site are generally restricted to seeds, nectar, insects and vertebrate prey items (or carrion). The Project site largely lacked a permanent or abundant supply of fruit producing plant species, suggesting fructivorous species are less likely to occur.

7.3.2 Observed Species

A combined total of 65 bird species were recorded on the Project site during the wet and dry season surveys, with all species considered common throughout the region. All bird species recorded on the Project site are listed in Appendix C.

Granivorous birds were well represented on Project site with the Peaceful Dove (*Geopelia striata*), Spinifex Pigeon (*Geophaps plumiferal*), Crested/Spinifex Pigeon (*Ocyphaps lophotes*), Common Bronzewing (*Phaps chalcoptera*), Sulphur-crested Cockatoo (*Cacatua galerita*), Galah (*Cacatua roseicapilla*), Painted Finch (*Emblema pictum*), Double-barred Finch (*Taeniopygia bichenovii*) and Zebra Finch (*Taeniopygia guttata*) commonly observed.

Four raptor species were observed on the Project site during the surveys, including the Wedge-tail Eagle (*Aquila audax*), Black Falcon (*Falco subniger*), Whistling Kite (*Haliastur sphenurus*) and Black Kite (*Milvus migrans*). In addition to these species several other birds were detected that are known to feed on vertebrate species, including the Azure Kingfisher (*Alcedo azurea*), Laughing Kookaburra (*Dacelo novaeguineae*), and Tawny Frogmouth (*Podargus strigoides*) (Photo Plate 14).

7.3.3 Birds of Conservation Significance

No bird species of conservation significance under the NCWR were observed on the Project site during the wet or dry season surveys. Species of conservation significance known from the region which were not detected during the surveys are discussed in Section 7.6.

7.3.3.1 EPBC Act Listed Migratory and Marine Species

One Migratory species listed under the EPBC Act were observed on the Project site during the survey, the Rainbow Bee-eater (*Merops ornatus*). The Rainbow Bee-eater (*Merops ornatus*) inhabits all of mainland Queensland, as well as Indonesia, New Guinea and the Solomon Islands. This species is widespread and breeds throughout most of its range, with the exception of southern birds, which move north to breed. Species which utilise the Project site are not at the extent of their known range and the population in the area do not constitute an „ecologically significant proportion" of the total population of this species. Impacts from the Project are unlikely to have influence on the regional population the Rainbow Bee-eater (*Merops ornatus*).

Three Marine species listed under the EPBC Act were observed on the Project site, which included the Whistling Kite (*Haliastur sphenurus*), Sacred Kingfisher (*Todiramphus sanctus*) and Rainbow Bee-

eater (*Merops ornatus*). The Sacred Kingfisher (*Todiramphus sanctus*) is common throughout mainland Australia, as well as Indonesia and New Zealand. This species spends the winter in the north of its distributional range, returning south in the spring to breed. The number of species on site does not form an „ecologically significant portion" of the total species population. The distribution of the Whistling Kite (*Haliastur sphenurus*) includes most of Australia, as well as New Guinea, the Solomons and New Caledonia. The species is a resident to northern and western Australia. Therefore, it is unlikely the Project will have a significant impact on the regional populations of these species.The local populations of all three abovementioned species observed on the Project site are unlikely to constitute an „ecologically significant proportion" of the total population of each species. Furthermore, the Project site is not at the limit of these species" range, nor are these species considered to be declining within the region.



Photo Plate 14 The Tawny Frogmouth was observed on Site during a Spotlighting Activity

7.4 MAMMALS

7.4.1 Habitat Values

The morphology of mammal species varies widely from small rodents to larger kangaroos and even bats. The ecology of each of these groups is equally variable and they are assessed separately in the following sections.

7.4.1.1 Small Mammals

Habitats suitable for small mammals include areas that provide a plentiful food source and suitable shelter sites. The highest density of small mammal species is usually associated with reliable rainfall which is reflected in a reliable source of food and dense ground vegetation, particularly shrubs and grasses.

The diversity of small mammals is often limited by the lack of a predictable food supply and open ground vegetation. Consequently, small mammal populations can fluctuate dramatically in response to rain which increases seed production and insect abundance. During less favourable periods, small mammal populations can be very low.

The Project site provided a variety of habitat types suitable for small ground-dwelling mammals, including open woodlands, vegetated water courses and rocky outcrops and escarpments. Despite the range of habitat types, the presence of water was minimal during the survey which is a significant limiting factor regarding the abundance of small mammals.

7.4.1.2 Medium and Large Mammals

Factors affecting the occurrence of medium and large sized mammals are varied. Important factors can include land-clearing, feral animal predation and grazing pressures. Consequently, medium-sized mammals are considered to be highly populated in most of eastern Australia.

Habitats on the Project site do not include areas of dense native vegetation. Rather, the open grassy woodland is typical of the region, and this is likely to be reflected in the medium-sized mammal community. Rocky outcrops associated with the Knapdale Range provides habitat for rock-wallabies to roost and forage.

In contrast, larger mammals such as kangaroos have been much less affected by predation and land clearing activities. In fact, many species have flourished in response to increased areas of grassland and open vegetation. Habitat on the Project site for this mammal group is favourable.

7.4.1.3 Arboreal Mammals

The majority of arboreal mammals that occur in Australia utilise tree hollows for nesting and shelter (Menkhorst and Knight 2004). A shortage of nest hollows is likely to limit arboreal mammal populations where the density of hollow bearing trees is less than two to eight trees per ha (Smith and Lindenmayer 1988).

Hollow-bearing trees in the broader region generally occur along creek-lines, separated by open areas that would be difficult for arboreal mammals to cross without venturing onto the ground. This vegetation structure is comparable on the Project site, with hollow bearing trees noted in the River Red Gum Riparian Woodland (RE 1.3.7b).

7.4.1.4 Bats

The density and diversity of Australian bat species is determined primarily by the availability of suitable nesting and roosting sites. Roosting sites can include locations such as thick foliage, loose exfoliating bark, rock caves or cavities, tree hollows or even fabricated structures such as old buildings and culverts (Churchill 1998).

Consequently, areas with a large number of hollow-bearing trees that occur within remnant vegetation are of high value to many bat species. As bats have a small body size, these hollows can be much smaller in size than required by arboreal mammals. Possible roosting sites were present on the Project site and included tree hollows in the River Red Gum Riparian Woodland (RE 1.3.7b), caves and crevices in the rocky outcrop areas and disused mining shafts. Hollows were also observed in the Snappy Gum (*Eucalyptus leucophloia*) trees, in both RE 1.11.2a and RE 1.11.2e.

7.4.2 Observed Species

In total, 26 mammal species were observed on the Project site, comprising 22 native and four introduced species.

Three of the introduced species are classified as Class 2 pest animals under the LP Act, including the Dingo (*Canis familiaris dingo*), Feral Cat (*Felis catus*) and Feral Pig (*Sus scrofa*), with the House Mouse (*Mus musculus*) classified as a Class 1 pest. Discussion of these introduced species is provided in Section 7.6. All mammal species recorded on the Project site are listed in Appendix C.

Four mammal species observed on the Project site included the Desert Mouse (*Pseudomys desertor*), an unidentified mouse (*Pseudomys sp.*) Common Rock Rat (*Zyzomys argurus*), Common Wallaroo (*Macropus robustus*) and Red Kangaroo (*Macropus rufus*). The unidentified mouse (*Pseudomys sp.*) was captured in March 2008. Supplementary trapping was conducted during March 2011, within similar habitat types, but no small mammals were captured during this time.

A total of 14 micro-bat species were identified on the Project site, all of which are not listed under the EPBC Act or NCWR. Commonly identified species, with more than 20 positive calls recorded most nights, included Inland Broad-nosed Bat (*Scotorepens balstoni*), Inland Forest Bat (*Vespadelus baverstocki*) and Yellow-bellied Sheath-tailed Bat (*Saccolaimus flaviventris*). Species identified less frequently include the Troughton"s Sheathtail Bat (*Taphozous troughtoni*), Common Sheathtail Bat (*Taphozous georgianus*) and unknown Freetail Bat (*Mormopterus sp.*). Additional species identified included the Beccari;s Freetail Bat (*Mormopeterus beccarii*), Eastern Little Freetail Bat (*Mormopterus loriae ridei*), Gould"s Wattled Bat (*Chalinolobus gouldii*), Northern Free-tailed Bat (*Chaerephon jobensis*), unknown Long-eared Bat (*Nyctophilus sp.*), Little Broad-nosed Bat (*Scotorepens greyii*), Northern Cave Bat (*Vespadelus courinus*) and Hoary Wattled Bat (*Chalinolobus nigrogriseus*). The Long-eared Bat *(Nyctophilus sp.)* could not be identified to species because it cannot be reliably differentiated from call data. Long-eared Bats generally produce distinctive calls. The species likeliest to be present in the Project area is *N. geoffroyi.* Three other species *(N. arnhemensis, N. daedelus and N. walkeri)* also occur in the far northwest of Queensland but are primarily restricted to moist habitats such as watercourses lined with pandanus and paperbark.

The River Red Gum Riparian Woodland (RE 1.3.7b) held the highest abundance of microbats, although areas such as rocky outcrops on hills, Snappy Gum (*Eucalyptus leucophloia*) hollows and manmade structures such as abandoned mine shafts and the current exploration camp provided ample roosting and feeding habitat.

Appendix D details the ANABAT analysis results.

7.4.3 Mammal Species of Conservation Significance

One mammal of conservation significance was observed on the Project site, the Purple-necked Rock-wallaby (*Petrogale purpureicollis*). The Rock-wallaby species is listed as Vulnerable under the NC Act. Species listed under the NC Act are published in the associated NCWR. This species is not listed under the Commonwealth EPBC Act.

This species inhabits steep hillsides with rocky outcrops, most of which were adjacent watercourses. The Purple-necked Rock-wallaby (*Petrogale purpureicollis*) inhabits areas along lower faces of the Knapdale Range and was observed within REs 1.11.2a and 1.3.7b. A total of five individuals were counted at three different outcrop structures, although it is expected many more individuals would be present along the Knapdale Range.

All Rock-wallabies favour habitat with cliffs, rocky slopes and outcrops or boulder piles. They are often found in outcrop formations, in association with dry Eucalypt (*Eucalytpus spp.*) and Wattle (*Acacia spp.*) woodlands and Spinifex (*Triodia spp.*) grasslands. Large successful populations generally have access to permanent freshwater and populations may wither without it during extended droughts. However, Purple-necked Rock-wallabies are highly adapted to dry conditions and can obtain their water from dew and by extracting it from herbage (Van Dyck and Strahan 2008). Rock-wallabies exhibit strong fidelity to home ranges and their movements between roosting sites and feeding areas are highly predictable (Horsup 1994).

Rocky habitat used by Rock-wallabies provides protection from predation by species such as Dingos (*Canis lupus dingo*), Foxes (*Vulpes vulpes*) and Wedge-tailed Eagles (*Aquila audux*) as well as temperature extremes during the day. At night they move over larger areas to feed on plants growing in deeper soils (Law and Dickman 1988). Caves within rocky outcrops provide a micro environment that buffers temperatures and maintain higher levels of humidity than outside the rocks (Short 1982).

Menkhorst and Knight (2011) describe Purple-necked Rock-wallaby (*Petrogale purpureicollis*) distribution as locally common in rocky areas of central western Queensland from Kajabbi south to Dajarra and from west of Mt Isa to the eastern end of Selwyn Range. AARC has recorded this species on a number of fauna surveys conducted in the region

Species of conservation significance known from the region which were not detected during the survey are discussed in Section 7.5.

7.5 OTHER THREATENED SPECIES FROM THE REGION

This section discusses species of conservation significance that are known from the broader region but that are considered unlikely to occur on the Project site. These species have been identified from wildlife database searches (Appendix A) and scientific literature searches. The assessment is based on the knowledge and opinion of AARC staff, information obtained from the current field surveys, scientific literature, and communications with relevant experts or interest groups.

Table 16 Threatened Fauna from the Region Not Observed on the Project site

Scientific Name Common Name	Conservation Status		Habitat	Notes
	EPBC Act	NCWR		
Heteromunia pectoralis Pictorella Mannikin	-	Near Threatened	Prefers tall grass in Acacia woodlands near water and grassy flats and occasionally Spinifex tuffs. Distributed in tropical northern Australia, noted to migrate coastward in dry season and inland in wet (Pizzey and Knight 2010).	Some suitable habitat may occur on Site. However given the amount of surrounding habitat it is unlikely the Site constitutes critical habitat range. Furthermore, given the species range, it is unlikely the Project will have an adverse impact on this species should it occur intermittently.
Ephippiorhynchus asiaticus Black-Necked Stork	-	Near Threatened	Prefers open freshwater environments, including the margins of swamps, shallow floodwaters over grasslands, wet shorelines, margins of mangroves, mudflats and estuaries (Morcombe 2002).	Limited habitat occurs on Site, furthermore given the habitat associated with major watercourses in the region such as the Dugald River, it is likely the species would prefer these sites given their habitat suitability.
Melithreptus gularis Black Chinned Honey Eater	-	Near Threatened	The Black-chinned Honeyeater is found on mainland Australia from the Gulf Country of Queensland south to Cloncurry and is widespread in central and eastern Queensland. It is found in the upper levels of open eucalypt forests and woodlands dominated by box and ironback eucalypts. It is often found along waterways, especially in arid and semi-arid areas (Birds in Backyards website).	Suitable habitat occurs on Site. Although unlikely, given its scarcity, it is possible that this species may intermittently occur on Site.
Rostratula australis Australian Painted Snipe	Vulnerable	Vulnerable	This species inhabits shallow inland wetlands, either permanent or temporary (Marchant and Higgins 1993).	Limited habitat occurs on Site, furthermore given the habitat associated with major watercourses in the region such as the Dugald River, it is likely the species would prefer these sites given their habitat suitability.

Scientific Name Common Name	Conservation Status		Habitat	Notes
	EPBC Act	NCWR		
Julia Creek Dunnart	Endangered	Endangered	Inhabits the Mitchell Grass Downs and Desert Uplands bioregion, sheltering in cracking clay soils during dry seasons and in low grasses during summer rain.	Cracking clays do not occur on or adjacent to the Project site, therefore it is unlikely this species would utilise the Project site.
Pristis microdon Freshwater Sawfish	Vulnerable	-	A bottom-dweller of estuaries and the lower reaches of large river systems; sometimes penetrating substantial distances upstream (Allen, Midgley and Allen 2003).	No suitable habitat occurs on the Project site nor is likely to occur in the event of seasonally high rainfall.
Haliaeetus leucogaster White-bellied Sea-Eagle	Migratory/Marine	-	White-bellied Sea-Eagles are a common sight in coastal and near coastal areas of Australia. Often seen perched high in a tree, or soaring over waterways and adjacent land (Birds in Backyards website).	Unlikely to occur on Site given the range of the species and Project distance from the coast.
Ardea alba Great Egret, White Egret	Migratory/Marine	-	Great Egrets occur throughout most of the world. They are common throughout Australia, with the exception of the most arid areas. Known to prefer shallow water, particularly when flowing, but may be seen on any watered area, including damp grasslands (Birds in Backyards website).	Limited habitat occurs on Site, furthermore given the habitat associated with major watercourses in the region such as the Dugald River, it is likely the species would prefer these sites given their habitat suitability.
Ardea ibis Cattle Egret	Migratory/Marine	-	In Australia it is most widespread and common in north-eastern Western Australia across the Top End, Northern Territory, and in south-eastern Australia from Bundaberg, Queensland to Port Augusta, South Australia, including Tasmania. The species is found in grasslands, woodlands and wetlands, and is not common in arid areas. It also uses pastures and croplands, especially where drainage is poor. Will also forage at garbage dumps, and is often seen with cattle and other stock (Birds in Backyards website).	Limited habitat occurs on Site, furthermore given the habitat associated with major watercourses in the region such as the Dugald River, it is likely the species would prefer these sites given their habitat suitability.

Scientific Name Common Name	Conservation Status		Habitat	Notes
	EPBC Act	NCWR		
Charadrius veredus Oriental Plover, Oriental Dotterel	Migratory/Marine	-	The Oriental Plover has been recorded in all states but most common in coastal areas across northern Australia. The species is found generally inland; in open grasslands in arid and semi-arid zones; and less often in estuarine or littoral environments. Known to prefer flat inland plains, sparsely vegetated short grass with hard bare ground including claypans, playing fields, lawns and cattle camps (Birds in Backyards website).	May intermittently occur on Site, however given the species range, the Project is unlikely to constitute an ecologically proportion of its habitat.
Glareola maldivarum Oriental Pratincole	Migratory/Marine	-	The Oriental Pratincole prefers open country, and is often seen near water in the evening, hawking for insects. They are found in warmer parts of south and east Asia, breeding from northern India across to China and Europe, wintering in India, Indonesia and northern Australia (Birds in Backyards website).	Unlikely to occur on Site given the lack of preferred habitat and highly transient behaviour.
Numenius minutes Little Curlew, Little Whimbrel	Migratory/Marine	-	Prefers coastal grasslands, plains and often recreational areas. May forage in dry habitat but congregate at freshwater sources. Most commonly inhabits sheltered coastal and inshore waters, and migrates regularly across the region (Pizzey and Knight 2010)	Unlikely to occur on Site given the lack of permanent water and highly transient behaviour.
Rostratula benghalensis s. lat Painted Snipe	Migratory/Marine	-	Occurs in terrestrial shallow freshwater wetlands, ephemeral waterbodies, dams and permanent lakes etc (Marchant and Higgins 1993).	Limited habitat occurs on Site, furthermore given the habitat associated with major watercourses in the region such as the Dugald River, it is likely the species would prefer these sites given their habitat suitability

Scientific Name Common Name	Conservation Status		Habitat	Notes
	EPBC Act	NCWR		
Apus pacificus Fork-tailed Swift	Migratory/Marine	-	Pacific Swifts breeds from central Siberia eastwards through Asia, wintering south to Australia. They are aerial birds.	May seasonally occur on Site, however despite extensive searches during the dry season survey, no species were observed.
Crocodylus johnstoni Freshwater Crocodile	Marine	-	Known to inhabit freshwater lagoons, billabongs, lakes and ephemeral watercourses throughout northern Australia.	No suitable habitat occurs on Site and therefore is unlikely to occur on Site.

7.6 PEST SPECIES

Four introduced species, listed as pest species under the LP Act, were detected on the Project site during the wet and dry season surveys. Species observed included:

1. House Mouse (*Mus musculus*) listed as a Class 1 pest under the LP Act;
2. Dingo (*Canis lupus familiaris*) listed as a Class 2 pest under the LP Act;
3. Feral Cat (*Felis catus*) listed as a Class 2 pest under the LP Act; and
4. Feral Pig (*Sus scrofa*) listed as a Class 2 pest under the LP Act.

Each of the Class 2 pests are discussed below, while Appendix D details Department of Employment, Economic Development and Innovation (DEEDI) Pest Fact Sheets for all observed pest species.

Dingoes (*Canis lupus familiaris*) can carry diseases such as distemper, parvovirus as well as parasites and are known to prey on native fauna and farm species, causing both ecological and economic damage. Dingoes (*Canis lupus familiaris*) were observed during routine assessment activities during both daylight hours and during spotlighting events. They were considered common on Project site and are known from the broader region.

The Feral Cat (*Felis catus*) is listed as a Class 2 pest under the LP Act. Most active at night, with peak hunting occurring soon after sunset and in the early hours before sunrise, cats display a distinct green eye shine under spotlight. Feral Cats (*Felis catus*) were observed whilst spotlighting on the Project site. Known to cause ecological harm, via habitat destruction, disease distribution and native species predation, cats are present Australia wide, thriving under all climatic conditions and in vastly different types of terrain.

Feral Pigs (*Sus scrofa*) will eat almost any available plant material, but prefer succulent green herbage. They wallow in mud along watercourses, destroy habitat for native animals, and spread weed seeds. They damage almost all crops from sowing to harvest, damage pastures by grazing and rooting and carry many diseases and parasites. And their destructive nature is often a hindrance to any re-vegetation/ rehabilitation plans. Pigs were observed on Project site along and within watercourses. They were not considered a resident population given the lack of water and subsequent available habitat.

8.0 CORRIDOR RESULTS

8.1 POWERLINE

The powerline corridor spans 60 km, from the Chumvale sub-station near Cloncurry north to the Project site. A width of 400 m has been assessed to define vegetation communities, identify and map features of conservation significance and identify and locate weed species. Features of conservation significance inhabiting the powerline corridor include the River Red Gum Riparian Woodland (RE 1.3.7) community and Purple-necked Rock-wallaby (*Petrogale purpureicollis*) habitat.

8.1.1 Vegetation Communities

Six vegetation communities inhabit the powerline corridor (refer to Figure 8, Figure 9 and Figure 10 for community locations). Each of these are briefly described, with corresponding conservation status in Table 17 below. Sections 8.1.1.1 to 8.1.1.6 further describe each vegetation community.

Table 17 Vegetation Communities and Corresponding Conservation Status within the Powerline Corridor

Vegetation Community / RE	Community Description	EPBC Status	Queensland VMR	DERM Biodiversity Status
Snappy Gum Open Woodland / 1.11.2a	Low open-woodland of *Eucalyptus leucophloia* often with *Corymbia spp., Terminalia aridicola and Eucalyptus leucophylla* with shrub layer of *Acacia spp.* and ground layer of *Triodia spp.* Occurs on steep hills and strike ridges	Not Listed	Least Concern	No Concern at Present
Cloncurry Box Open Woodland / 1.11.3x1	Low open-woodland of *Eucalyptus leucophylla* often with *Corymbia terminalis* and *Eucalyptus leucophloia* with i. dominated shrub layer and ground layer of *Triodia spp*. and/or tussock grasses. Includes areas of *Acacia spp*. shrubland and *Triodia spp*. grassland. Occurs on hills on strongly folded pre-Cambrian rocks; skeletal soils, some shallow loams	Not Listed	Least Concern	No Concern at Present

Vegetation Community / RE	Community Description	EPBC Status	Queensland VMR	DERM Biodiversity Status
River Red Gum Riparian Woodland / RE 1.3.7a / RE 1.3.7b	Riverine wetland or fringing riverine wetland. Fringing woodland of *Eucalyptus camaldulensis*, usually with *Lophostemon grandiflorus* and *Melaleuca leucadendra* and/or *M. argentea*. Occurs on recent levees and channel deposits of major watercourses and larger tributaries.	Not Listed	Least Concern	Endangered
Gidgee Open Woodland / 1.11.2x2	Low open-woodland and low woodland of *Acacia cambagei* over annual grasses. Occasional *Atalaya hemiglauca, Hakea lorea subsp. lorea, Grevillea striata and Acacia excelsa*. Occurs on red or brown earths and clays.	Not Listed	Least Concern	No Concern at Present
Mixed Bloodwood Riparian Woodland / 1.3.6	Woodland and low woodland of *Corymbia aparrerinja* and *C. terminalis. Acacia victoriae* may dominate heavier soils. Occurs on terraces and floodplains on Quaternary alluvium; alluvial soils, some earths and deep yellow podzolics.	Not Listed	Least Concern	Of Concern
Non-remnant Grassland	Cleared woodlands with species composition different than prior to clearing.	Not Listed	Not Listed	Not Listed

8.1.1.1 Snappy Gum Open Woodland

The Snappy Gum Open Woodland (RE 1.11.2a) community is equivalent to the community found on the Project site. Refer to Section 6.1 for a detailed community description.

The Snappy Gum Open Woodland (RE 1.11.2a), is listed as „Least Concern" under the VMR, „No Concern at Present" under the DERM Biodiversity Status and is not listed under the EPBC Act.

Based on proposed disturbance plans for the Project, additional clearing of the Snappy Gum Open Woodland (RE 1.11.2a)will be required. The powerline easement is proposed to be 80 m in width; this width has been used to calculate the footprint disturbance within the Snappy Gum Open Woodland community. Estimated vegetation disturbance from construction of the powerline is approximately 54 ha. It is unlikely disturbance within this community will significantly impact on the regional occurrence of this community.

8.1.1.2 Cloncurry Box Open Woodland

The Cloncurry Box Open Woodland (RE 1.11.3x1) community is identical to the community found within the Project site. Refer to Section 6.4 for a detailed community description.

The Cloncurry Box Open Woodland (RE 1.11.3x1), is listed as „Least Concern" under the VMR, „No Concern at Present" under the DERM Biodiversity Status and is not listed under the EPBC Act.

Based on proposed disturbance plans for the Project and an assumed disturbance width of 80 m, the estimated additional vegetation disturbance within the Cloncurry Box Open Woodland (RE 1.11.3x1) is approximately 328 ha. It is unlikely disturbance within the powerline corridor will significantly impact on the regional occurrence of this community.

8.1.1.3 River Red Gum Riparian Woodland

Two variations of the River Red Gum Riparian Woodland (RE 1.3.7) exist along the powerline corridor; (i) vegetation associated with smaller creek lines (RE 1.3.7b), and (ii) vegetation associated with larger watercourses (Re 1.3.7a). The River Red Gum community along the smaller creek lines (variation a) is identical to the community within the Project site. Refer to Section 6.6 for a detailed community description. Dominant vegetation associated with larger watercourses (variation ii) is listed in Table 18 below.

The River Red Gum Riparian Woodland (RE 1.3.7a) is listed as „Least Concern" under the VMR and is not listed under the EPBC Act. However, the DERM Biodiversity Status lists this RE as being „Endangered".

Based on proposed disturbance plans for the Project and the assumed corridor width of 80 m, additional vegetation disturbance of the River Red Gum Riparian Woodland is estimated to be approximately 23 ha. As RE 1.3.7 is defined as a “riverine wetland” or “fringing riverine wetland”, the *Policy for Vegetation Management Offsets* may be applied (refer to Section 3.7). Assuming appropriate mitigation strategies are implemented, it is unlikely the Project will adversely affect the health or abundance of this community.

Table 18 Community 6 (RE 1.3.7a) – Vegetation Community Description

Community	River Red Gum Riparian Woodland
Regional Ecosystem	RE 1.3.7a: 1.3.7a: Riverine wetland or fringing riverine wetland. Fringing woodland of *Eucalyptus camaldulensis*, usually with *Lophostemon grandiflorus* and *Melaleuca leucadendra* and/or *Melaleuca argentea*. Occurs on recent levees and channel deposits of major watercourses and larger tributaries. (BVG1M: 16a)
Biodiversity Status	Endangered
VMR Status	Least concern
EPBC Act	Not listed
Tree Layer	15 – 18 metres *Eucalyptus camaldulensis, Melaleuca leucadendra, Lophostomon grandiflorus, Corymbia aparrerinjia*

Shrub Layer	1 – 3 metres *Acacia holosericea, Atalaya hemiglauca, Lysiphyllum cunninghamii Vitex trifolia var trifolia Acacia monticola, Acacia retivenea, Acacia torulosa,Carissa lanceolata, Sesbania javacina, Ficus aculeata, Hakea aborescens,*
Groundcover	0 – 1 metre *Pennisetum ciliare, Aristida latifolia, Cymbopogon bombycinus, Dicanthium sericeum, Eragrostis basedowii, Cyperus conicus car conicus, Cyperus difformis, Cyperus pulchellus, Cyperus microcephalus, Fimbristylis littoralis, Frimbristylis microcarya, Alternanthera denticulata, Anisomeles malabartica, Bonamia media, Crotalaria dissitiflora, Evolvulus alsinoides, Indigofera colutea, Iphigenia indica*
Structure Category	Sparse

8.1.1.4 Gidgee Open Woodland

The Gidgee Open Woodland (RE 1.11.2x2) inhabiting the power line corridor is synonymous with the community found on the Project site. Refer to Section 6.7 for a detailed description of this community.

The Gidgee Open Woodland (RE 1.11.2x2) community is listed as „Least Concern" under the VMR, „No Concern at Present" under the DERM Biodiversity Status and is not listed under the EPBC Act.

Based on the proposed powerline width being 80 m, additional vegetation disturbance of the Gidgee Open Woodland (RE 1.11.2x2) will be required. The estimated total area of disturbance within the Gidgee Open Woodland community caused by the powerline construction is estimated to be approximately 75 ha. It is unlikely disturbance within the power line corridor will significantly impact on the regional occurrence or health of this community.

8.1.1.5 Mixed Bloodwood Riparian Woodland

The Mixed Bloodwood Riparian Woodland (RE 1.3.6b) inhabiting the power line corridor is identical with the community found on the Project site. Refer to Section 6.5 for a detailed description of this community.

The Mixed Bloodwood Riparian Woodland (RE 1.3.6b) community is listed as „Least Concern" under the VMR and is not listed under the EPBC Act. However, the DERM Biodiversity Status lists this RE as being „Of Concern".

Based on proposed disturbance plans for the Project and a corridor footprint width of 80 m, the estimated additional vegetation disturbance of the Mixed Bloodwood Riparian Woodland (Re 1.3.6b) will be approximately 12 ha. It is unlikely disturbance within the powerline corridor will significantly impact on the regional occurrence of this community.

8.1.1.6 Non-remnant Grassland

One section of the powerline corridor area has been cleared and is primarily used for stock grazing. Based upon the proposed plans for the Project and an assumed footprint width of 80 m, the estimated

area of Non-remnant Grassland within the corridor is 15 ha. This community is not listed under any Queensland or Commonwealth legislation.

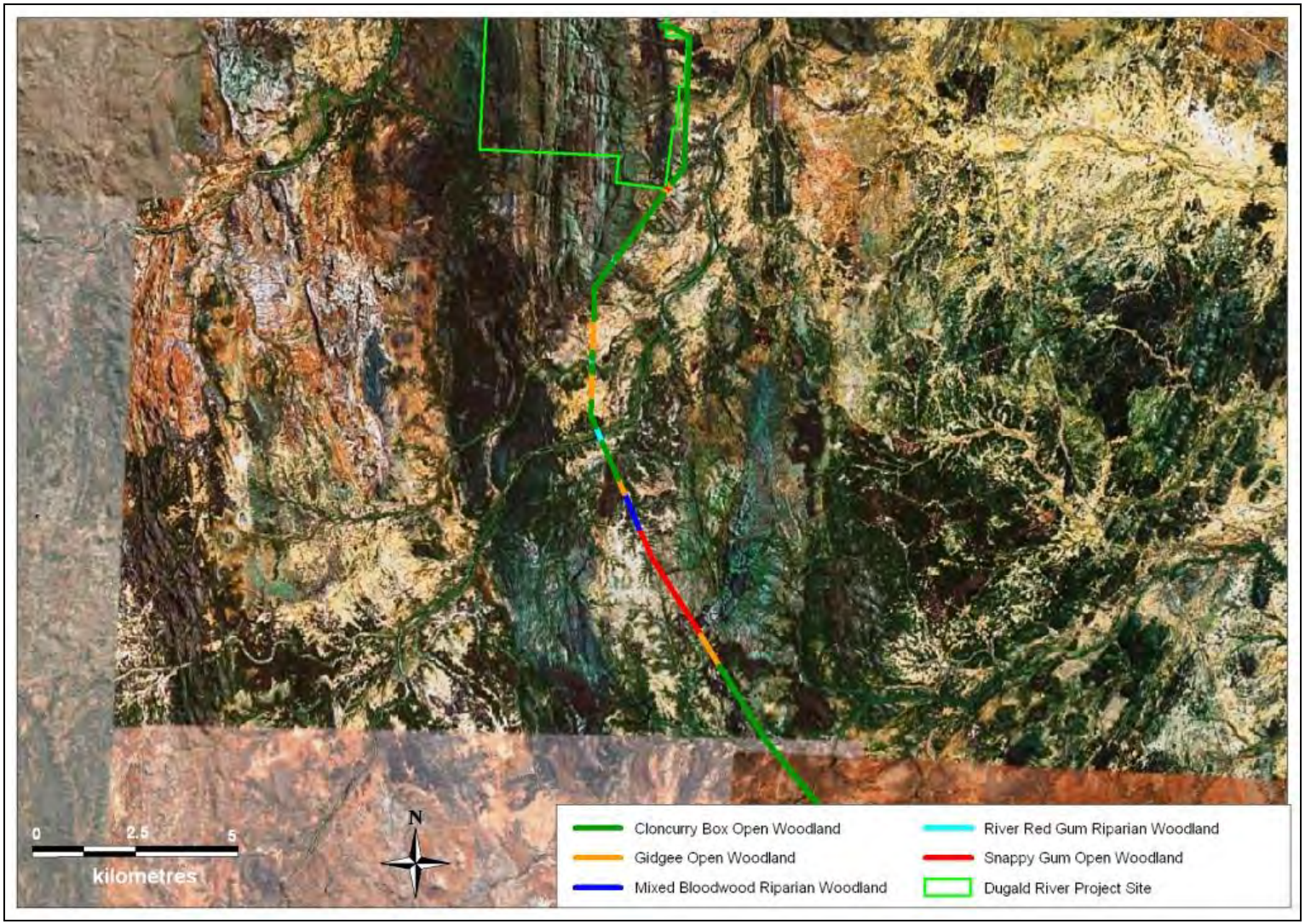


Figure 8 Vegetation Communities within the Northern Section of the Powerline Corridor

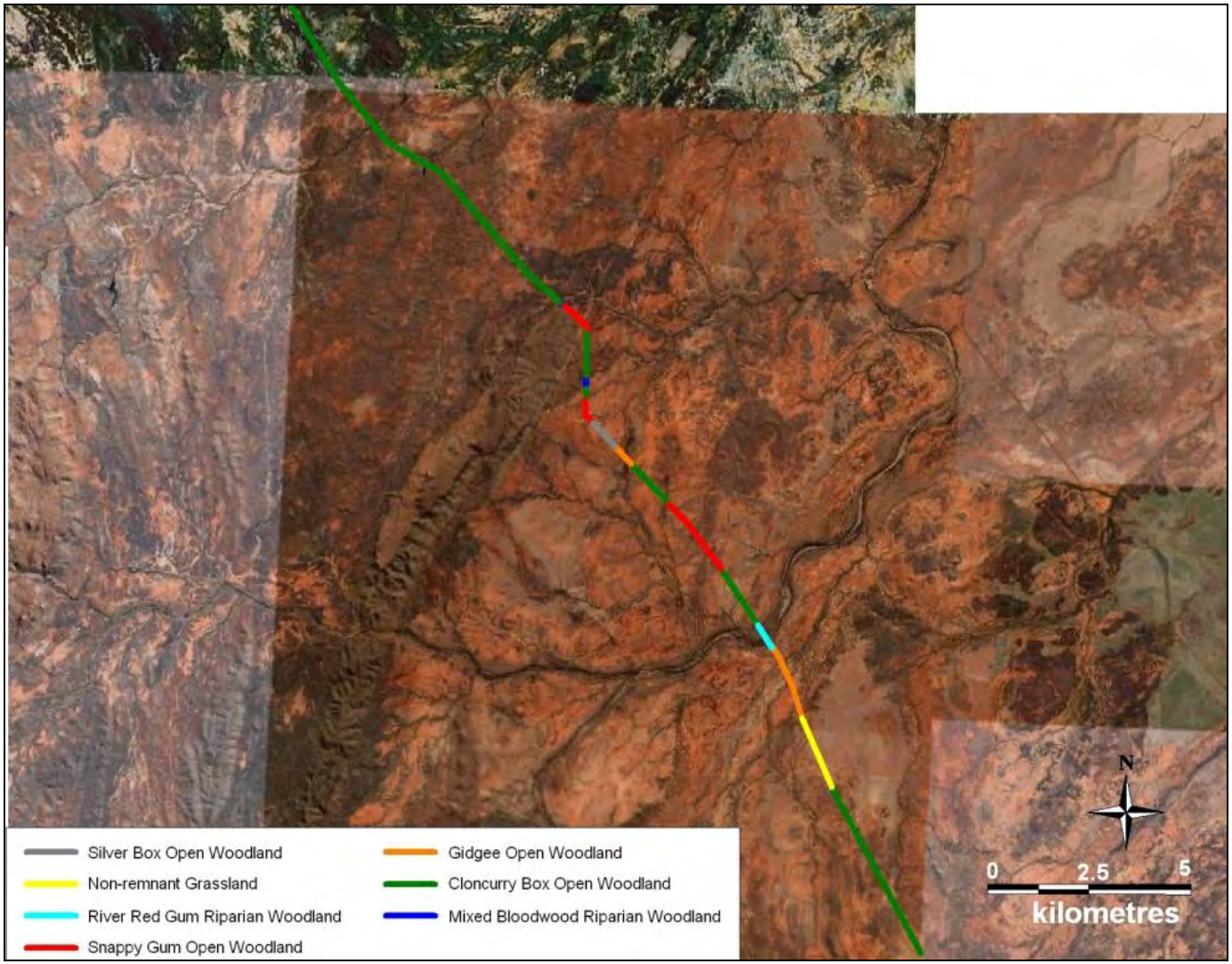


Figure 9 Vegetation Communities within the Central Section of the Powerline Corridor



Figure 10 Vegetation Communities within the Southern Section of the Powerline Corridor

8.1.2 Features of Conservation and Management Significance

Two features of conservation significance inhabit the powerline corridor. These include:

- River Red Gum Riparian community (RE 1.3.7). This community is listed as Endangered under the DERM Biodiversity Status; and
- Rocky outcrops containing Purple-necked Rock-wallaby (*Petrogale purpureicollis*) habitat. This Rock-wallaby species is listed as Vulnerable under the NCWR.

Two areas of weed management significance were also identified within the powerline corridor. These areas contain a high number of introduced species and are discussed further in Section 8.1.2.4.

Features of conservation and management significance are depicted in Figure 11, Figure 12 and Figure 13 below. Transect locations have been overlaid on aerial photographs and have been divided into three sections, northern, central and southern. The powerline corridor maps were divided in this manner due to the length making it difficult to distinguish features on a single map.

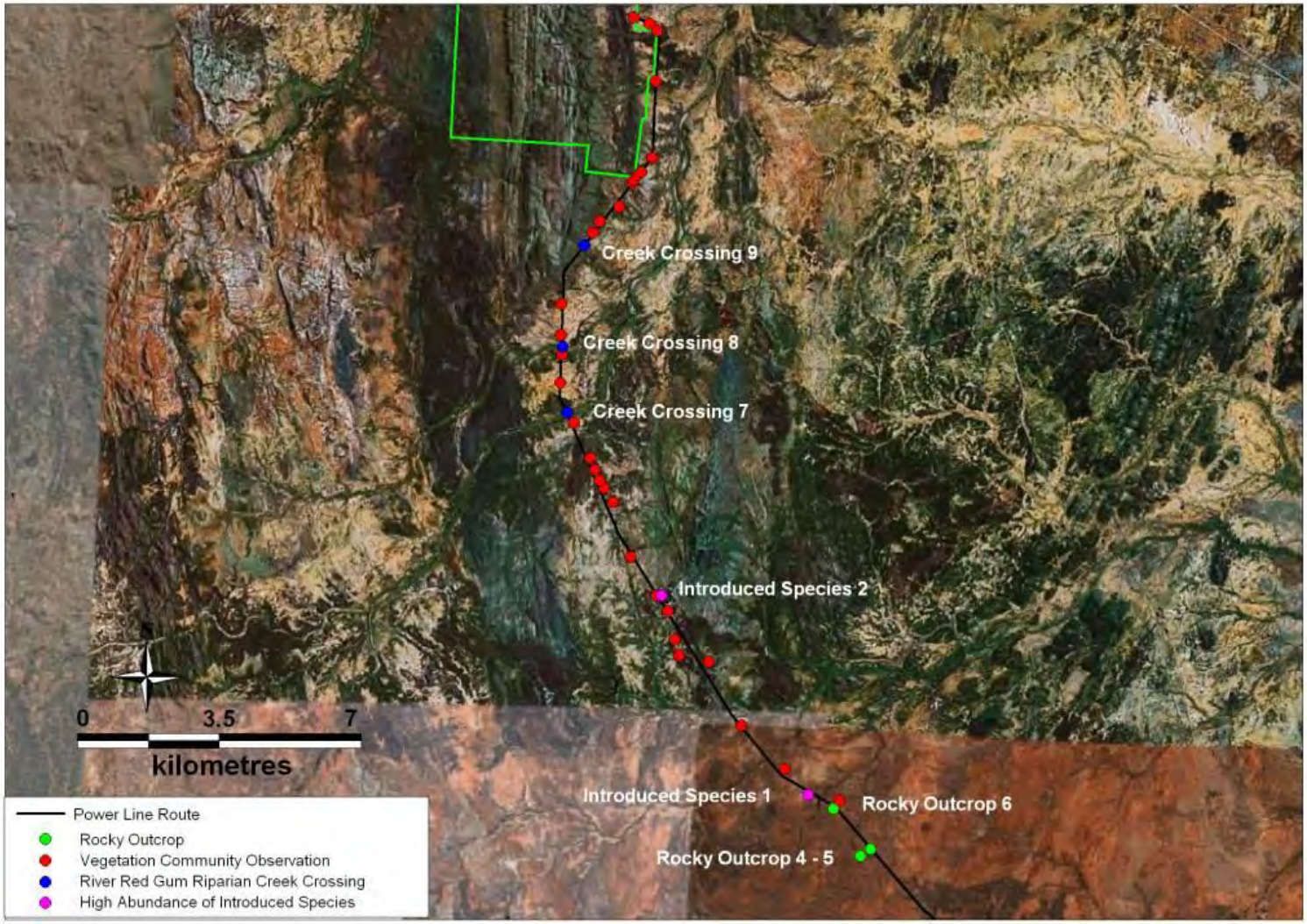


Figure 11 Northern Section of Powerline Corridor – Significant Features

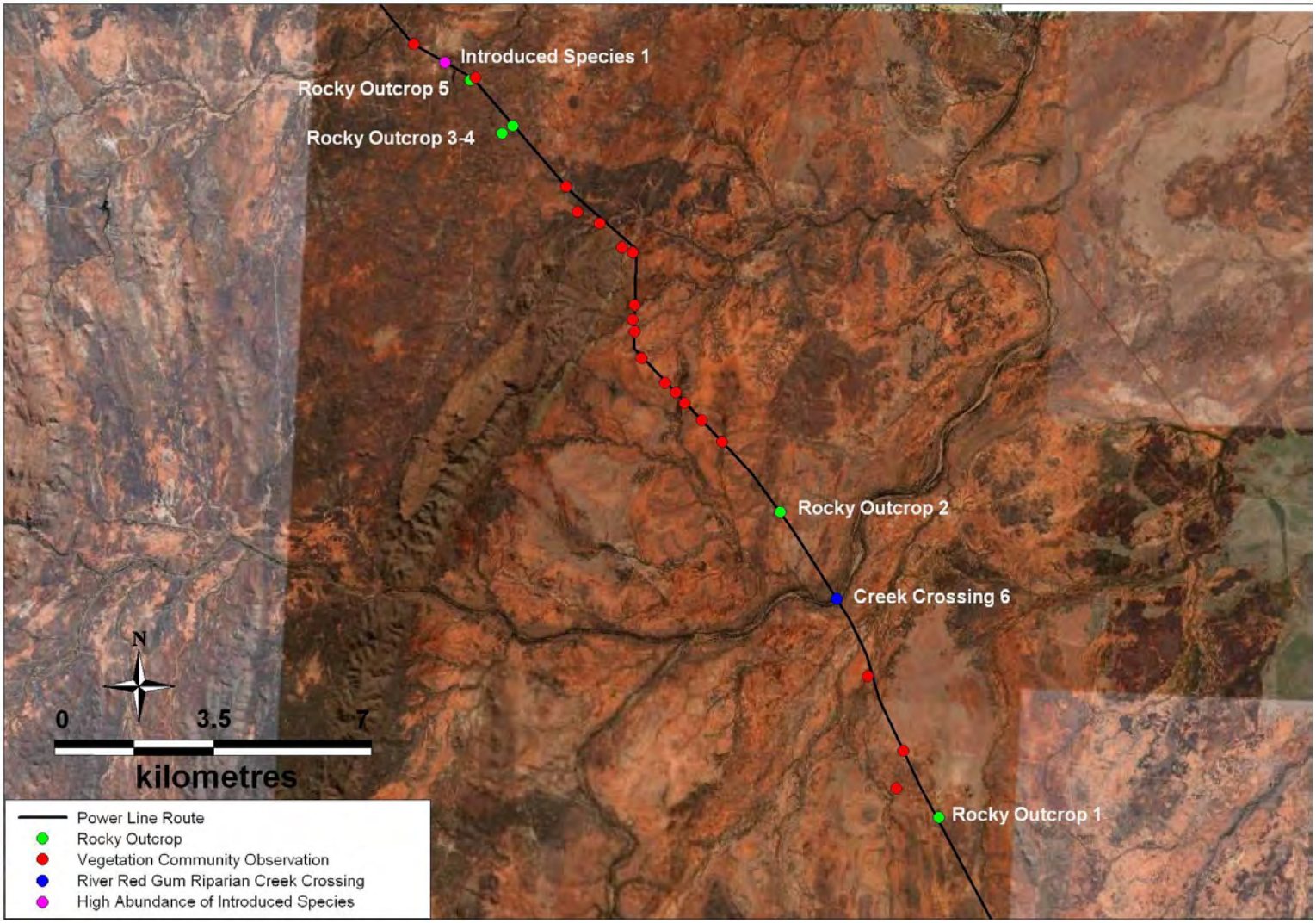


Figure 12 Central Section of Powerline Corridor – Significant Features

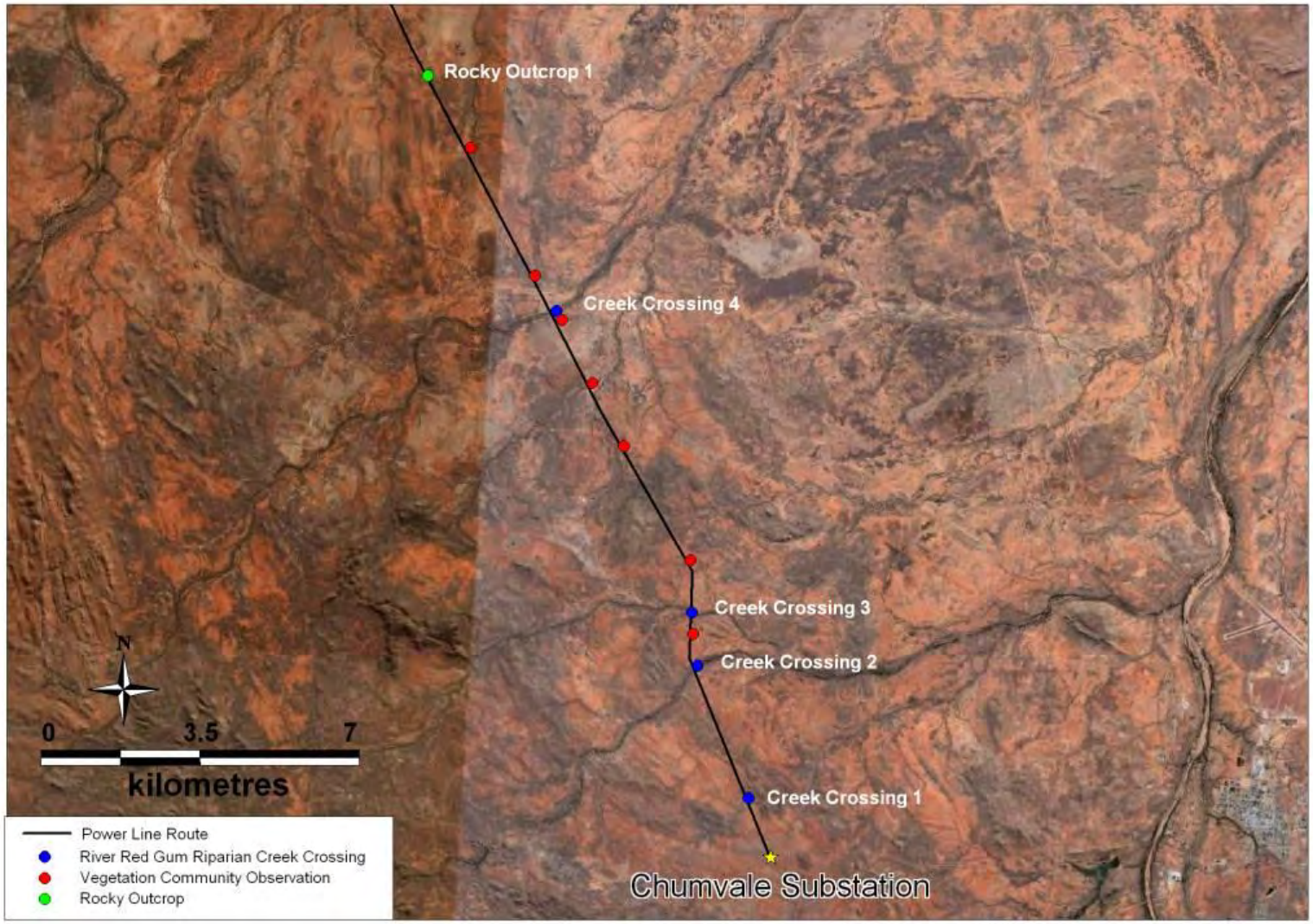


Figure 13 Southern Section of Powerline Corridor – Significant Features

8.1.2.1 River Red Gum Riparian Community

The River Red Gum Riparian Woodland (RE 1.3.7) community is valuable to the local fauna as it provides shelter around water holes and nesting holes within tree hollows. This community provides a shady and productive ecosystem for fauna in comparison to the arid, inhospitable communities surrounding the area. Floristically, it is the most diverse community within the local area of the Project site and helps maintain the environmental integrity of watercourses. The root system of the River Red Gum (*Eucalyptus camaldulensis*) helps stabilize the banks of a watercourse and prevents erosion during flooding events.

Seven creek crossing were identified within the powerline corridor. Table 19 below summarises GPS coordinates, creek width and photo plate numbers for each creek crossing of conservation significance.

Table 19 Summary of River Red Gum Riparian Communities Found within Powerline Route

Survey Site	Geographic Coordinates*		Estimated Creek Width (in m)	Photo Plate
Creek Crossing 1	0438476 mE	7709231 mN	50	25
Creek Crossing 2	0435959 mE	7712548 mN	50	26
Creek Crossing 3	0435991 mE	7713846 mN	40	27
Creek Crossing 4	0432436 mE	7720219 mN	100	28
Creek Crossing 5	0432090 mE	7720953 mN	25	29
Creek Crossing 6	0426561 mE	7729667 mN	200	30,31
Creek Crossing 7	0412381 mE	7753349 mN	70	32

* All coordinates are in AGD 84 Zone 54 projection.

Creek Crossing 1 (Photo Plate 15) was approximately 50 m in width. Vegetation was moderate in density with average canopy height of 7 m.



Photo Plate 15 Creek Crossing 1

Creek Crossing 2 (Photo Plate 16) averaged 50 m in width, with maturing vegetation. The River Red Gum (*Eucalyptus camaldulensis*) canopy height was up to 17 m. Along a 50 m long transect, 19 trees over 6 m in height were present.



Photo Plate 16 Creek Crossing 2

Creek Crossing 3 (Photo Plate 17) was a smaller creek line, averaging between 30 – 50 m in width.



Photo Plate 17 Creek Crossing 3

Creek Crossing 4 (Photo Plate 18) was a major drainage line approximately 100 m in width. River Red Gum (*Eucalyptus camaldulensis*) was the dominant canopy species. Buffel Grass (*Pennisetum ciliare*) was present and a moderate degree of cattle grazing effects were noted.



Photo Plate 18 Creek Crossing 4

Creek Crossing 5 (Photo Plate 19) was a minor drainage line 25 m in width. Effects from cattle grazing and erosion were noted. Few mature trees inhabited this survey point.



Photo Plate 19 Creek Crossing 5

Creek Crossing 6 consisted of two drainage lines, Corella River (Photo Plate 20) and a deep, yet narrow secondary drainage line (Photo Plate 21). This crossing is mature and well established.



Photo Plate 20 Creek Crossing 6 – Primary Drainage Line



Photo Plate 21 Creek Crossing 6 – Secondary Drainage Line

Creek Crossing 7 (Photo Plate 22) was a survey point which traversed the Dugald River. The creek averaged 70 m in width and was a mature riparian community.



Photo Plate 22 Creek Crossing 7

8.1.2.2 Rocky Outcrops

A total of 6 rocky outcrop areas were found along the powerline corridor. Rocky outcrops provide suitable habitat for the Purple-necked Rock-wallaby (*Petrogale purpureicollis*), listed as Vulnerable under Schedule 3 of the NCWR. Purple-necked Rock-wallabies (*Petrogale purpureicollis*) are known to inhabit suitable rocky outcrops in North-west Queensland, particularly in the Cloncurry region, and are known to regularly travel short distances, with animals often required to travel to neighbouring mobs for reproductive purposes (Clancy and Close 1997). Sightings were made at two of the six rocky outcrops.

A summary of outcrops, GPS coordinates, estimated size and photo plate numbers can be found below in Table 20. A brief description of each outcrop follows.

Table 20 Summary of Rocky Outcrops Found Within the Powerline Route

Survey Site	Geographic Coordinates*		Estimated Outcrop Length x Width (m)	Photo Plate Number	Comments
Rocky Outcrop 1	0429437 mE	7725139 mN	200 x 75	33,34	1 PNRW sighted, existing PNRW habitat
Rocky Outcrop 2	0425541 mE	7731717 mN	50 x 50	-	Minimal potential PNRW habitat
Rocky Outcrop 3	0423276 mE	7735328 mN	200 x 100	35,36	Potential PNRW habitat
Rocky Outcrop 4	0419128 mE	7739942 mN	100 x 50	37,38,39	1 PNRW sighted, existing PNRW habitat
Rocky Outcrop 5	0418906 mE	7739756 mN	30 x 50	40	Potential PNRW foraging habitat
Rocky Outcrop 6	0418151 mE	7740894 mN	Series of outcrops	41	Potential PNRW foraging habitat

*All coordinates are in AGD 84 Zone 54 projection.

Rocky Outcrop 1 (Photo Plate 23 and Photo Plate 24) was estimated to be 200 x 75 m in size and up to 12 m in height. Favourable habitat for the Purple-necked Rock-wallaby (*Petrogale purpureicollis*) was present with many crevices and cracks, and one Purple-necked Rock-wallaby (*Petrogale purpureicollis*) was observed.



Photo Plate 23 View North of Rocky Outcrop 1

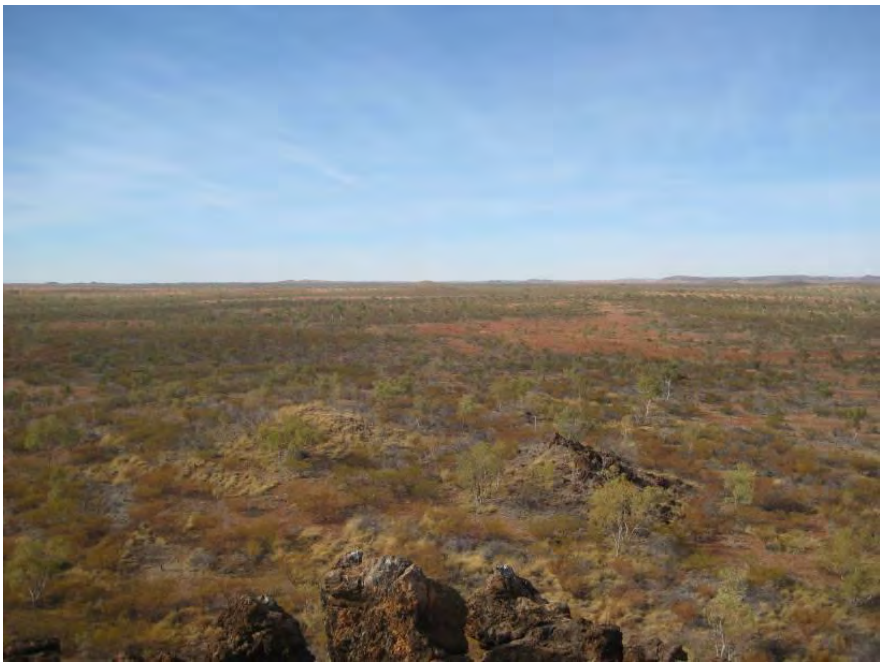


Photo Plate 24 View South of Rocky Outcrop 1

Rocky Outcrop 2 was a small rocky outcrop with an estimated size of 50 x 50 m and average elevation of 8 m. Many larger marsupial scats were observed within outcrop formation, but the smaller cylindrical shaped Rock-wallaby scat was absent. It is AARC"s opinion Rocky Outcrop 2 provides little

habitat for species of conservation significance, as the outcrop did not entail cavernous formations and held few crevices.

Rocky Outcrop 3 (Photo Plate 25) was estimated to be 200 x 100 m in size. Although the Purple-neck Rock-wallaby (*Petrogale purpureicollis*) was not observed, potential habitat was present.



Photo Plate 25 Rocky Outcrop 3

Rocky Outcrop 4 (Photo Plate 26) was estimated to be 100 x 50 m in size with an average elevation of 10 m. A Purple-necked Rock-wallaby (*Petrogale purpureicollis*) was sighted by AARC staff. Many crevices and caves presented favourable habitat for the rock-wallaby (Photo Plate 27). Scats were collected and sent to a specialist for confirmation. This outcrop holds high conservation significance. Areas to the west of this site were noted to be free of medium to large outcrops (Photo Plate 28).



Photo Plate 26 Rocky Outcrop 4



Photo Plate 27 Purple-necked Rock-wallaby Habitat within Rocky Outcrop 4



Photo Plate 28 View West of Rocky Outcrop 4

Rocky Outcrop 5 was found directly east of Rocky Outcrop 4. This outcrop was relatively small, estimated 25 x 50 m in size. No significant habitat for the Purple-necked Rock-wallaby (*Petrogale purpureicollis*) to reside in was identified within this outcrop; therefore the outcrop may be potentially used as a foraging site only. Photo Plate 29 presents a view looking eastward towards Rocky Outcrop 5.



Photo Plate 29 View East to Rocky Outcrop 5

Rocky Outcrop 6 (Photo Plate 30) was a series of 4 outcrops. Each section was approximately 20 m wide with 5 m in between each outcrop. Sparse areas were identified as Purple-necked Rock-wallaby

(*Petrogale purpureicollis*) habitat, including small crevices. It is AARC"s opinion that Rocky Outcrop 6 does not entail the significant structural complexity necessary to be a residence form the Rock-wallaby, but may potentially act as foraging habitat.



Photo Plate 30 Rocky Outcrop 6

8.1.2.3 Introduced Flora Species

Several introduced flora species were identified within the powerline corridor. Table 21below summarises which species were found predominantly in two areas; „Introduced Species 1" and „Introduced Species 2" (refer to Figure 11 and Figure 12).

Although no species are listed under the LP Act, many of these species establish rapidly and out-compete existing native plants. None of these species are listed as a weed of national significance.

Table 21 Summary of Introduced Flora Species within the Power-line Route

Scientific Name	Common Name	Geographic Coordinates*		Corresponding Survey Point
Acacia farnesiana	Mimosa Bush	Common throughout site, dominant patch at 0413907 mE	Common throughout site, dominant patch at 7745937 mN	Introduced Species 1
Aerva javanica	Kapok Bush	0417739 mE	7740988 mN	Introduced Species 2
Calotropis procera	Calotrope	0417739 mE	7740988 mN	Introduced Species 2
Pennisetum ciliare	Buffel Grass	Common throughout site	Common throughout site	--

Scientific Name	Common Name	Geographic Coordinates*		Corresponding Survey Point
Citrullus colocynthis	Colocynth	0417739 mE	7740988 mN	Introduced Species 2
Datura inoxia	Downy Thornapple	0417739 mE	7740988 mN	Introduced Species 2

* All coordinates are in AGD 84 Zone 54 projection.

The survey point „Introduced Species 1" (refer to Figure 11) held a high abundance of Mimosa (*Acacia farnesiana*). The estimated size of this patch was 50 x 100 m. Photo Plate 31 below portrays a section of this area.



Photo Plate 31 Mimosa Bush (Acacia farnesiana)

The survey point „Introduced Species 2" held an array of non-native species. „Introduced Species 2" was a previously disturbed area, a stock watering yard, which allowed establishment of non-native plants. Species included Calotrope (*Caltropsis procera*), Mimosa Bush (*Acacia farnesiana*), Kapok Bush (*Aerva javanica*), Downy Thornapple (*Datura inoxia)* and Colocynth (*Citrullus colocynthis)*. Photo Plate 32 shows the area.



Photo Plate 32 Survey Point 'Introduced Species 2'

8.2 ACCESS ROUTE

The primary access route corridor follows along an existing track for approximately 9 km from the Project site (see Figure 13). At the eastern end of the primary access route corridor, the primary access route diverts from the existing track for 1 km along a straight route across open terrain to join up with the Burke Developmental Road.

An alternate access road route is being proposed and may be used in the foreseeable future. This route follows the primary access road route from the Project site for 4 km, and then diverts directly east for 5 km, ultimately joining the Burke Developmental Road.

It may also be necessary to use a temporary access road deviation (called the Longamundi Deviation), if mining activity occurs on adjacent tenures. This deviation will divert the access road from the Project site around the Longamundi mineral deposit. The deviation will commence at the Project site approximately 850 m north of the primary access route. The deviation is approximately 2 km in length and connects with the primary access track at Creek Crossing 2 before the alternate access road diversion (see Figure 13).

The following sections will discuss vegetation communities and creek crossings existing on the corridor. Although communities of conservation significance are present, no individual floral or faunal species of conservation significance are present. No weeds classified under the LP Act inhabit the access route corridor.

8.2.1 Vegetation Communities

A total of five vegetation communities inhabit the access route corridor area (refer to Figure 14). These communities and corresponding conservation status is listed in Table 22.

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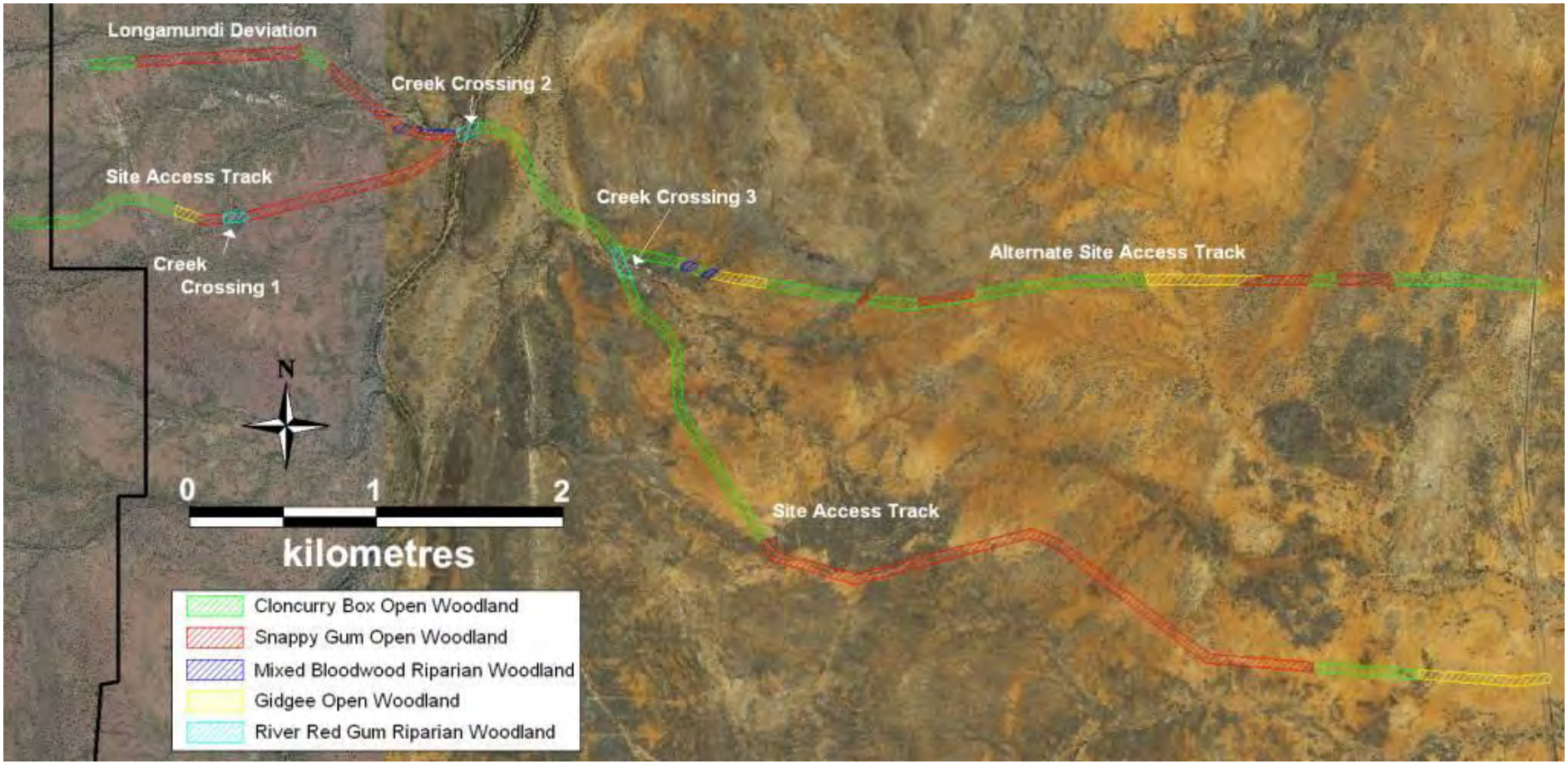


Figure 14 Access Route Corridor Vegetation Communities and Creek Crossing Locations

Table 22 Vegetation Communities on the Access Route Corridor

Vegetation Community / RE	Community Description	EPBC Status	Queensland VMR	DERM Biodiversity Status
Snappy Gum Open Woodland / 1.11.2e	Low open-woodland of *Eucalyptus leucophylla* and *Eucalyptus leucophloia* often *with Acacia cambagei* and *Corymbia terminalis* with a sparse ground layer of *Triodia pungens* and/*or Triodia longiceps*. Occurs on footslopes and lower slopes, broken by creeks and drainages	Not Listed	Least Concern	No Concern at Present
Cloncurry Box Open Woodland / 1.11.3x1	Low open-woodland of *Eucalyptus leucophylla* often with *Corymbia terminalis* and *Eucalyptus. leucophloia* with Acacia spp. dominated shrub layer and ground layer of *Triodia spp*. and/or tussock grasses. Includes areas of *Acacia spp*. shrubland and *Triodia spp*. grassland. Occurs on hills on strongly folded pre-Cambrian rocks; skeletal soils, some shallow loams	Not Listed	Least Concern	No Concern at Present
River Red Gum Riparian Woodland / 1.3.7a / RE 1.3.7b	Riverine wetland or fringing riverine wetland. Fringing woodland of *Eucalyptus camaldulensis*, usually with *Lophostemon grandiflorus* and *Melaleuca leucadendra* and/or *M. argentea*. Occurs on recent levees and channel deposits of major watercourses and larger tributaries.	Not Listed	Least Concern	Endangered
Gidgee Open Woodland / 1.11.2x2	Low open-woodland and low woodland of *Acacia cambagei* over annual grasses. Occasional *Atalaya hemiglauca, Hakea lorea subsp. lorea, Grevillea striata and Acacia excelsa*. Occurs on red or brown earths and clays.	Not Listed	Least Concern	No Concern at Present

Vegetation Community / RE	Community Description	EPBC Status	Queensland VMR	DERM Biodiversity Status
Mixed Bloodwood Riparian Woodland / 1.3.6b	Woodland and low woodland of *Corymbia aparrerinja* and *Corymbia terminalis. Acacia victoriae* may dominate heavier soils. Occurs on terraces and floodplains on Quaternary alluvium; alluvial soils, some earths and deep yellow podzolics.	Not Listed	Least Concern	Of Concern

8.2.1.1 Snappy Gum Open Woodland

The Snappy Gum Open Woodland (RE 1.11.2e) community is equivalent to the community found on the Project site. Refer to Section 6.2 for a detailed community description.

As detailed in Table 22, Snappy Gum Open Woodland (RE 1.11.2e), is listed as „Least Concern" under the VMR, „No Concern at Present" under the DERM Biodiversity Status and is not listed under the EPBC Act.

Based on proposed disturbance plans for the Project, the estimated disturbance footprint area within this community is 7.2 ha. It is unlikely the Project will affect the Snappy Gum Open Woodland at a regional scale.

8.2.1.2 Cloncurry Box Open Woodland

The Cloncurry Box Open Woodland (RE 1.11.3x1) community is identical to the community found within the Project site. Refer to Section 6.4for a detailed community description.

As detailed in Table 22, Cloncurry Box Open Woodland (RE 1.11.3x1), is listed as „Least Concern" under the VMR, „No Concern at Present" under the DERM Biodiversity Status and is not listed under the EPBC Act.

Based on proposed disturbance plans for the Project, the disturbance footprint within this vegetation community is estimated to be 3.2 ha. It is unlikely the Cloncurry Box Open Woodland will be affected at regional scale.

8.2.1.3 River Red Gum Riparian Woodland

The River Red Gum Riparian Woodland (Re 1.3.7a) occurs in three separate areas along the access route corridor. One riparian site is a larger watercourse (variation b), while two sites (Creek Crossing 1 and 3 – refer to Figure 12) are along relatively smaller creek lines (variation a). The creek line River Red Gum community (variation a) is synonymous to the community found within the Project site (refer to Section 6.6), whilst the larger watercourse (variation b) is similar to the community described in section 8.1.1.3. Two introduced species were noted within this community; the Calotrope (*Caltropsis procera*) and Buffel Grass (*Pennisetum ciliare*).

The River Red Gum Riparian Woodland (RE 1.3.7) is listed as „Least Concern" under the VMR and is not listed under the EPBC Act. However, the DERM Biodiversity Status lists this RE as being „Endangered".

Based on proposed disturbance plans for the Project, current access track disturbance, and a proposed access road clearance width of 8 m, no additional clearing will be necessary within the River Red Gum Riparian Woodland.

8.2.1.4 Gidgee Open Woodland

The Gidgee Open Woodland (RE 1.11.2x2) community occurs in two patches along the corridor (refer to Figure 12). This community is synonymous with the Gidgee Open Woodland community on the Project site. Refer to Section 6.7 for a detailed community description.

The Gidgee Open Woodland (RE 1.11.2x2) community is listed as „Least Concern" under the VMR, „No Concern at Present" under the DERM Biodiversity Status and is not listed under the EPBC Act.

Based on proposed disturbance plans for the Project, the estimated disturbance footprint area within the Gidgee Open Woodland from the access track will be 1.3 ha. It is unlikely disturbance within the access route corridor will significantly impact on the regional occurrence of this community.

8.2.1.5 Mixed Bloodwood Riparian Woodland

The Mixed Bloodwood Riparian Woodland (RE 1.3.6b) inhabiting the proposed site access road is identical with the community found on the Project site. Refer to Section 6.5 for a detailed description of this community.

The Mixed Bloodwood Riparian Woodland (RE 1.3.6b) community is listed as „Least Concern" under the VMR and is not listed under the EPBC Act. However, the DERM Biodiversity Status lists this RE as being „Of Concern".

Based on proposed disturbance plans for the Project and a site access road clearance width of 8 m, the estimated additional clearing of the Mixed Bloodwood Riparian Woodland will be 0.16 ha. It is unlikely this disturbance will significantly impact on the regional occurrence of this community.

8.2.2 Creek Crossings

Three major creek crossings exist along the access route corridor (refer to Figure 14). These larger crossings are the River Red Gum Riparian Woodland (RE 1.3.7). Four minor creek crossings are present along the alternate access road and temporary deviation.

Creek Crossing 1 is the Silvermine Creek (Photo Plate 33). It spans approximately 30 m wide and is a mature creek.



Photo Plate 33 Creek Crossing 1

Creek Crossing 2 is the Dugald River (Photo Plate 34 and Photo Plate 35). The Dugald River is a mature, major watercourse. This crossing is approximately 150 m wide, including floodplains.



Photo Plate 34 Creek Crossing 2 – Dugald River



Photo Plate 35 Creek Crossing 2 and Existing Track

Creek Crossing 3 is relatively small, approximately 8 – 10 m wide (Photo Plate 36). Surrounding vegetation density is moderate, and includes Turpentine.



Photo Plate 36 Creek Crossing 3

8.3 WATER PIPELINE

The survey of the water pipeline corridor included a 40 m wide assessment of the condition of the vegetation type with regard to quality and conservation value and the mapping of the REs. Since the water pipeline corridor travels close to the base of Mount Rose Bee, which is potential Purple-necked Rock-wallaby (*Petrogale purpureicollis*) habitat, scats were collected for analysis and outcrops were surveyed on foot to determine extent of habitat.

The following sections present a vegetation community map (Figure 15 and Figure 16), define the vegetation communities and describe the rocky outcrops along the corridor.

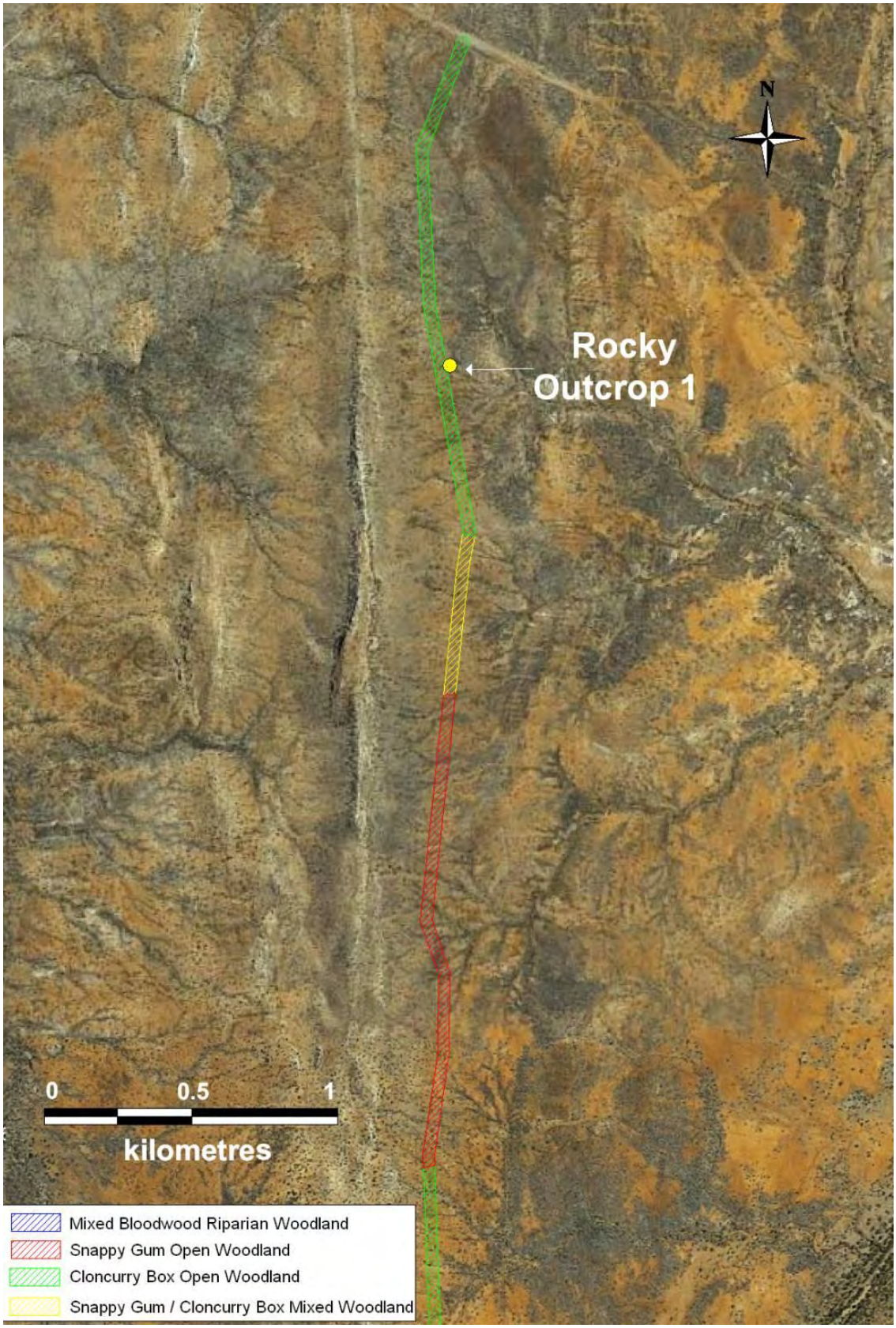


Figure 15 **Northern Section of Water Pipeline Corridor Vegetation Communities and Rocky Outcrops**

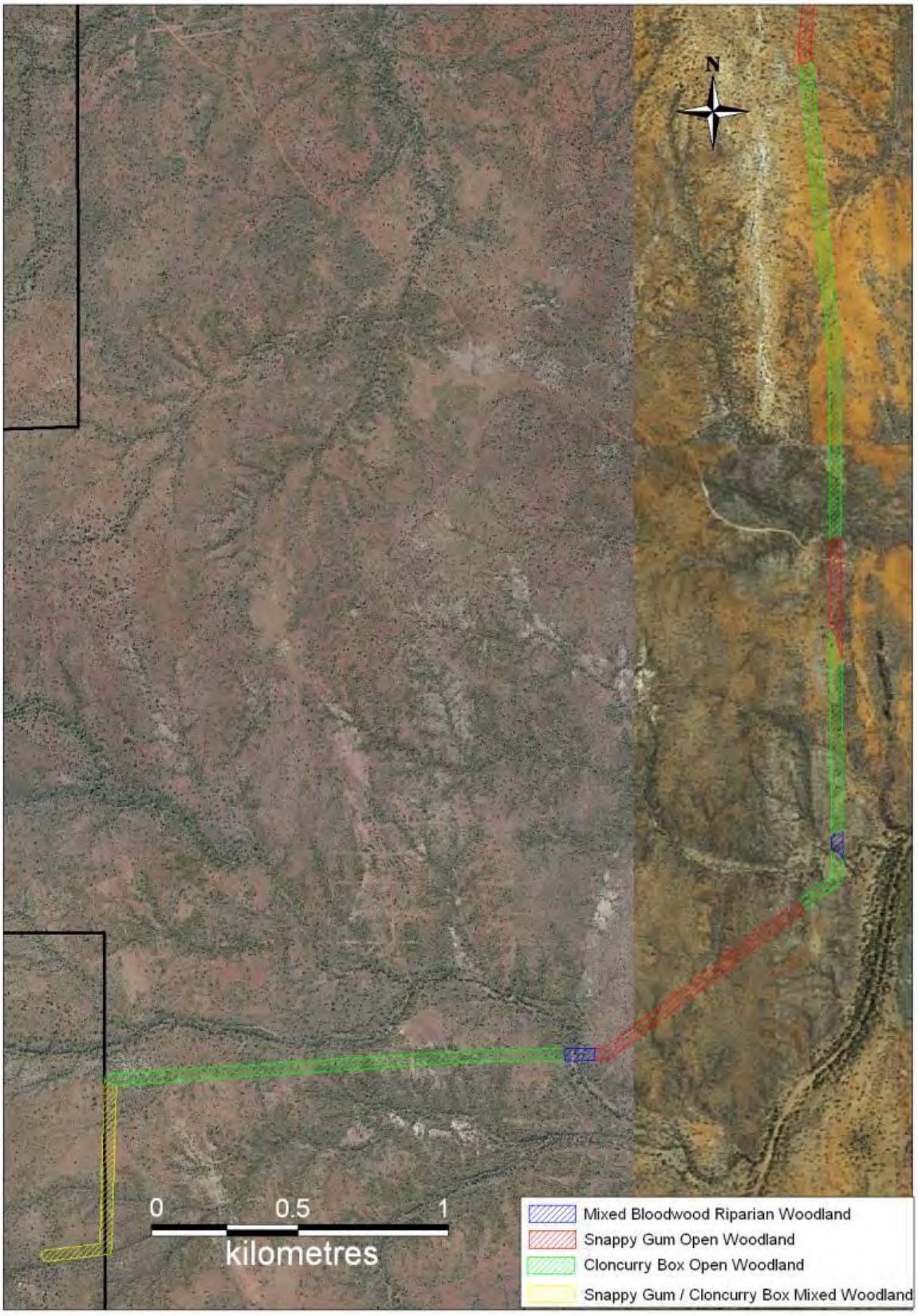


Figure 16 Southern Section of Water Pipeline Corridor Vegetation Communities

8.3.1 Vegetation Communities

Four vegetation communities are present along the water pipeline corridor; Cloncurry Box Open Woodland (RE 1.11.3x1), Snappy Gum Open Woodland (RE 1.11.2a), Mixed Bloodwood Riparian Woodland (RE 1.3.6b) and a co-dominant open woodland of Cloncurry Box and Snappy Gum (RE 1.11.2e) (refer to Figure 15 and Figure 16).

Each community is summarised with RE equivalents and corresponding conservation status (Table 23 below and in the following sections.

Table 23 Vegetation Communities on the Water Pipeline Corridor

Vegetation Community / RE	Community Description	EPBC Status	Queensland VMR	DERM Biodiversity Status
Snappy Gum Open Woodland / 1.11.2a	Low open-woodland of *Eucalyptus leucophloia* often with *Corymbia spp., Terminalia aridicola* and *Eucalyptus leucophylla* with shrub layer of *Acacia spp*. and ground layer of *Triodia spp.* Occurs on steep hills and strike ridges	Not Listed	Least Concern	No Concern at Present
Cloncurry Box Open Woodland / 1.11.3x1	Low open-woodland of *Eucalyptus leucophylla* often with *Corymbia terminalis* and *Eucalyptus leucophloia* with Acacia spp. dominated shrub layer and ground layer of *Triodia spp*. and/or tussock grasses. Includes areas of *Acacia spp*. shrubland and *Triodia spp*. grassland. Occurs on hills on strongly folded pre-Cambrian rocks; skeletal soils, some shallow loams	Not Listed	Least Concern	No Concern at Present
Snappy Gum / Cloncurry Box Open Woodland / RE 1.11.2e	Low open-woodland *of Eucalyptus leucophylla* and *Eucalyptus leucophloia* often with *Acacia cambagei* and *Corymbia terminalis* with a sparse ground layer of *Triodia pungens* and/or *Triodia longiceps*. Occurs on footslopes and lower slopes, broken by creeks and drainages	Not Listed	Least Concern	No Concern at Present
Mixed Bloodwood Riparian Woodland 1.3.6b	Woodland and low woodland of *Corymbia aparrerinja* and *Corymbia terminalis*. *Acacia victoriae* may dominate heavier soils. Occurs on terraces and	Not Listed	Least Concern	Of Concern

	floodplains on Quaternary alluvium; alluvial soils, some earths and deep yellow podzolics			

8.3.1.1 Snappy Gum Open Woodland

The Snappy Gum Open Woodland (RE 1.11.2a) community is equivalent to the community found on the Project site. Refer to Section 6.1 for a detailed community description.

The Snappy Gum Open Woodland (RE 1.11.2a), is listed as „Least Concern" under the VMR, „No Concern at Present" under the DERM Biodiversity Status and is not listed under the EPBC Act.

Based on proposed disturbance plans for the Project, additional clearing of the Snappy Gum Open Woodland will be required. It is unlikely disturbance within this community will significantly impact on the regional occurrence of this community.

8.3.1.2 Cloncurry Box Open Woodland

The Cloncurry Box Open Woodland community is equivalent to the community found within the Project site. Refer to Section 6.3 for a detailed community description.

Cloncurry Box Open Woodland (RE 1.11.3x1), is listed as „Least Concern" under the VMR, „No Concern at Present" under the DERM Biodiversity Status and is not listed under the EPBC Act.

Based on proposed disturbance plans for the Project, additional clearing of the Cloncurry Box Open Woodland will be required. It is unlikely disturbance within the pipeline corridor will significantly impact on the regional occurrence of this community.

8.3.1.3 Mixed Bloodwood Riparian Woodland

The Mixed Bloodwood Riparian Woodland is classified as RE 1.3.6b, and has similar structural composition as described in Section 6.5.

This community is listed as „Least Concern" under the VMR, „Of Concern" under the DERM Biodiversity Status and is not listed under the EPBC Act.

Proposed disturbance plans for the Project, show that clearing of this community will be required, with an estimated disturbance footprint of approximately 0.2 ha. Assuming appropriate sediment and erosion controls are in place, it is unlikely this community will be affected at a regional scale.

8.3.1.4 Snappy Gum / Cloncurry Box Open Woodland

The Snappy Gum Open / Cloncurry Box Woodland (RE 1.11.2e) community is equivalent to the community found on the Project site. Refer to Section 6.2 for a detailed community description.

The Snappy Gum Open Woodland (RE 1.11.2e), is listed as „Least Concern" under the VMR, „No Concern at Present" under the DERM Biodiversity Status and is not listed under the EPBC Act.

Based on proposed disturbance plans for the Project, additional clearing of the Snappy Gum / Cloncurry Box Open Woodland will be required. It is unlikely disturbance within this community will significantly impact on the regional occurrence of this community.

8.3.2 Rocky Outcrops

One rocky outcrop is located within the water pipeline corridor. Rocky Outcrop 1 is located along the northern section of the water pipeline corridor (refer to Figure 15). The outcrop is 80 m in length, with a maximum relief of approximately 4 m (Photo Plate 37 and Photo Plate 38). A few small crevices are present in this rock system. Marsupial scat samples have been collected and identified; however no Purple-necked Rock-wallaby (*Petrogale purpureicollis*) scats were present. The absence of Rock-wallaby scats suggests that this species is unlikely to reside at this small outcrop.



Photo Plate 37 Extent of Rocky Outcrop 1



Photo Plate 38 Rocky Outcrop 1

9.0 SUGGESTED MITIGATION AND REHABILITATION STRATEGIES

Suggested strategies to minimise the impacts on native flora and fauna, and recommendations regarding rehabilitation of the Project site are outlined below.

9.1 ENVIRONMENTAL VALUES

- The River Red Gum Riparian Woodland (RE 1.3.7a and RE 1.3.7b) and Mixed Bloodwood Riparian Woodland (RE 1.3.6b) provide refuge for fauna by providing water, shade and larger tree species with hollows;

- The River Red Gum Riparian Woodland is floristically the most diverse vegetation community within the local area of the project and it helps maintain the environmental integrity of watercourses by stabilising the banks with the root system and preventing erosion during flooding events;

- Rocky outcrops within the Cloncurry Box Open Woodland and Snappy Gum Open Woodland provide microhabitat for certain fauna;

- Silver Box / Cloncurry Box Open Woodland (RE 1.5.4x3), River Red Gum Riparian Woodland (RE 1.3.7) and Mixed Bloodwood Riparian Woodland (RE 1.3.6b) are listed are „Of Concern" or „Endangered" under DERM"s Biodiversity Status. These intact stands contribute to overall preservation of threatened ecosystems.

9.2 POTENTIAL IMPACTS FROM PROJECT

Potential impacts of the Project include habitat loss and fragmentation, increased traffic, noise, dust and artificial lighting over a greater area than currently exists, due to the proposed Project.

In order to preserve the native biodiversity of the immediate and greater regions, ecological processes, such as natural disturbance regimes, hydrological processes, nutrient cycles and biotic interactions, should be maintained. Additionally, landscapes and communities must be managed to be responsive to short-term and long-term environmental change.

Each habitat type, including open woodlands, tussock grasslands, riparian woodlands and stony hills, provides unique habitat which supports ecological processes within the landscape. Ecotones (boundaries between vegetation communities) may be especially important for resources, as these areas frequently have a higher diversity and abundance of species (Hunter, 1990).

The following potential impacts on nature conservation values may occur from the Project:

- Land clearing for the Project will reduce the current extent of vegetation communities and associated faunal habitats. The extent of disturbance within each RE is summarised in Table 24;

- Fauna injury or death may occur during the Project, with the greatest potential to occur during the construction phase;

- Edge effects resulting from the proposed works can include the establishment of weeds, alteration to microclimatic conditions (such as greater light intensity, more wind penetration,

lower humidity) and a reduction in plant health through loss of photosynthetic potential (as a result of plants being covered by dust generated from vehicle movement on unsealed tracks). In the absence of appropriate control measures, the Project has the potential to cause impacts in relation to edge effects, and particularly in relation to the introduction and / or spread of weed species throughout the Project site;

- Additional noise from mine site operations may disturb fauna or reduce available habitat for certain flora and fauna on the Project site. Noise effects can be highly species dependant and may vary widely. Impacts from noise will be concentrated around the process plant / decline area, which leaves the majority of the Project site and associated habitat types unaffected

- Increased lighting around the process plant and accommodation camp area may affect both nocturnal and diurnal fauna. The effects of artificial lighting will vary with different species. Additional lighting commonly attracts insects, which will result in a higher abundance of amphibians, microbats and reptiles ready to take advantage of concentrated prey;

- Loss of vegetation may cause fragmentation or loss of individual species" local population. Watercourses within the Project site are important linear habitat corridors, as they provide shelter and a water source for flora and fauna species. As the unnamed creek and associated valley within the TSF area will be disturbed, some loss of connectivity will occur. This may affect smaller, less mobile species;

- Loss of habitat may result in a loss of biological diversity (with associated removal of leaf litter, hollow bearing trees, fallen timber and resultant changes to soil biota);

- Altered fire regimes may occur as a result of the Project, as the risk of fire is greater with anthropogenic presence. Fire often increases nutrient availability to post-fire pioneer species. The proposed Project is not expected to significantly impact upon current natural fire systems;

- A change in population dynamics may occur, although it is not expected to be significant. Species most susceptible to a decline are low mobility species. Species such as amphibians and smaller reptiles may become genetically isolated, as a result of disrupting habitat connectivity near the TSF within the unnamed creek;

- Land clearing activities associated with the Project may increase soil erosion, inadvertently causing silting or sedimentation of riverine habitats and waterholes downstream. Soil erosion may also trigger a loss of nutrients to one area, causing a disruption of nutrient natural cycling;

- Processing and mining activities on the Project site may have the potential to contaminate riverine habitats and waterholes downstream;

- An increase of pest fauna species identified as utilising the Project site may occur, including the Cane Toad (*Rhinella marina*), Feral Pig (*Sus scrofa*) and Feral Cat (*Felis catus*); and

- The introduction of additional weed species and spread of weeds on the Project site via transport of seeds on vehicles and machinery.

Table 24 Regional Ecosystem Total Area and Disturbance Area

Vegetation Community	Regional Ecosystem Equivalents	Total Area on Project Site (ha)	Total Disturbance Area on Project Site (ha)
Snappy Gum Open Woodland on steep hills and strike ridges	1.11.2a	1,186	97.7
Snappy Gum Open Woodland on foothills	1.11.2e	555.5	30.4
Cloncurry Box Open Woodland on low broad hills	1.11.3a	365.5	0.0
Cloncurry Box Open Woodland on hills	1.11.3x1	331.6	24.5
Mixed Bloodwood Riparian Woodland	1.3.6b	11.2	0.0
River Red Gum Riparian Woodland	1.3.7b	98.4	16.7
Gidgee Open Woodland	1.3.4	97.12	0.0
Silver Box/ Cloncurry Box Open Woodland on red earths	1.5.4x3	155.1	23.6

9.2.1 Impacts on Threatened Species

The Purple-necked Rock-wallaby (*Petrogale purpureicollis*) was identified inhabiting sections of the Knapdale Range and along the powerline corridor. This species is listed as Vulnerable under NCWR. It is not listed under the EPBC Act.

The proposed development of the TSF may cause stress to the Rock-wallaby population present along the lower slopes of the Knapdale Range. The construction of the proposed project may have both detrimental as well as positive impacts on the local Rock-wallaby population. Positive impacts may include:

- Assuming that cattle grazing is not carried out during the proposed mine life, a slight increase in the availability of food through the reduction of grazing and hence reduced competition from cattle (Clancy and Close 1997); and

- Increased access to water resources, which may be beneficial during extended dry periods. Rock-wallabies do not require water, but will take advantage of nearby water resources when available (Sharman and Maynes 1998).

The proposed development of the TSF and powerline corridor will not necessitate clearing rocky outcrop structures.

Potential negative impacts may include:

- Effects of increased noise and vibration on Rock-wallabies are unknown and impossible to quantify prior to construction activities. Although blasting only lasts for a few seconds each day, this may induce an added stress to the rock wallabies;

- Pest species are known to increase around human habitation. The chances of higher predation may increase when the mine is in operation. Dingos (*Canis lupus dingo*) and feral cats (*Felis catus*) are of particular concern;

- Increased water availability and greater abundance of fodder may increase the number of competing macropods and other herbivorous species (i.e. European Rabbit, *Oryctolagus cuniculus*); and

- Additional roadways may result in an increase of Rock-wallaby injuries or death.

Mitigation strategies aimed at reducing or eliminating impacts from the Project on the Rock-wallaby population should include the creation of a vertebrate pest control program and roadway regulation.

9.2.2 Cumulative Impacts

The potential ecological impacts identified above are considered as a consequence of the construction and operation of the Project. The combined effect of multiple sources of impact (past, present and future) is referred to as „cumulative impacts" whereby the effects of multiple impacts may be additive within a region or accumulate over time. Consideration of cumulative impacts is necessary so impacts associated with the Project can be assessed with additional regional impacts from external sources.

Potential regional developments that may interact with the construction of the Project include:

- Other mines which may establish in the future within the region, as the Project site is adjacent to many exploration tenures;

- Low intensity stock graziers in the vicinity of the Project.

Residual impacts are those which will remain after a Project's mitigation and rehabilitation strategies have been carried out. Potential residual impacts include modification of vegetation and associated fauna habitat associated from Project infrastructure, including the waste rock dump and TSF. In the case of impacts of residual loss occurring subsequent to mine decommissioning, compensation in the form of further habitat rehabilitation in areas adjacent to the Project site or vegetation offsets can be employed.

All such developments are likely to contribute to a greater extent of ecological pressures on habitat and flora/fauna, such as vegetation clearing and a further fragmentation of habitat. Given mitigation measures are in place and that programs will be in place to monitor the success of rehabilitation, cumulative impacts of the Project are considered low.

9.3 MITIGATION STRATEGIES

Following the desktop assessment, literature review and on-site survey data, it has been determined that there is no significant hindrance, regarding terrestrial flora and fauna, to the development of the Dugald River Project. Suggested strategies to minimise the potential environmental impacts on native flora and fauna, and recommendations regarding rehabilitation of the Project site, are outlined below.

A general principle of environmental management, in order of preference, is to:

- Avoid environmental impacts;
- Minimise the impacts;
- Mitigate for impact; and
- Where impact cannot be avoided or minimised, compensation for residual impact by mitigative means such as offsets.

9.3.1 Avoidance of Environmental Impact

Avoiding environmental impacts has been planned for where possible throughout Project planning and design phases. There will also be ongoing opportunities to further avoid impacts at a local scale through the detailed design process. Infrastructure layout has been designed to avoid disconnection in the water flow regimes.

9.3.2 General Mitigation Strategies

- The River Red Gum riparian community should be managed using relevant strategies suggested under the QGEOP, with considerations for riverine wetland habitat;
- To maintain the integrity of vegetated land that is not cleared, appropriate erosion and sediment controls are recommended to prevent sediment deposition in remaining habitat. Maintenance of retained areas of native vegetation would also provide a source of seed for mine rehabilitation works;
- Native vegetation removal should be conducted only after:
  - the areas to be cleared have been clearly delineated and identified to equipment operators and supervisors;
  - Weed control measures such as vehicle wash downs should be implemented to prevent the spread of weed species along riparian corridors. The most relevant examples being Noogoora Burr (*Xanthium strumianum*) and Caltrope (*Calotropis procera*) which was found along most riparian vegetation, but appeared to be more abundant downstream of the Project site; and
  - Appropriate erosion and sediment control structures are in place.
- Clear trees with hollows in the following manner:

- Use the biggest bulldozer available - it needs to take the weight of a tree - tap the trunk with the blade a few times to wake up anything inside the tree, wait a few minutes and watch for anything to come out;

- Push the tree slowly from the side with the hollow - the hollow needs to be upwards, not crushed on the ground - with the base of the blade about one metre up to get leverage; and

- As the tree starts to lean, lower the blade to the ground to catch the base/roots portion, and then lower the tree slowly by raising the blade.

- Salvage any good hollows for placement off site - wire them to other trees, pointing at the same compass aspect; and

- Relocate branches/roost trees that to a non-impacted area in the immediate neighbourhood. Where relocation of whole trees is not feasible, the extent of the tree hollow can be estimated and that section can be chain sawed out and fastened to nearby trees in a non-impacted area. Artificial nest boxes can also be installed within the non-impacted area.

- It is recommended that the methodologies for the rehabilitation/re-vegetation works for the Project use the most appropriate species for the landscape elements of the site. Such methodologies should include habitat matching of species to ensure rehabilitation success. Areas such as the waste rock dump should be assessed for species to ensure long-term stability and rehabilitation success rather than “quick fixes” that may not be successful in the long term;

- It is recommended that recreated landforms are contoured to resemble the original local topography. This includes replicating any stony hillocks, riverine areas and flat sandy plains which may be disturbed;

- Infrastructure planning should avoid the creation of permanent, shallow water areas, such as septic and other tank overflows that form a permanent seep. These areas attract Cane Toads (*Rhinella marina*) that are lethal to most snakes and other fauna species when ingested;

- Measures should be taken to minimise harm to affected fauna communities by inspecting the vegetation to be disturbed prior to clearing to ascertain whether any fauna are present. If fauna is present, it should be given the opportunity to move on naturally before clearing occurs;

- A segment of the Staff Induction Program should be allocated to informing staff of the conservation values on the Project site to increase staff awareness of the species present. This could include photographs, brief descriptions and management requirements of native species; and

- A rehabilitation strategy should be developed for the Project site. This strategy should embody the concepts and recommendations presented above and include provision for monitoring of rehabilitation progress over the life of the operation.

9.3.3 Threatened Species Management Strategies

The Purple-necked Rock-wallaby (*Petrogale purpureicollis*) was identified along sections of the Knapdale Range and in the vicinity of the proposed TSF area. This species is listed as Vulnerable under the NCWR. Strategies to manage and mitigate for impacts which may affect the Rock-wallaby include creating a vertebrate pest control program, regulate roadways and further monitoring. These strategies are described below.

Creation of a Vertebrate Pest Control Program

A Pest Control Program is recommended to commence before land clearing for mine infrastructure takes place on the Project site. This program is aimed at minimising populations and adverse impacts of pest fauna known to prey on Rock-wallabies, thereby reducing pressures on the Purple-necked Rock-wallaby (*Petrogale purpureicollis*) population. Recommendations for the Pest Control Program include:

- A pest inventory should put into practice, identifying types, abundance and location of pest animals. The data should be collected and managed in a standardised way so that trends can be determined;
- A process for reporting and identification of new pest species should be in place, along with a rapid response process for the management of new infestations;
- The Pest Control Program should directly relate to a Monitoring Program, with survey of both Purple-necked Rock-wallaby (*Petrogale purpureicollis*) numbers and pest species numbers;
- Targeting more than one pest species is important as the control of one pest species may benefit another (e.g. Control of Dingos (*Canis lupus familiaris*) may benefit the European rabbit (*Oryctolagus cuniculus*));
- A qualified pest control consultant or ecologist should be consulted prior to the commencement of the program as inappropriately designed baiting programs can be detrimental to other native fauna species;
- Pest management awareness should be included as a segment of the Staff Induction Program;
- Food scraps and waste should not be accessible or exposed to fauna, as this may attract pest wildlife and increase their food supply;
- Pest control strategies should be conducted in accordance with local government strategies;

Fencing along the TSF

It is recommended to enclose the TSF area with metal fencing, to prohibit access for the Purple-necked Rock-wallaby (*Petrogale purpureicollis*). Although the TSF location does not necessitate removal of outcrops, it is directly adjacent to outcrops and does include some foraging area. The fence would assist in preventing any unintentional harm to a Rock-wallaby, such as an individual becoming stuck in TSF slurry.

Roadway Regulation

As the proposed access roads to the TSF are in the vicinity of current habitat, foraging and roosting may be potentially impeded. An increase in Rock-wallabies crossing roadways may result in an increase in road injuries or death. To reduce the chances of road fatalities, mitigation strategies may include:

- Utilisation of wildlife reflectors along unfenced roads; and
- All personnel should be informed of the conservation value of the Rock-wallabies.

Further Research and Monitoring

A monitoring program would provide information on the impact (if any) on the affected animals. A monitoring program should consist of two sampling events each year, one in the wet season and the other in the dry season. This will ensure that seasonal behaviour patterns and population fluctuations are adequately accounted for. Data to be included in each sampling event should include, but is not limited to:

- An estimate of the number of Purple-necked Rock-wallabies (*Petrogale purpureicollis*) inhabiting the TSF area, or an indication of any changes in the population size;
- An estimate of the number and type of pest species occurring along the Knapdale Range within the Project site, or any changes in population size; and
- A continuation of data collection on suitable shelter sites and foraging areas as prescribed in this study.

The program should be flexible enough to allow changes in the methodology in response to previous results, which may include a reduction or addition of sample intensity. It is recommended qualified scientists or consultants who are familiar with the species, its faecal pellets and the Project should conduct the monitoring program. Monitoring results will be included in the Annual Audit report, which is submitted to DERM.

9.3.4 Powerline Construction Management Strategies

Strategies to minimise impacts on the River Red Gum Riparian Woodland (RE 1.3.7a) community whilst constructing the powerline corridor may include, but are not limited to:

- Employing horticulturists and tree cutting specialists to trim trees;
- Only trimming up to one third of the River Red Gum (*Eucalyptus camaldulensis*) height at any one time;
- Trimming should occur at the nearest growth point (tree stem or trunk offshoot) to protect trees from infections and disease. Trees should not be cut straight across to a standard clearance;
- Retention of large trees as close as feasible to powerline;
- Presence of a wildlife carer or specialist to determine hollows used by fauna and to aid in fauna relocation when clearing/trimming. Hollows used by fauna that have been removed should be replaced by appropriate nesting boxes; and

- Encourage natural regeneration of native shrubs by removing weeds, which will aid in keeping canopy at a lower height.

The powerline corridor should be aligned to avoid any ground disturbance near rocky outcrops by at least 150m, to protect the habitat of the Purple-necked Rock-wallaby (*Petrogale purpureicollis*).

9.3.5 Weed Management Strategies

No plant species declared under the LP Act were recorded in riparian areas during the survey.

However, a pest management plan may diminish the liability costs associated with weed infestation eradication and rather prevent seed spreading before infestations occur.

As it is an offence to move or transport a vehicle on a road if it is known, or should be known, that it is contaminated with a declared plant. Measures to control the spread of these weeds should be adopted across the Project.

It is recommended that a Pest Management Plan be developed to limit the spread of these species on the Project site. Staff should be informed of the species of weed likely to be encountered on the Project site, the location of known weed infestations, and how to report the presence of new infestations.

Cost effective and simple control measures should include:

- Remain on designated roads where practical;
- Stop water and fertilisers (when used) from running into bushland;
- Manage buffer or windbreak around disused revegetated areas (when applicable);
- Clean machinery; and
- Clean off-road vehicles (including visitors)

Biosecurity Queensland promotes a number of wash-down procedures, enabling industry to meet these requirements.

- Pest fact Sheets (made available from DEEDI) of the weed species which were identified within the River Red Gum Riparian Woodland and Bloodwood Riparian Woodland Regional Ecosystems detail the most effective methods of eradication. These Pest fact Sheets should be consulted, Appendix E, when requiring weed eradication/management strategies.

9.3.6 Management Strategies for Introduced Fauna Species

Under the LP Act, land managers must take reasonable steps to ensure that lands are kept free of Class 2 pests. Given this legal requirement in addition to the potential for these species to impact the environmental values of the Project site, management strategies for each of the Class 2 pests are addressed below:

1. **Dingo/Wild Dog (*Canis familiaris dingo*)** Different control methods including shooting, poisoning, trapping and fencing in combination with current land management practices are most effective to control Dingoes;

2. **Feral Cat (*Felis catus*)** Control methods for feral cats include shooting, poisoning, trapping and fencing in combination with current land management practices; and

3. **Feral Pigs (*Sus scrofa*)** Difficult to control, it is recommended that a combination of physical controls be employed, including shooting, poisoning, trapping and/or barrier construction.

10.0 REFERENCES

AARC (2006a) *Roseby Copper Project – Aquatic Flora and Fauna Assessment*. In Roseby Copper Project Environmental Impact Statement 2007, Universal Resources Limited.

AARC (2006b) *Roseby Copper Project – Terrestrial Flora and Fauna Assessment*. In Roseby Copper Project Environmental Impact Statement 2007, Universal Resources Limited.

Allen, G.R., Midgley, S.H., and Allen, M. (2003) *Field Guide to the Freshwater Fishes of Australia,* Western Australian Museum.

Birds in Backyards: A research, education and conservation program. Available at: www.birdsinbackyards.net.

Churchill, S. (1998) *Australian Bats*, Reed New Holland, Sydney.

Clancy, T. F., and Close, R. L. (1997), *The Queensland rock-wallabies – an overview of their conservation status, threats and management*, Australian Mammalogy.

Cogger, H.G. (2000) *Reptiles and Amphibians of Australia*, Reed New Holland, Sydney.

Department of Environment and Resource Management *Guidelines for Flora Survey and Assessment in North Queensland.*

Department of Environment and Resource Management (2009) *Recommended Fauna Survey Methodology for Environmental Impact Assessments.*

Earth Tech (2004) *Physical and Ecological Assessment of Groundwater Discharge to Kolar Creek*, WMC Fertilizers, Phosphate Hill.

Glover, C.G.M. (1982) "Adaptations of fishes in arid Australia", *Evolution of the Flora and Fauna of Arid Australia*, eds. Barker, W.R. and Greenslade, P.J.M. Peacock Publications, South Australia.

Holmes, G. (1991) *Vascular Flora and Vertebrate Fauna of the Dugald River Mining Project Cloncurry District, Queensland,* AGC Woodward-Clyde.

Horsup A. (1994), *Home Range of the Allied Rock-wallaby, Petrogale assimilis*, Wildlife Research, 21, 65–84

Law B. S. and Dickman C. R. (1998), *The use of habitat mosaics by terrestrial vertebrate fauna: implications for conservation and management*, Biodiversity and Conservation, 7, 323–333.

Marchant, S. and Higgins, P.J. (eds.) (1993) *Handbook of Australian, New Zealand and Antarctic Birds*, Volume 2: Raptors to Lapwings, Oxford University Press, Melbourne.

Menkhorst, P. and Knight, F. (2011). *A Field Guide to the Mammals of Australia*, Oxford University Press.

Morcombe, M. (2002) *Field Guide to Australian Birds*, Steve Parish Publishing, Pty, Ltd.

Neldner, V.J., Wilson, B. A., Thompson, E.J. and Dillewaard, H.A. (2005) *Methodology for Survey and Mapping of Regional Ecosystems and Vegetation Communities in Queensland. Version 3.1*. Updated

September 2005. Queensland Herbarium, Department of Environment and Resource Management, Brisbane.

Sharman, G. B. and Maynes, G. M. (1998). „Rock-wallabies, *Petrogale, Peradorcas*" in Strahan, R. (ed). The Mammals of Australia. Red New Holland Publishers, Melbourne.

New South Wales National Parks and Wildlife Service (2001). *Threatened Species Survey and Assessment: Guidelines for Developments and Activities*. Draft for Comment. Prepared by the NSW National Parks and Wildlife Service and SMEC Australia.

Pianka, E.R. (1969a) *Habitat Specificity, speciation and species density in Australian desert lizards*. Ecology **50**: 498-502.

Pianka, E.R. (1969b) *Sympatry of Desert Lizards (Ctenotus) in Western Australia*. Ecology **50**: 1012-1030.

Pizzey, G. and Knight, F. (1997) *The Field Guide to the Birds of Australia*, HarperCollins Publishers, Pty, Ltd.

Sattler, P.S. and Williams, R.D. (eds.) (1999) *The Conservation Status of Queensland's Bioregional Ecosystems*, Environmental Protection Agency, Brisbane.

Short J. (1982), *Habitat Requirements of the Brush-Tailed Rock-Wallaby, Petrogale penicillata, in New South Wales*, Australian Wildlife Research, 9, 239–246.

Smith, A. P. and Lindenmayer, D. (1988) *Tree Hollow Requirements of Leadbeaters Possum and Other Possums and Gliders in Timber Production Ash Forests of the Victorian Central Highlands,* Australian Wildlife Research **15**: 347-362.

Van Dyck S., Strahan R. (2008), *The Mammals of Australia*, Third Edition, Reed New Holland, Sydney.

Wilson, S. and Swan, G. (2003). *A Complete Guide to Reptiles of Australia*, New Holland Publishers, Sydney.

Withers, P.C. (1995). *Cocoon formation and structure in the aestivating Australian desert frogs*, Neobatrachus and Cyclorana. Australian Journal of Zoology **43**: 429-441.

Appendix A: Database Search Results

Australian Government
Department of the Environment, Water, Heritage and the Arts

Protected Matters Search Tool

You are here: Environment Home > EPBC Act > Search

7 October 2008 14:01

EPBC Act Protected Matters Report

This report provides general guidance on matters of national environmental significance and other matters protected by the EPBC Act in the area you have selected. Information on the coverage of this report and qualifications on data supporting this report are contained in the caveat at the end of the report.

You may wish to print this report for reference before moving to other pages or websites.

The Australian Natural Resources Atlas at http://www.environment.gov.au/atlas may provide further environmental information relevant to your selected area. Information about the EPBC Act including significance guidelines, forms and application process details can be found at http://www.environment.gov.au/epbc/assessmentsapprovals/index.html

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Search Type:	Point
Buffer:	30 km
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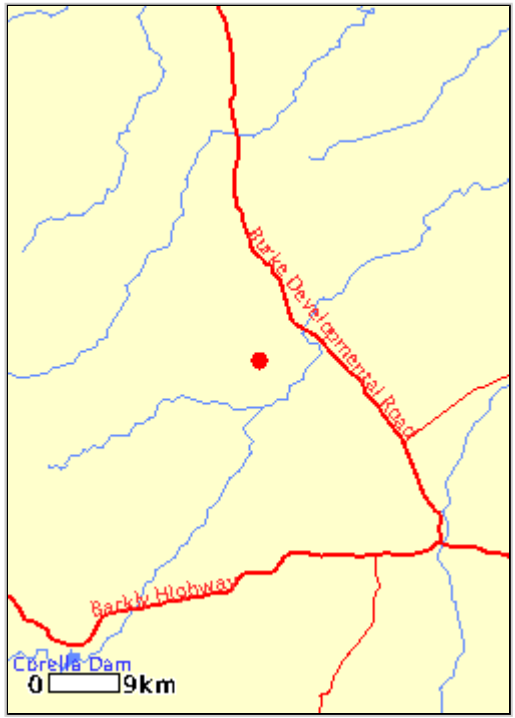


Report Contents:

Summary
Details
- Matters of NES
- Other matters protected by the EPBC Act

- Extra Information

Caveat
Acknowledgments



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Summary

Matters of National Environmental Significance

This part of the report summarises the matters of national environmental significance that may occur in, or may relate to, the area you nominated. Further

information is available in the detail part of the report, which can be accessed by scrolling or following the links below. If you are proposing to undertake an activity that may have a significant impact on one or more matters of national environmental significance then you should consider the Administrative Guidelines on Significance - see http://www.environment.gov.au/epbc/assessmentsapprovals/guidelines/index.html.

World Heritage Properties:	None
National Heritage Places:	None
Wetlands of International Significance: (Ramsar Sites)	None
Commonwealth Marine Areas:	None
Threatened Ecological Communities:	None
Threatened Species:	3
Migratory Species:	11

Other Matters Protected by the EPBC Act

This part of the report summarises other matters protected under the Act that may relate to the area you nominated. Approval may be required for a proposed activity that significantly affects the environment on Commonwealth land, when the action is outside the Commonwealth land, or the environment anywhere when the action is taken on Commonwealth land. Approval may also be required for the Commonwealth or Commonwealth agencies proposing to take an action that is likely to have a significant impact on the environment anywhere.

The EPBC Act protects the environment on Commonwealth land, the environment from the actions taken on Commonwealth land, and the environment from actions taken by Commonwealth agencies. As heritage values of a place are part of the 'environment', these aspects of the EPBC Act protect the Commonwealth Heritage values of a Commonwealth Heritage place and the heritage values of a place on the Register of the National Estate. Information on the new heritage laws can be found at http://www.environment.gov.au/heritage/index.html.

Please note that the current dataset on Commonwealth land is not complete. Further information on Commonwealth land would need to be obtained from relevant sources including Commonwealth agencies, local agencies, and land tenure maps.

A permit may be required for activities in or on a Commonwealth area that may affect a member of a listed threatened species or ecological community, a member of a listed migratory species, whales and other cetaceans, or a member of a listed marine species. Information on EPBC Act permit requirements and application forms can be found at http://www.environment.gov.au/epbc/permits/index.html.

Commonwealth Lands:	None
Commonwealth Heritage Places:	None
Places on the RNE:	1
Listed Marine Species:	10
Whales and Other Cetaceans:	None
Critical Habitats:	None
Commonwealth Reserves:	None

Extra Information

This part of the report provides information that may also be relevant to the area you have nominated.

State and Territory Reserves:	None
Other Commonwealth Reserves:	None
Regional Forest Agreements:	None

Details

Matters of National Environmental Significance

Threatened Species [Dataset Information]	Status	Type of Presence

Birds		
Rostratula australis Australian Painted Snipe	Vulnerable	Species or species habitat may occur within area
Mammals		
Sminthopsis douglasi Julia Creek Dunnart	Endangered	Species or species habitat may occur within area
Sharks		
Pristis microdon Freshwater Sawfish	Vulnerable	Species or species habitat likely to occur within area
Migratory Species [Dataset Information]	Status	Type of Presence
Migratory Terrestrial Species		
Birds		
Haliaeetus leucogaster White-bellied Sea-Eagle	Migratory	Species or species habitat likely to occur within area
Merops ornatus Rainbow Bee-eater	Migratory	Species or species habitat may occur within area
Migratory Wetland Species		
Birds		
Ardea alba Great Egret, White Egret	Migratory	Species or species habitat may occur within area
Ardea ibis Cattle Egret	Migratory	Species or species habitat may occur within area
Charadrius veredus Oriental Plover, Oriental Dotterel	Migratory	Species or species habitat may occur within area

Glareola maldivarum Oriental Pratincole	Migratory	Species or species habitat may occur within area
Numenius minutus Little Curlew, Little Whimbrel	Migratory	Species or species habitat may occur within area
Rostratula benghalensis s. lat. Painted Snipe	Migratory	Species or species habitat may occur within area
Migratory Marine Birds		
Apus pacificus Fork-tailed Swift	Migratory	Species or species habitat may occur within area
Ardea alba Great Egret, White Egret	Migratory	Species or species habitat may occur within area
Ardea ibis Cattle Egret	Migratory	Species or species habitat may occur within area

Other Matters Protected by the EPBC Act

Listed Marine Species [Dataset Information]	Status	Type of Presence
Birds		
Apus pacificus Fork-tailed Swift	Listed - overfly marine area	Species or species habitat may occur within area
Ardea alba Great Egret, White Egret	Listed - overfly marine area	Species or species habitat may occur within area
Ardea ibis Cattle Egret	Listed - overfly marine area	Species or species habitat may occur within area
Charadrius veredus	Listed -	Species or species habitat may occur within area

Oriental Plover, Oriental Dotterel	overfly marine area	
Glareola maldivarum Oriental Pratincole	Listed - overfly marine area	Species or species habitat may occur within area
Haliaeetus leucogaster White-bellied Sea-Eagle	Listed	Species or species habitat likely to occur within area
Merops ornatus Rainbow Bee-eater	Listed - overfly marine area	Species or species habitat may occur within area
Numenius minutus Little Curlew, Little Whimbrel	Listed - overfly marine area	Species or species habitat may occur within area
Rostratula benghalensis s. lat. Painted Snipe	Listed - overfly marine area	Species or species habitat may occur within area
Reptiles		
Crocodylus johnstoni Freshwater Crocodile	Listed	Species or species habitat may occur within area

Places on the RNE [Dataset Information]
Note that not all Indigenous sites may be listed.

Indigenous

The Granites Area QLD

Caveat

The information presented in this report has been provided by a range of data sources as acknowledged at the end of the report.

This report is designed to assist in identifying the locations of places which may be relevant in determining obligations under the *Environment Protection and Biodiversity Conservation Act 1999*. It holds mapped locations of World Heritage and Register of National Estate properties, Wetlands of International Importance, Commonwealth and State/Territory reserves, listed threatened, migratory and marine species and listed threatened ecological communities. Mapping of Commonwealth land is not complete at this stage. Maps have been collated from a range of sources at various resolutions.

Not all species listed under the EPBC Act have been mapped (see below) and therefore a report is a general guide only. Where available data supports mapping, the type of presence that can be determined from the data is indicated in general terms. People using this information in making a referral may need to consider the qualifications below and may need to seek and consider other information sources.

For threatened ecological communities where the distribution is well known, maps are derived from recovery plans, State vegetation maps, remote sensing imagery and other sources. Where threatened ecological community distributions are less well known, existing vegetation maps and point location data are used to produce indicative distribution maps.

For species where the distributions are well known, maps are digitised from sources such as recovery plans and detailed habitat studies. Where appropriate, core breeding, foraging and roosting areas are indicated under "type of presence". For species whose distributions are less well known, point locations are collated from government wildlife authorities, museums, and non-government organisations; bioclimatic distribution models are generated and these validated by experts. In some cases, the distribution maps are based solely on expert knowledge.

Only selected species covered by the migratory and marine provisions of the Act have been mapped.

The following species and ecological communities have not been mapped and do not appear in reports produced from this database:

- threatened species listed as extinct or considered as vagrants
- some species and ecological communities that have only recently been listed
- some terrestrial species that overfly the Commonwealth marine area
- migratory species that are very widespread, vagrant, or only occur in small numbers.

The following groups have been mapped, but may not cover the complete distribution of the species:

- non-threatened seabirds which have only been mapped for recorded breeding sites;
- seals which have only been mapped for breeding sites near the Australian continent.

Such breeding sites may be important for the protection of the Commonwealth Marine environment.

Acknowledgments

This database has been compiled from a range of data sources. The Department acknowledges the following custodians who have contributed valuable data and advice:

- New South Wales National Parks and Wildlife Service
- Department of Sustainability and Environment, Victoria
- Department of Primary Industries, Water and Environment, Tasmania
- Department of Environment and Heritage, South Australia Planning SA
- Parks and Wildlife Commission of the Northern Territory
- Environmental Protection Agency, Queensland
- Birds Australia
- Australian Bird and Bat Banding Scheme
- Australian National Wildlife Collection
- Natural history museums of Australia
- Queensland Herbarium
- National Herbarium of NSW
- Royal Botanic Gardens and National Herbarium of Victoria
- Tasmanian Herbarium
- State Herbarium of South Australia

- Northern Territory Herbarium
- Western Australian Herbarium
- Australian National Herbarium, Atherton and Canberra
- University of New England
- Other groups and individuals

ANUCliM Version 1.8, Centre for Resource and Environmental Studies, Australian National University was used extensively for the production of draft maps of species distribution. Environment Australia is extremely grateful to the many organisations and individuals who provided expert advice and information on numerous draft distributions.

Last updated: Monday, 21-Jul-2008 10:56:50 EST

Department of the Environment, Water, Heritage and the Arts
GPO Box 787 Canberra ACT 2601 Australia
Telephone: +61 (0)2 6274 1111

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EPBC Act Protected Matters Report: Coordinates

This report provides general guidance on matters of national environmental significance and other matters protected by the EPBC Act in the area you have selected.

Information on the coverage of this report and qualifications on data supporting this report are contained in the caveat at the end of the report.

You may wish to print this report for reference before moving to other pages or websites.

Information about the EPBC Act including significance guidelines, forms and application process details can be found at http://www.environment.gov.au/epbc/assessmentsapprovals/index.html

Report created: 18/04/11 11:48:18



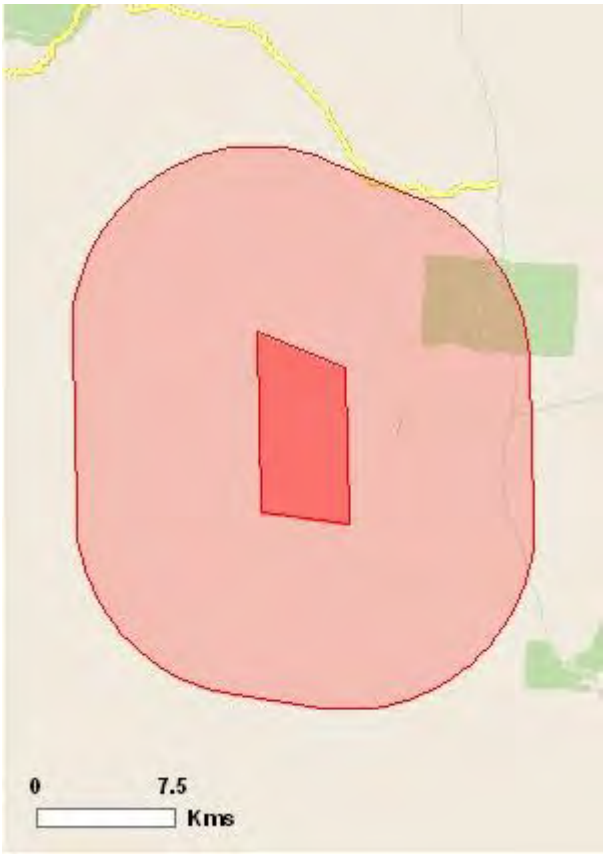
Summary

Details

Matters of NES
Other matters protected by the EPBC Act
Extra Information

Caveat

Acknowledgements



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Coordinates
Buffer: 10Km

Summary

Matters of National Environmental Significance

This part of the report summarises the matters of national environmental significance that may occur in, or may relate to, the area you nominated. Further information is available in the detail part of the report, which can be accessed by scrolling or following the links below. If you are proposing to undertake an activity that may have a significant impact on one or more matters of national environmental significance then you should consider the Administrative Guidelines on Significance - see http://www.environment.gov.au/epbc/assessmentsapprovals/guidelines/index.html.

World Heritage Properties:	None
National Heritage Places:	None
Wetlands of International Significance (Ramsar Wetlands):	None
Great Barrier Reef Marine Park:	None
Commonwealth Marine Areas:	None
Threatened Ecological Communitites:	None
Threatened Species:	3
Migratory Species:	10

Other Matters Protected by the EPBC Act

This part of the report summarises other matters protected under the Act that may relate to the area you nominated. Approval may be required for a proposed activity that significantly affects the environment on Commonwealth land, when the action is outside the Commonwealth land, or the environment anywhere when the action is taken on Commonwealth land. Approval may also be required for the Commonwealth or Commonwealth agencies proposing to take an action that is likely to have a significant impact on the environment anywhere.

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Please note that the current dataset on Commonwealth land is not complete. Further information on Commonwealth land would need to be obtained from relevant sources including Commonwealth agencies, local agencies, and land tenure maps.

A permit may be required for activities in or on a Commonwealth area that may affect a member of a listed threatened species or ecological community, a member of a listed migratory species, whales and other cetaceans, or a member of a listed marine species. Information on EPBC Act permit requirements and application forms can be found at http://www.environment.gov.au/epbc/permits/index.html.

Commonwealth Lands:	None
Commonwealth Heritage Places:	None
Listed Marine Species:	9

Whales and Other Cetaceans:	None
Critical Habitats:	None
Commonwealth Reserves:	None

Report Summary for Extra Information

This part of the report provides information that may also be relevant to the area you have nominated.

Place on the RNE:	None
State and Territory Reserves:	None
Regional Forest Agreements:	None
Invasive Species:	12
Nationally Important Wetlands:	None

Details

Matters of National Environmental Significance

Threatened Species		**[Resource Information]**
Name	Status	Type of Presence
BIRDS		
Rostratula australis		
Australian Painted Snipe [77037]	Vulnerable	Species or species habitat may occur within area
MAMMALS		
Sminthopsis douglasi		
Julia Creek Dunnart [305]	Endangered	Species or species habitat may occur within area
SHARKS		
Pristis microdon		
Freshwater Sawfish [66182]	Vulnerable	Species or species habitat likely to occur within area

Migratory Species		**[Resource Information]**
Name	Status	Type of Presence
Migratory Marine Birds		
Apus pacificus		
Fork-tailed Swift [678]		Species or species habitat may occur within area
Ardea alba		
Great Egret, White Egret [59541]		Species or species habitat may occur within area
Ardea ibis		
Cattle Egret [59542]		Species or species habitat may occur within area
Migratory Terrestrial Species		
Haliaeetus leucogaster		
White-bellied Sea-Eagle [943]		Species or species habitat likely to occur within area
Merops ornatus		
Rainbow Bee-eater [670]		Species or species habitat may occur within area
Migratory Wetlands Species		
Ardea alba		

Great Egret, White Egret [59541] Ardea ibis	Species or species habitat may occur within area
Cattle Egret [59542] Charadrius veredus	Species or species habitat may occur within area
Oriental Plover, Oriental Dotterel [882] Glareola maldivarum	Species or species habitat may occur within area
Oriental Pratincole [840] Rostratula benghalensis s. lat.	Species or species habitat may occur within area
Painted Snipe [889]	Species or species habitat may occur within area

Other Matters Protected by the EPBC Act

Listed Marine Species **[Resource Information]**

Name	Status	Type of Presence
Birds		
Apus pacificus Fork-tailed Swift [678]		Species or species habitat may occur within area
Ardea alba Great Egret, White Egret [59541]		Species or species habitat may occur within area
Ardea ibis Cattle Egret [59542]		Species or species habitat may occur within area
Charadrius veredus Oriental Plover, Oriental Dotterel [882]		Species or species habitat may occur within area
Glareola maldivarum Oriental Pratincole [840]		Species or species habitat may occur within area
Haliaeetus leucogaster White-bellied Sea-Eagle [943]		Species or species habitat likely to occur within area
Merops ornatus Rainbow Bee-eater [670]		Species or species habitat may occur within area
Rostratula benghalensis s. lat. Painted Snipe [889]		Species or species habitat may occur within area
Reptiles		
Crocodylus johnstoni Freshwater Crocodile, Johnston's Crocodile, Johnston's River Crocodile [1773]		Species or species habitat may occur within area

Extra Information

Invasive Species **[Resource Information]**

Weeds reported here are the 20 species of national significance (WoNS), along with other introduced plants that are considered by the States and Territories to pose a particularly significant threat to biodiversity. The following feral animals are reported: Goat, Red Fox, Cat, Rabbit, Pig, Water Buffalo and Cane Toad. Maps from Landscape Health Project, National Land and Water Resouces Audit, 2001.

Name	Status	Type of Presence
Frogs		
Bufo marinus Cane Toad [1772]		Species or species habitat likely to occur within area

Mammals	
Felis catus	
Cat, House Cat, Domestic Cat [19]	Species or species habitat may occur within area
Oryctolagus cuniculus	
Rabbit, European Rabbit [128]	Species or species habitat may occur within area
Sus scrofa	
Pig [6]	Species or species habitat likely to occur within area
Vulpes vulpes	
Red Fox, Fox [18]	Species or species habitat may occur within area
Plants	
Acacia nilotica subsp. indica	
Prickly Acacia [6196]	Species or species habitat may occur within area
Cenchrus ciliaris	
Buffel-grass, Black Buffel-grass [20213]	Species or species habitat likely to occur within area
Cryptostegia grandiflora	
Rubber Vine, Rubbervine, India Rubber Vine, India Rubbervine, Palay Rubbervine, Purple Allamanda [18913]	Species or species habitat may occur within area
Hymenachne amplexicaulis	
Hymenachne, Olive Hymenachne, Water Stargrass, West Indian Grass, West Indian Marsh Grass [31754]	Species or species habitat may occur within area
Parkinsonia aculeata	
Parkinsonia, Jerusalem Thorn, Jelly Bean Tree, Horse Bean [12301]	Species or species habitat may occur within area
Parthenium hysterophorus	
Parthenium Weed, Bitter Weed, Carrot Grass, False Ragweed [19566]	Species or species habitat may occur within area
Prosopis spp.	
Mesquite, Algaroba [68407]	Species or species habitat may occur within area

Caveat

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Only selected species covered by the following provisions of the EPBC Act have been mapped:
- migratory and
- marine

The following species and ecological communities have not been mapped and do not appear in reports produced from this database:
- threatened species listed as extinct or considered as vagrants
- some species and ecological communities that have only recently been listed
- some terrestrial species that overfly the Commonwealth marine area
- migratory species that are very widespread, vagrant, or only occur in small numbers.

The following groups have been mapped, but may not cover the complete distribution of the species:
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- seals which have only been mapped for breeding sites near the Australian continent.

Such breeding sites may be important for the protection of the Commonwealth Marine environment.

Coordinates

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Acknowledgements

This database has been compiled from a range of data sources. The department acknowledges the following custodians who have contributed valuable data and advice:

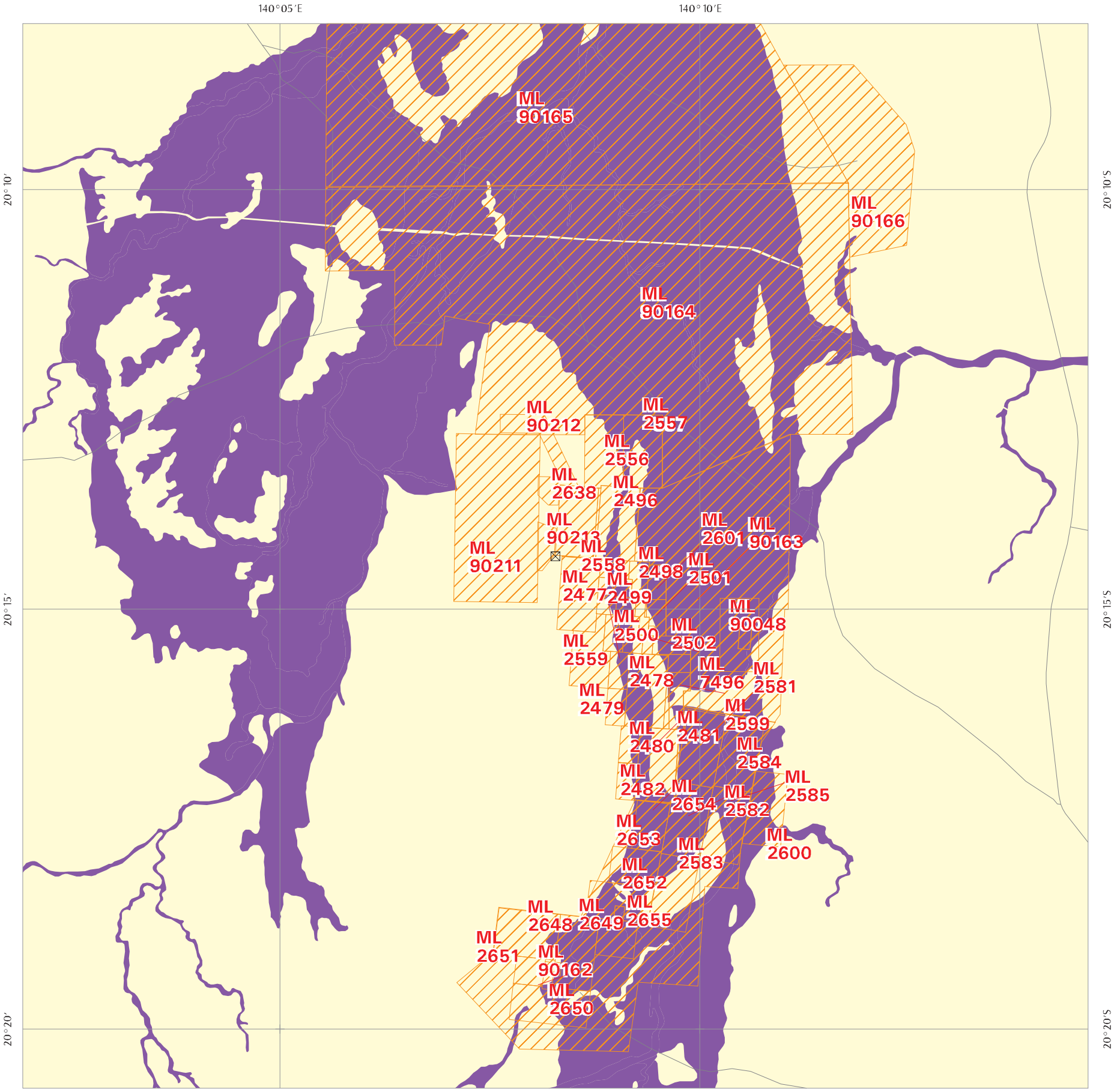
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-Department of Sustainability and Environment, Victoria
-Department of Primary Industries, Parks, Water and Environment, Tasmania
-Department of Environment and Natural Resources, South Australia
-Parks and Wildlife Service NT, NT Dept of Natural Resources, Environment and the Arts
-Environmental and Resource Management, Queensland
-Department of Environment and Conservation, Western Australia
-Department of the Environment, Climate Change, Energy and Water
-Birds Australia
-Australian Bird and Bat Banding Scheme
-Australian National Wildlife Collection
-Natural history museums of Australia
-Museum Victoria
-Australian Museum

-SA Museum
-Queensland Museum
-Online Zoological Collections of Australian Museums
-Queensland Herbarium
-National Herbarium of NSW
-Royal Botanic Gardens and National Herbarium of Victoria
-Tasmanian Herbarium
-State Herbarium of South Australia
-Northern Territory Herbarium
-Western Australian Herbarium
-Australian National Herbarium, Atherton and Canberra
-University of New England
-Ocean Biogeographic Information System
-Australian Government, Department of Defence
-State Forests of NSW
-Other groups and individuals

Environment Australia is extremely grateful to the many organisations and individuals who provided expert advice and information on numerous draft distributions.

Please feel free to provide feedback via the Contact Us page.

Department of Sustainability, Environment, Water, Population and Communities
GPO Box 787
Canberra ACT 2601 Australia
+61 2 6274 1111 ABN



Legend

- Mining Leases

CATEGORY A
- National Parks
- Conservation Parks
- Forest Reserves
- Wet Tropics World Heritage Area
- Great Barrier Reef Marine Park Region
- Marine Parks other than General Use Zones

CATEGORY B
- World Heritage Areas
- Queensland Heritage Register Places
- Ramsar Sites
- Cultural Heritage Registered Areas and DLA's other than Stanbroke
- Special Forestry Areas
- Fish Habitat Areas
- Koala Plan
- Coordinated Conservation Areas
- Endangered Regional Ecosystems (Biodiversity Status)
- General Use Zones of Marine Parks
- Marine Plants

CATEGORY C
- Nature Refuges
- Resources Reserves
- Declared Catchment Areas
- Declared Irrigation Areas
- Drainage Areas
- River Improvement Areas
- Stanbroke DLA
- State Forests
- Timber Reserves
- Coastal Management Control Districts
- Dams and Weirs

OTHERS
- Roads
- Towns
- Wild River Nominated Waterways
- Wild River High Preservation Areas
- Wild River Preservation Areas
- Mahogany Glider Habitat
- Directory of Important Wetlands
- Queensland

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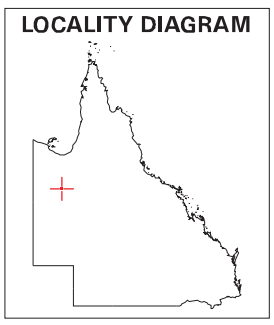
ENVIRONMENTALLY SENSITIVE AREAS - Mining Activities

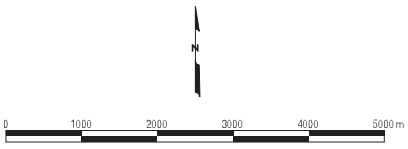
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Date: 19 Apr 11 Time: 11.15.28

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(decimal degrees)

Queensland Government

LOCALITY DIAGRAM





This scale bar is approximate only
Horizontal Datum: Geocentric Datum of Australia 1994 (GDA94)
This product is unprojected and is not suitable for measuring distances

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NOTE TO USER: Themes presented in this map are indicative only. Field survey may be required to verify the 'true' spatial extent and value. Not all environmentally sensitive areas are presented in this map. A user should refer to the particular circumstances relevant to their situation to assess the 'completeness' of themes provided.

The user should note that some boundaries and indicated values are ambient and may change over time (e.g. regional ecosystem boundaries and conservation status, watercourse mapping etc).

The user should be aware that due to multiple overlapping themes/ layers present, some themes/layers may be obscured by others. Ordering in the Legend does not accurately reflect the order by which themes/layers are displayed.

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Aq_Nr	Batch_Nr	Cultivated	Group_Code	Group_Name	Family_Name	Status	Botanical_Name	Bc_Nr	Collect_Name	Collect_Code	Additional_Collectors	Collect_Date	Deter_Name	Deter_Date	Region_Name	District_Name	Locality	Floristic	Habitat	Additional	Altitude	Depth	Locn_Der	Geosource	Geodetic	Precision
326262	1		A	Angiosperm	Sterculiaceae	R	Brachychiton collinus Guymer	15244	Cole M.	105	Provan,D.;	15APR1962	Guymer G.		Queensland	Burke	DUGALD RIVER NEAR VOLGA	+---+000--+-	FT----				Hrb Convert	Lat/Long	AGD66	16000

Latitude	Longitude	Long_Decimal	Lat_Decimal	Amg_Zone	Amg_Easting	Amg_Northing	Grid	Label	Cultiv_Reference_Set	Public_Reference_Set	Reference_Set	Historical	Regional_Ecosystem1	Regional_Ecosystem2	Regional_Ecosystem3	Spirit	Carpological	Wood	Photo	Corveg	Date_Created	Last_Updated	GDA_lat_decimal	GDA_long_decimal
S20 15	E140 15	140.25	-20.25	54	421669	7760668	6957-216606	Dugald River near Volga. On rocky hill. Carpological material at BRI.													7/11/2000	16/08/2007	-20.2484874	140.251185

Aq_Nr	Batch_Nr	Group_Name	Family_Name	Status	Botanical_Name	Collect_Name	Collect_Code	Additional_Collectors	Collect_Date
724420	6592	Pteridophyte	Salviniaceae	*	Salvinia molesta D.S.Mitch.	Bean A.R.	24188		12JUN2005
747412	6833	Angiosperm	Amaranthaceae	N	Ptilotus maconochiei Benl	Kelman D.T.	141		10APR2002
650038	5645	Angiosperm	Amaranthaceae	N	Ptilotus maconochiei Benl	Barrs S.	SB24		18JUN1996
394031	1	Angiosperm	Amaranthaceae	N	Ptilotus maconochiei Benl	Schmid A.	684		20MAY1983
394030	1	Angiosperm	Amaranthaceae	N	Ptilotus maconochiei Benl	Schmid A.	648		20JUN1983
440883	1	Angiosperm	Amaranthaceae	N	Ptilotus maconochiei Benl	Harris P.L.	105		14NOV1986
178815	1	Angiosperm	Amaranthaceae	N	Ptilotus maconochiei Benl	Bishop H.G.			02AUG1969
440872	1	Angiosperm	Amaranthaceae	N	Ptilotus maconochiei Benl	Harris P.L.	93		16NOV1986
332686	1	Angiosperm	Amaranthaceae	N	Ptilotus maconochiei Benl	Benl G.	AU64	Maconochie,J.;	08MAR1978

394029	1	Angiosperm	Amaranthaceae	N	Ptilotus maconochiei Benl	Schmid A.	681		23MAY1983
699277	6568	Angiosperm	Amaranthaceae	N	Ptilotus maconochiei Benl	Johnston M.	05-101		06SEP2005
323904	1	Angiosperm	Amaranthaceae	N	Ptilotus maconochiei Benl	Blake S.T.	8783		28APR1935
114013	1	Angiosperm	Amaranthaceae	N	Ptilotus maconochiei Benl	Mason K.			1975
456557	1	Angiosperm	Amaranthaceae	N	Ptilotus maconochiei Benl	Harris P.L.	411		22JUL1989
850649	6930	Angiosperm	Convolvulaceae	N	Ipomoea antonschmidii R.W.Johnson	Booth R.	5541	Kelman,D.T.;	30JUN2010
749309	6868	Angiosperm	Convolvulaceae	N	Ipomoea antonschmidii R.W.Johnson	Booth R.	4484	Kelman,D.T.;	18MAY2006
451790	1	Angiosperm	Convolvulaceae	N	Ipomoea antonschmidii R.W.Johnson	Harris P.L.	201		04JUL1987
747455	6835	Angiosperm	Convolvulaceae	N	Ipomoea antonschmidii R.W.Johnson	Kelman D.T.		Turpin,G.P.;	10APR2002
407422	1	Angiosperm	Convolvulaceae	N	Ipomoea antonschmidii R.W.Johnson	Harris P.L.	155		22MAR1987

258552	1	Angiosperm	Convolvulaceae	N	Ipomoea antonschmidii R.W.Johnson	Schmid A.	AS430		20FEB1978
378135	1	Angiosperm	Convolvulaceae	N	Ipomoea antonschmidii R.W.Johnson	Schmid A.	756		19JAN1984
472703	1	Angiosperm	Convolvulaceae	N	Ipomoea antonschmidii R.W.Johnson	Harris P.L.	514		07APR1990
341042	1	Angiosperm	Cyperaceae	N	Fimbristylis distincta S.T.Blake	Blake S.T.	8715		22APR1935
406108	1	Angiosperm	Goodeniaceae	N	Goodenia angustifolia Carolin	Neldner V.J.	1615		OCT1984
406120	1	Angiosperm	Goodeniaceae	N	Goodenia angustifolia Carolin	Neldner V.J.	1627		OCT1984
405472	1	Angiosperm	Goodeniaceae	N	Goodenia angustifolia Carolin	Ollerenshaw P.	1253	Kratzing,D.;	06JUL1974
723395	6528	Angiosperm	Scrophulariaceae	N	Rhamphicarpa australiensis Steenis	McDonald K.R.	KRM4087		27MAR2005

769877	6735	Angiosperm	Scrophulariaceae	N	Rhamphicarpa australiensis Steenis	Fox I.D.	IDF3600	Wilson,G.W.;Kr	01MAR2005

Deter_Name	Deter_Date	Region_Name	District_Name	Locality	Floristic	Habitat
		Queensland	Burke	CORELLA DAM, C. 70KM E OF MT ISA.	----------	XDFA--
		Queensland	Burke	JUST OFF WAGER CREEK, 350M W OF LAKE JULIUS	+0+0000----	LT----
		Queensland	Burke	OSKARS VALLEY 15KM N MT ISA	+-+-000----	AT----
		Queensland	Burke	1.6KM N OF HILTON MINE	+++0000----	FTFA--
		Queensland	Burke	11KM N 2KM W OF MT ISA (REFSET)	+++0000----	L----G
		Queensland	Burke	11KM NE OF MT ISA OFF LM RD	+000000----	F-FA--
		Queensland	Burke	MT ISA CITY MAIN LOOKOUT	+000000----	FT----
		Queensland	Burke	MT ISA CITY LOOKOUT	+000000----	F-FA--
		Queensland	Burke	MT ISA CITY LOOKOUT	+000000----	F-----

		Queensland	Burke	MT ISA CITY MAIN LOOKOUT	+++-000----	-T----
		Queensland	Burke	MT ISA LOOKOUT	+0++000----	LT----
Benl G.		Queensland	Burke	MT ISA	+000000----	FTYC--
		Queensland	Burke	MT ISA	+000000----	------
		Queensland	Burke	FOUNTAIN RA 54KM SE OF MT ISA	+++-000----	K-FA-K
Johnson R.W.	NOV2010	Queensland	Burke	CA. 110KM NNE OF MT ISA.	++++000----	A-FA--
May A.R.		Queensland	Burke	CALTON HILLS STATION, NW OF GUNPOWDER	+++-000----	DD----
		Queensland	Burke	BULL CK 21KM E OF GUNPOWDER	+--+000----	D-----
Kelman D.T.		Queensland	Burke	WAGNER CREEK, EAST EDGE OF LAKE JULIUS, C. 70KM NNE OF MOUNT ISA	++++000----	-TFA--
		Queensland	Burke	LAKE JULIUS PIPELINE RD 66KM NNE OF MT ISA	+++0000----	------

	Queensland	Burke	CA 5KM SW LAKE JULIUS PUMP STN PIPELINE ROAD	+++0000----	------
	Queensland	Burke	5KM SW OF LAKE JULIUS PUMP STATION ON PIPELINE RD	++++000----	-K----
	Queensland	Burke	POLICE CK 42KM NNE OF MT ISA	+++-000----	X-OF--
	Queensland	Burke	UNDILLA	+000000----	C-----
	Queensland	Burke	6KM N OF MALBON	++++000----	ADYC--
	Queensland	Burke	NR RAILWAY CROSSING 5KM N OF MALBON VALE HS	++++000----	ADFA--
Taylor J.	Queensland	Gregory North	7M S OF DUCHESS ON RD TO TREKELANO MINE	+++0000----	------
	Queensland	Burke	14.1KM BY ROAD TOWARDS JULIA CREEK FROM JUNCTION WITH BURKE DEVELOPMENT RD.	++++000----	B-FA--

Queensland	Burke	IMMEDIATELY DOWNSTREAM OF THE ROAD CROSSING OF CROCODILE CREEK, SW OF BURKE AND WILLS ROADHOUSE.	++++000----	E-FF--

Additional	Altitude	Depth	Locn_Der	Geosource	Geodetic	Precision	Latitude	Longitude	Long_Decimal	Lat_Decimal	Amg_Zone
	297		GPS	Lat/Long	AGD84	100	S20 50 52.00	E140 03 02.00	140.0505556	-20.84777778	54
			GPS	AMG	WGS84	100	S20 08 28.21	E139 45 32.32	139.7589786	-20.14116946	54
G			Map	Lat/Long	AGD66	1600	S20 34 30.00	E139 28 30.00	139.475	-20.575	54
	350		Hrb Convert	Lat/Long	AGD66	1600	S20 34 30.00	E139 28 30.00	139.475	-20.575	54
	320		Hrb Convert	Lat/Long	AGD66	1600	S20 36 30.00	E139 28 30.00	139.475	-20.60833333	54
G	350		Hrb Convert	Lat/Long	AGD66	1600	S20 39 30.00	E139 33 30.00	139.5583333	-20.65833333	54
			GPS	Lat/Long	GDA94	100	S20 43 18.00	E139 30 02.00	139.5005556	-20.72166667	54
G	350		GPS	Lat/Long	GDA94	100	S20 43 18.00	E139 30 02.00	139.5005556	-20.72166667	54
T	570		GPS	Lat/Long	GDA94	100	S20 43 18.00	E139 30 02.00	139.5005556	-20.72166667	54

BF	380	GPS	Lat/Long	GDA94	100	S20 43 18.00	E139 30 02.00	139.5005556	-20.72166667	54
G		GPS	Lat/Long	AGD66	100	S20 43 23.46	E139 29 58.32	139.4995333	-20.72318333	54
		Hrb Convert	Lat/Long	AGD66	16000	S20 45	E139 25	139.4166667	-20.75	54
		Hrb Convert	Lat/Long	AGD66	16000	S20 45	E139 25	139.4166667	-20.75	54
G	520	Hrb Convert	Lat/Long	AGD66	1600	S20 59 30.00	E139 55 30.00	139.925	-20.99166667	54
J		GPS	AMG	WGS84	100	S19 25 18.77	E139 37 15.56	139.6209893	-19.42187953	54
J		GPS	Lat/Long	WGS84	100	S19 36 46.00	E139 21 15.00	139.3541667	-19.61277778	54
J	260	Hrb Convert	Lat/Long	AGD66	1600	S19 45 30.00	E139 35 30.00	139.5916667	-19.75833333	54
J		GPS	AMG	WGS84	100	S20 08 28.21	E139 45 32.32	139.7589786	-20.14116946	54
J	250	Hrb Convert	Lat/Long	AGD66	1600	S20 10 30.00	E139 43 30.00	139.725	-20.175	54

		Hrb Convert	Lat/Long	AGD66	1600	S20 15 30.00	E139 44 30.00	139.7416667	-20.25833333	54
TB		Hrb Convert	Lat/Long	AGD66	1600	S20 15 30.00	E139 44 30.00	139.7416667	-20.25833333	54
J	315	Hrb Convert	Lat/Long	AGD66	1600	S20 24 30.00	E139 41 30.00	139.6916667	-20.40833333	54
T		Hrb Convert	Lat/Long	AGD66	16000	S19 25	E138 45	138.75	-19.41666667	54
		Hrb Convert	Lat/Long	AGD66	1600	S21 01 30.00	E140 18 30.00	140.3083333	-21.025	54
		Hrb Convert	Lat/Long	AGD66	1600	S21 03 30.00	E139 35 30.00	139.5916667	-21.05833333	54
Q		Hrb Convert	Lat/Long	AGD66	1600	S21 27 30.00	E139 53 30.00	139.8916667	-21.45833333	54
G		GPS	Lat/Long	WGS84	100	S19 16 56.00	E140 27 43.00	140.4619444	-19.28222222	54

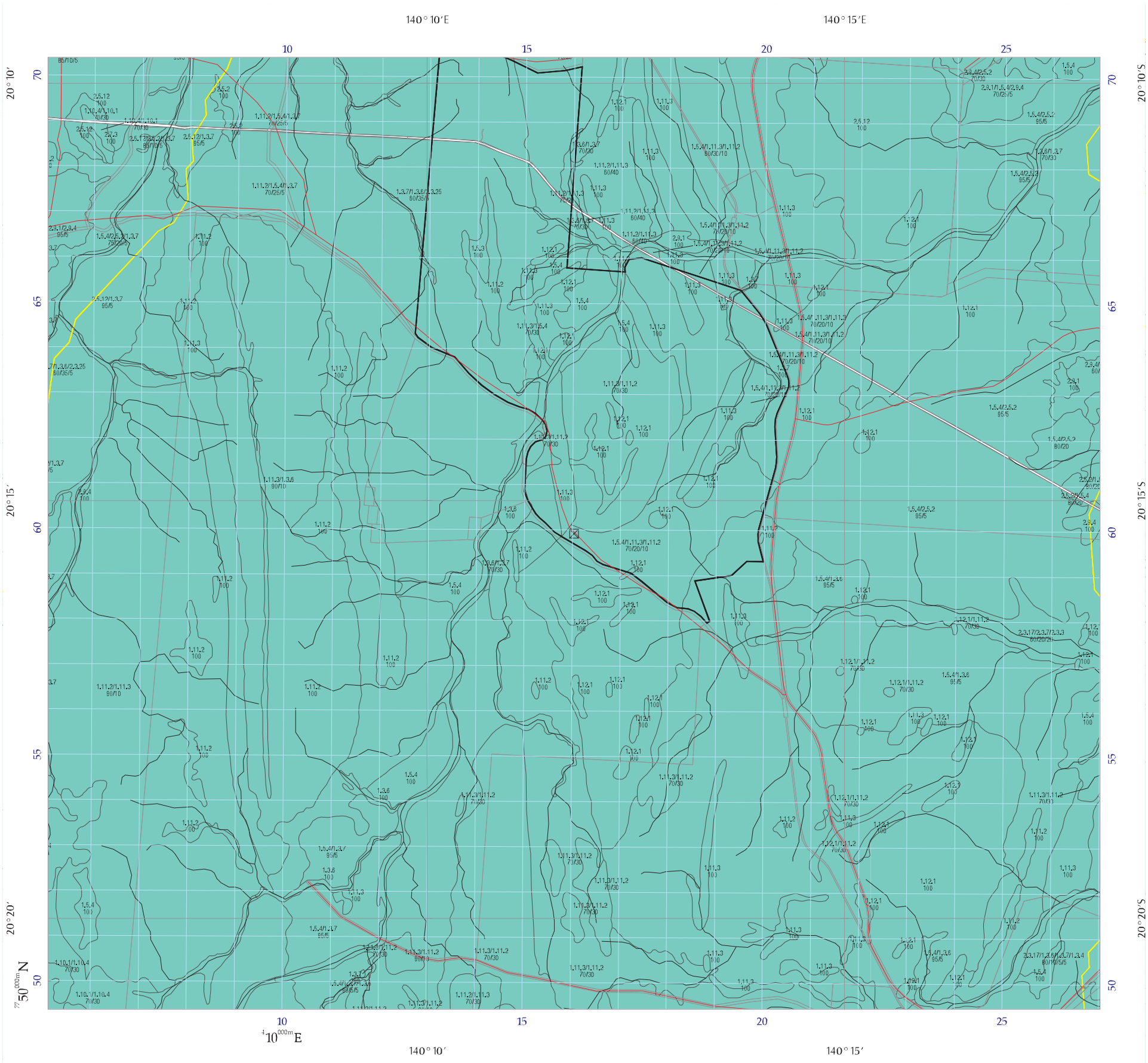
G	GPS	AMG	GDA94	100	S19 16 56.29	E140 27 39.26	140.4609048	-19.28230179	54

Amg_Easting	Amg_Northing	Grid	Label
			Corella Dam, c. 70km E of Mt Isa. Creek banks below dam wall. Woodland of Eucalyptus camaldulensis, Vitex benthamiana, Melaleuca trichostachya, Acacia hemsleyi.
401222	7694400	6956-012944	Plant floating on water surface. Abundant at site, choking entire creek.
			Just off Wager Creek, 350m W of Lake Julius.
370291	7772413	6857-702724	Rock face with Corymbia aspera, Terminalia aridicola, Eucalyptus leucophloia and Atalaya hemiglauca.
			Oskars Valley, 15km N Mt Isa.
341049	7724136	6756-410241	Herb growing abundantly on upper slope in rocky ground. Surrounding vegetation, Triodia longiceps hard spinifex, Eucalyptus leucophloia.
			1.6km N of Hilton mine.
341049	7724136	6756-410241	Slope, rocky soil, with Eucalyptus leucophloia and Triodia sp.
			11km N and 2km W of Mt Isa.
341084	7720446	6756-410204	Gorge E of Judean beds. Growing on rock outcrop (Magazine shale) with Acacia megalantha, A.orthocarpa, Dodonaea viscosa.
			11km NE of Mt Isa, off LM Road.
349818	7714990	6856-498149	Open woodland, slopes, Eucalyptus leucophloia, Triodia. Herb 0.4m. Growing with No.85 (Triodia sp.).
			Main lookout, Mt Isa city.
343864	7707933	6856-438079	Hillside, shale and rocky soil. Small shrub.
			Mt Isa city lookout.
343864	7707933	6856-438079	Eucalyptus leucophloia. Slope. Herb 0.4m.
			Mt Isa, city lookout.
343864	7707933	6856-438079	Shale hill slopes.

			Mt Isa city main lookout. Disturbed land. Breakaway shale, rock, skeletal soil. Growing with Cenchrus ciliaris.
343864	7707933	6856-438079	Shrub. Mt Isa lookout. Stony hillside, growing in rock crevices. Herb.
343759	7707756	6756-437077	Several plants seen. Mt Isa. Rocky quartzite hillsides with Triodia and mountain gums.
335157	7704705	6756-351047	Branched hairy shrub c 60cm, corolla deep pink within.
335157	7704705	6756-351047	Mt Isa. Fountain Range, 54km SE of Mt Isa. Open woodland, Eucalyptus aspera, E.exserta, E.capricornia and Triodia spp., on quartzite ridge top.
388265	7678391	6856-882783	Herb to 0.4m. Ca. 110km NNE of Mt Isa. Flat area at base of rise with Eucalyptus leucophloia.
355218	7851912	6859-552519	Velvety leaved prostrate plant with pink flowers. Scrambling over rocks. Calton Hills station, NW of Gunpowder. Sandy bank above rocky creek in small gorge; Hakea arborescens dominating bank.
327402	7830536	6758-274305	Ground-hugging vine, leaves grey-green, flowers pink. Bull Creek, 21km E of Gunpowder.
352445	7814640	6858-524146	Eucalyptus leucophloia, Acacia onticola. Wagner Creek, east edge of Lake Julius, c. 70km NNE of Mount Isa. Rocky area with Eucalyptus leucophloia, Corymbia capricornia and C. aparrerinja.
370291	7772413	6857-702724	Furry vine with large purple flowers. Lake Julius Pipeline Road, 66km NNE of Mt Isa. Eucalyptus leucophloia open woodland Acacia orthocarpa.
366767	7768634	6857-667686	Creeper with purple flowers.

368579	7759424	6857-685594	Ca 5km SW of Lake Julius Pump Station, Pipeline Road. Vine growing on road side.
368579	7759424	6857-685594	5K SW of Lake Julius pump station on Pipeline Rd. Growing in disturbed area in red clay with Acacia retivenia, Tephrosia sp, Hibiscus sturtii & Atalaya hemiglauca.
363488	7742780	6857-634427	Police Creek, 42km NNE of Mt Isa. Large creek, with Euc. camaldulensis and Melaleuca leucadendron. Creeper, blue flowers.
263735	7851518	6659-637515	Undilla. On a stream bank. Tufted, erect, c 3-5 in., subglaucous; spikelets black or nearly so.
428126	7674922	6955-281749	6km N of Malbon. On lower slope below quartzite hills; sandy loam on the surface. Triodia pungens dominates the ground layer with scattered Eucalyptus terminalis, E. argillacea and Atalaya hemiglauca.
353679	7670742	6855-536707	Near Railway Crossing, 5km N of Malbon Vale Homestead. In Eucalyptus terminalis low woodland on sandy loam soil.
385162	7626711	6855-851267	7 miles S of Duchess on road to Tredelano Mine. 25cm high. Yellow flowers. Common along roadside.
443465	7867857	6959-434678	14.1km by road towards Julia Creek from junction with Burke Development Rd. Riparian eucalypt open woodland on floodplain. White flowered soft herb near waterhole; clay soils. Scarce.

443356	7867848	6959-433678	Immediately downstream of the road crossing of Crocodile Creek, SW of Burke and Wills Roadhouse. Low open woodland of Eucalyptus camaldulensis, Cochlospermum gregorii and Terminalia platyphylla on a small creek channel in a landscape of ferruginous/calcrete rock. Herb at edge of the water. Common at site.



Vegetation Management Act Regional Ecosystem and Remnant Map-Version 6

Remnant vegetation containing endangered regional ecosystems
- Dominant
- Sub-dominant

Remnant vegetation containing of concern regional ecosystems
- Dominant
- Sub-dominant

- Remnant vegetation that is a least concern regional ecosystem
- Remnant vegetation under Section 20AH of the VMA
- Non-remnant
- Plantation Forest
- Dam or Reservoir
- Remnant Vegetation
- PMAV Category X area
- Great Barrier Reef Wetlands
- Vegetation Management Act Essential Habitat
  For further information on VMA Essential Habitat, please see the attached VMA Essential Habitat map.
- Subject Lot
- Watercourse (Stream order shown as black number against stream where available)
- Bioregion boundary
- Roads © MapInfo Australia Pty Ltd 2009
- National Park, Conservation Area State Forest and other reserves
- Cadastral line
  The maximum spatial error of parcels extracted for this map from the Digital Cadastral Data Base(DCDB) range from: 14m to 251m at a 95% confidence level. Property boundaries shown are provided as a locational aid only.
- Towns
- Coordinate entered

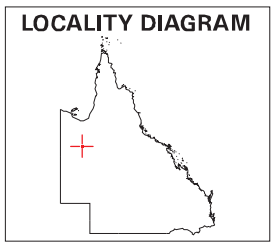
Based on 2006 Landsat TM imagery

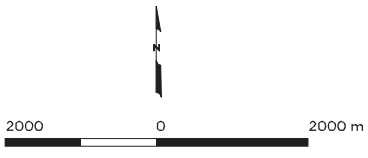
Requested By: JBYRD@AARC.NET.AU
Date: 06 May 10 Time: 12.58.42

Centered on point position:
Latitude: -20.2565 Longitude: 140.196 (decimal degrees)
Bioregion: North West Highlands

Queensland Government

LOCALITY DIAGRAM





Horizontal Datum: Geocentric Datum of Australia 1994 (GDA94)

A remnant map covers areas not covered by a regional ecosystem map.

Defined map areas are labelled with the regional ecosystem (RE) code along with the percentage breakdown if more than one RE occurs within the area. Detailed definitions of regional ecosystems are available from www.derm.qld.gov.au/REDD. Defined map areas smaller than 5ha may not be labelled.

Regional ecosystem linework has been compiled at a scale of 1:100 000, except in designated areas where a compilation scale of 1:50 000 is available. Linework should be used as a guide only. The positional accuracy of RE data mapped at a scale of 1:100 000 is +/-100 metres. The extent of remnant regional ecosystems as of 2006, depicted on this map is based on rectified 2006 Landsat TM imagery (supplied by the Statewide Landcover and Trees Study (SLATS), Department of Environment and Resource Management (DERM)).

Some watercourse lines are derived from GeoScience Australia 1:250 000 mapping.

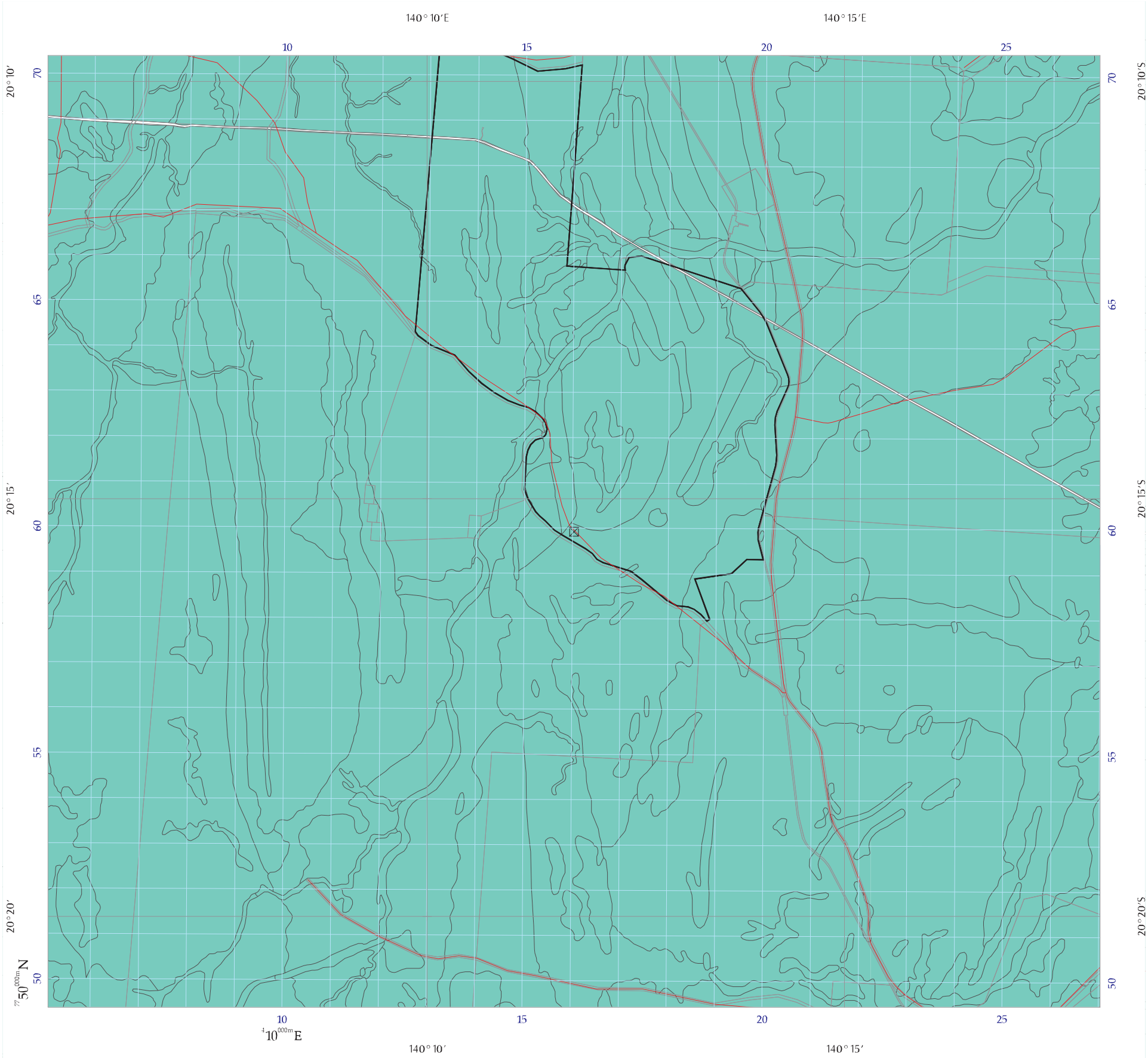
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All datasets are updated as they become available to provide the most current information as of the date shown on this map.

Additional information is required for the purposes of land clearing or assessment of a regional ecosystem map or PMAV applications. For further information go to the web site: www.derm.qld.gov.au/vegetation or contact the Department of Environment and Resource Management.

Digital regional ecosystem data is available in shapefile format, for Lot on Plans from www.derm.qld.gov.au/REDATA or from DERM for larger areas.

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Vegetation Management Act Essential Habitat Map Version 3.0

Remnant vegetation containing endangered regional ecosystems
- Dominant
- Sub-dominant

Remnant vegetation containing of concern regional ecosystems
- Dominant
- Sub-dominant

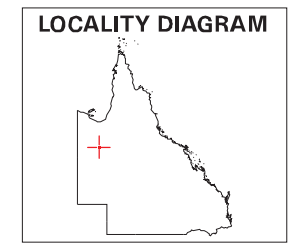
- Remnant vegetation that is a least concern regional ecosystem
- Remnant vegetation under Section 20AH of the VMA
- Non-remnant
- Plantation Forest
- Dam or Reservoir
- Remnant Vegetation
- PMAV Category X area
- Vegetation Management Act Essential Habitat
- Vegetation Management Act Essential Habitat Species Records
- Subject Lot
- Roads © MapInfo Australia Pty Ltd 2009
- National Park, Conservation Area State Forest and other reserves
- Cadastral line
  The maximum spatial error of parcels extracted for this map from the Digital Cadastral Data Base(DCDB) range from: 14m to 251m at a 95% confidence level. Property boundaries shown are provided as a locational aid only.
- Towns
- Coordinate entered

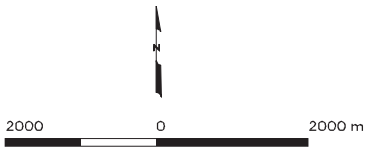
Requested By: JBYRD@AARC.NET.AU
Date: 06 May 10 Time: 12.58.45

Centered on point position:
Latitude: -20.2565 Longitude: 140.196 (decimal degrees)

Queensland Government

LOCALITY DIAGRAM





Horizontal Datum: Geocentric Datum of Australia 1994 (GDA94)

Labels for the Vegetation Management Act Essential Habitat are centred on the subject lot (1.1km surrounding and including a Lot on Plan). Labels correlate to the label field in the attached essential habitat database.

Regional ecosystem linework has been compiled at a scale of 1:100 000, except in designated areas where a compilation scale of 1:50 000 is available. Linework should be used as a guide only. The positional accuracy of RE data mapped at a scale of 1:100 000 is +/-100 metres. The extent of remnant regional ecosystems as of 2006, depicted on this map is based on rectified 2006 Landsat TM imagery (supplied by SLATS, Department of Environment and Resource Management).

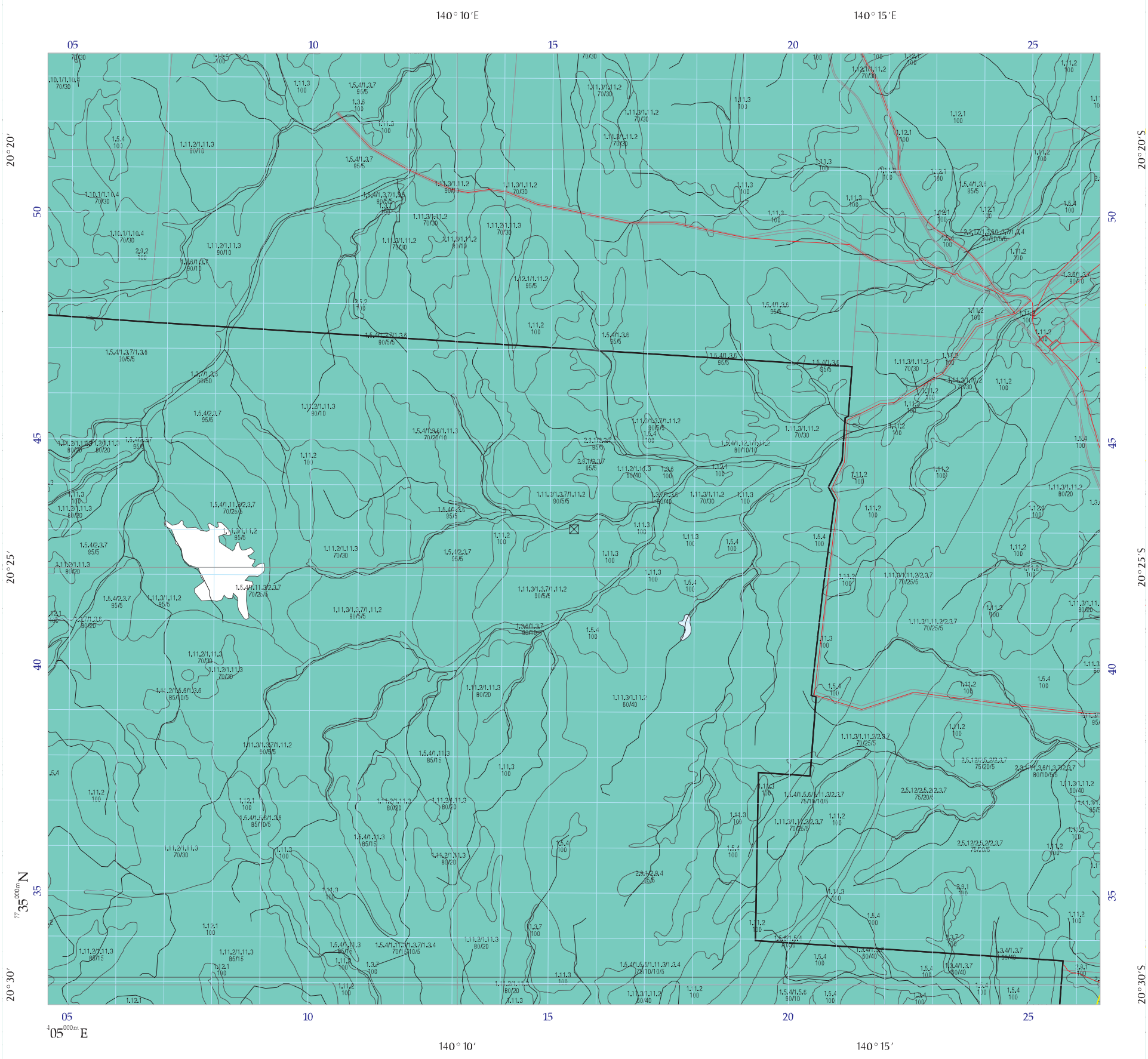
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All datasets are updated as they become available to provide the most current information as of the date shown on this map.

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Vegetation Management Act Regional Ecosystem and Remnant Map-Version 6

Remnant vegetation containing endangered regional ecosystems
- Dominant
- Sub-dominant

Remnant vegetation containing of concern regional ecosystems
- Dominant
- Sub-dominant

- Remnant vegetation that is a least concern regional ecosystem
- Remnant vegetation under Section 20AH of the VMA
- Non-remnant
- Plantation Forest
- Dam or Reservoir
- Remnant Vegetation
- PMAV Category X area
- Great Barrier Reef Wetlands
- Vegetation Management Act Essential Habitat
  For further information on VMA Essential Habitat, please see the attached VMA Essential Habitat map.
- Subject Lot
- Watercourse (Stream order shown as black number against stream where available)
- Bioregion boundary
- Roads © MapInfo Australia Pty Ltd 2009
- National Park, Conservation Area State Forest and other reserves
- Cadastral line
  The maximum spatial error of parcels extracted for this map from the Digital Cadastral Data Base(DCDB) range from: 14m to 251m at a 95% confidence level. Property boundaries shown are provided as a locational aid only.
- Towns
- Coordinate entered

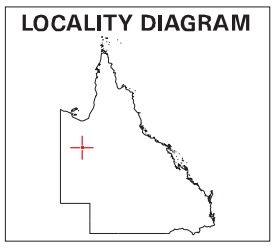
Based on 2006 Landsat TM imagery

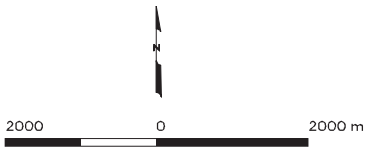
Requested By: JBYRD@AARC.NET.AU
Date: 06 May 10 Time: 13.01.59

Centered on point position:
Latitude: -20.409 Longitude: 140.19 (decimal degrees)
Bioregion: North West Highlands

Queensland Government

LOCALITY DIAGRAM





Horizontal Datum: Geocentric Datum of Australia 1994 (GDA94)

A remnant map covers areas not covered by a regional ecosystem map.

Defined map areas are labelled with the regional ecosystem (RE) code along with the percentage breakdown if more than one RE occurs within the area. Detailed definitions of regional ecosystems are available from www.derm.qld.gov.au/REDD. Defined map areas smaller than 5ha may not be labelled.

Regional ecosystem linework has been compiled at a scale of 1:100 000, except in designated areas where a compilation scale of 1:50 000 is available. Linework should be used as a guide only. The positional accuracy of RE data mapped at a scale of 1:100 000 is +/-100 metres. The extent of remnant regional ecosystems as of 2006, depicted on this map is based on rectified 2006 Landsat TM imagery (supplied by the Statewide Landcover and Trees Study (SLATS), Department of Environment and Resource Management (DERM)).

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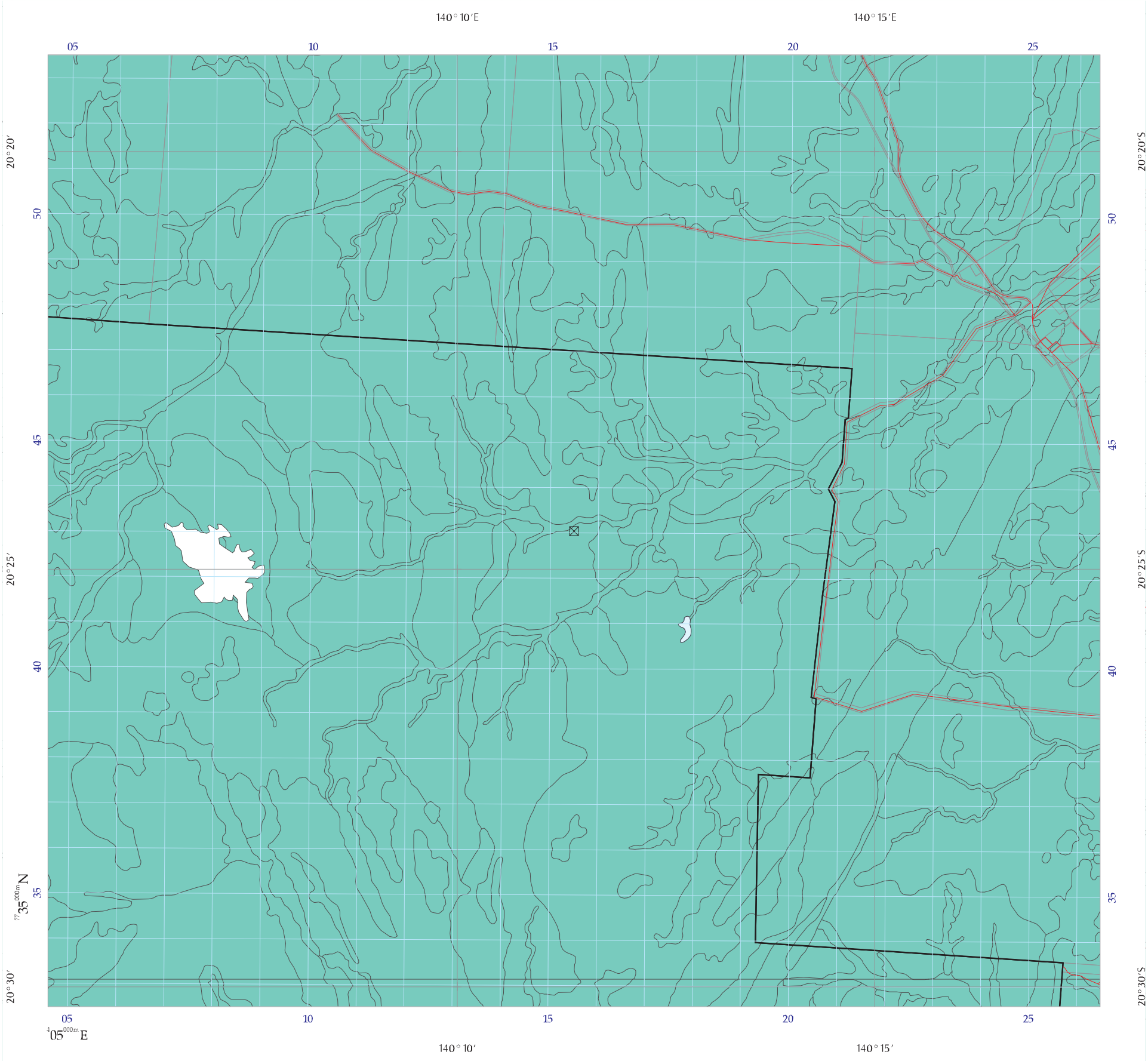
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Vegetation Management Act Essential Habitat Map Version 3.0

Remnant vegetation containing endangered regional ecosystems
- Dominant
- Sub-dominant

Remnant vegetation containing of concern regional ecosystems
- Dominant
- Sub-dominant

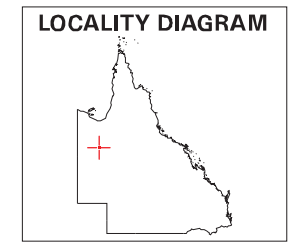
- Remnant vegetation that is a least concern regional ecosystem
- Remnant vegetation under Section 20AH of the VMA
- Non-remnant
- Plantation Forest
- Dam or Reservoir
- Remnant Vegetation
- PMAV Category X area
- Vegetation Management Act Essential Habitat
- Vegetation Management Act Essential Habitat Species Records
- Subject Lot
- Roads © MapInfo Australia Pty Ltd 2009
- National Park, Conservation Area State Forest and other reserves
- Cadastral line
  The maximum spatial error of parcels extracted for this map from the Digital Cadastral Data Base(DCDB) range from: 14m to 251m at a 95% confidence level. Property boundaries shown are provided as a locational aid only.
- Towns
- Coordinate entered

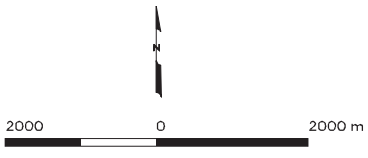
Requested By: JBYRD@AARC.NET.AU
Date: 06 May 10 Time: 13.02.03

Centered on point position:
Latitude: -20.409 Longitude: 140.19 (decimal degrees)

Queensland Government

LOCALITY DIAGRAM





Horizontal Datum: Geocentric Datum of Australia 1994 (GDA94)

Labels for the Vegetation Management Act Essential Habitat are centred on the subject lot (1.1km surrounding and including a Lot on Plan). Labels correlate to the label field in the attached essential habitat database.

Regional ecosystem linework has been compiled at a scale of 1:100 000, except in designated areas where a compilation scale of 1:50 000 is available. Linework should be used as a guide only. The positional accuracy of RE data mapped at a scale of 1:100 000 is +/-100 metres. The extent of remnant regional ecosystems as of 2006, depicted on this map is based on rectified 2006 Landsat TM imagery (supplied by SLATS, Department of Environment and Resource Management).

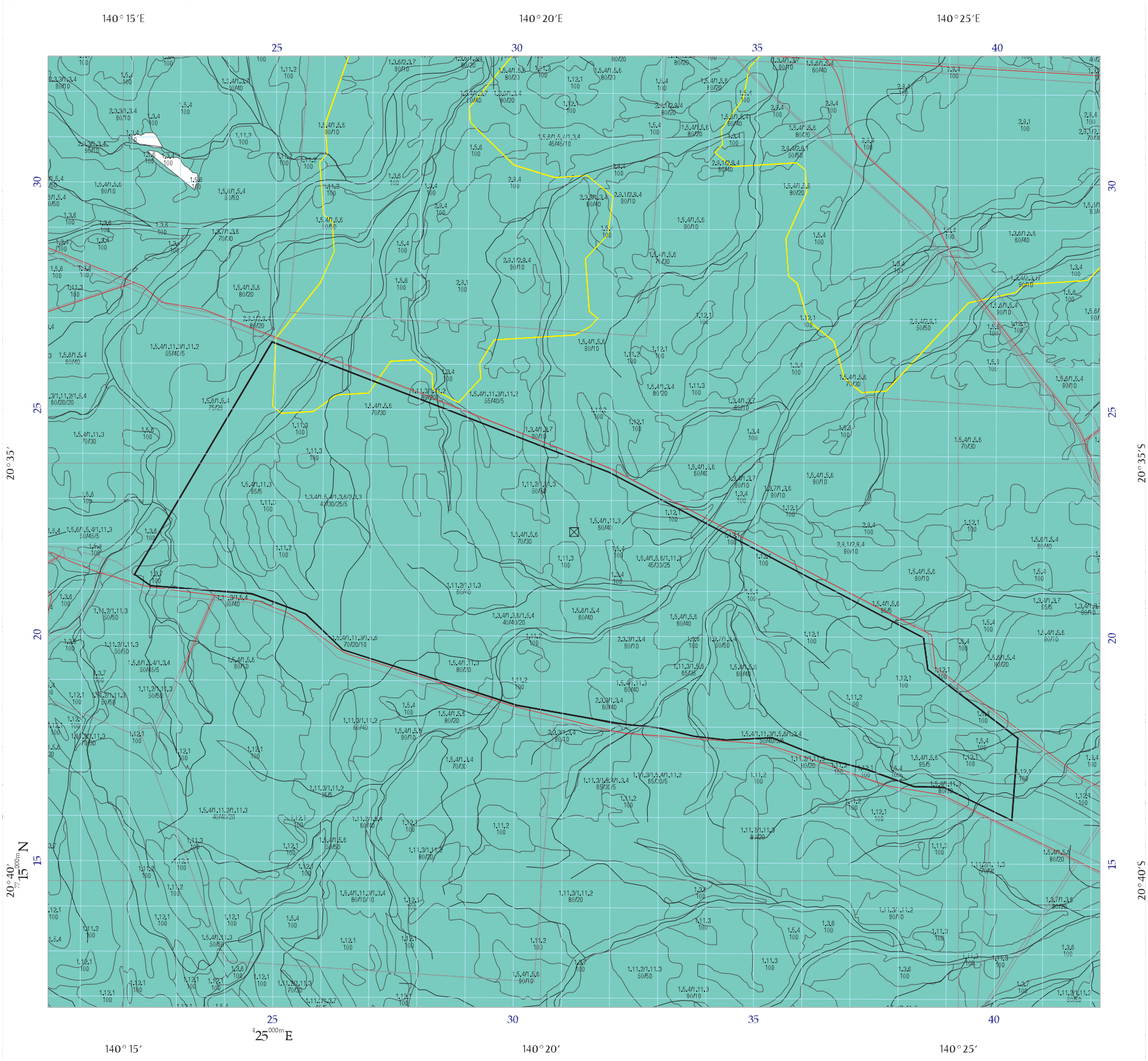
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Vegetation Management Act Regional Ecosystem and Remnant Map-Version 6

Remnant vegetation containing endangered regional ecosystems
- Dominant
- Sub-dominant

Remnant vegetation containing of concern regional ecosystems
- Dominant
- Sub-dominant

- Remnant vegetation that is a least concern regional ecosystem
- Remnant vegetation under Section 20AH of the VMA
- Non-remnant
- Plantation Forest
- Dam or Reservoir
- Remnant Vegetation
- PMAV Category X area
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- Vegetation Management Act Essential Habitat
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- Watercourse (Stream order shown as black number against stream where available)
- Bioregion boundary
- Roads © MapInfo Australia Pty Ltd 2009
- National Park, Conservation Area State Forest and other reserves
- Cadastral line
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- Towns
- Coordinate entered

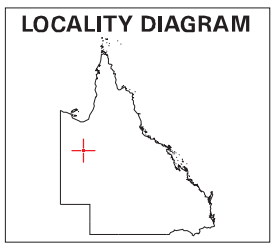
Based on 2006 Landsat TM imagery

Requested By: JBYRD@AARC.NET.AU
Date: 06 May 10 Time: 12.59.15

Centered on point position:
Latitude: -20.597 Longitude: 140.34 (decimal degrees)
Bioregion: North West Highlands

Queensland Government

LOCALITY DIAGRAM





Horizontal Datum: Geocentric Datum of Australia 1994 (GDA94)

A remnant map covers areas not covered by a regional ecosystem map.

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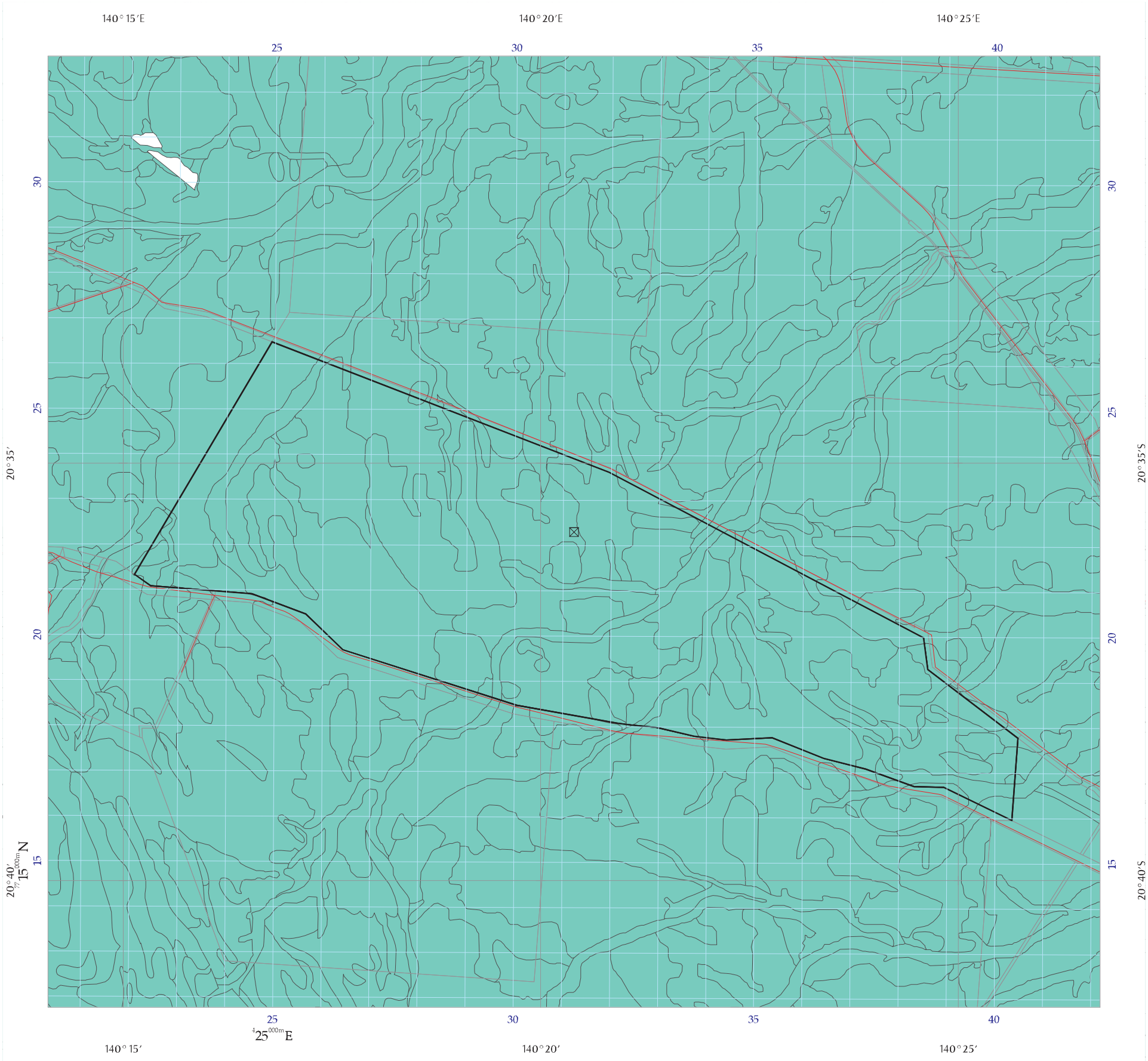
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Vegetation Management Act Essential Habitat Map Version 3.0

Remnant vegetation containing endangered regional ecosystems
- Dominant
- Sub-dominant

Remnant vegetation containing of concern regional ecosystems
- Dominant
- Sub-dominant

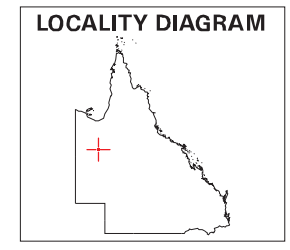
- Remnant vegetation that is a least concern regional ecosystem
- Remnant vegetation under Section 20AH of the VMA
- Non-remnant
- Plantation Forest
- Dam or Reservoir
- Remnant Vegetation
- PMAV Category X area
- Vegetation Management Act Essential Habitat
- Vegetation Management Act Essential Habitat Species Records
- Subject Lot
- Roads © MapInfo Australia Pty Ltd 2009
- National Park, Conservation Area State Forest and other reserves
- Cadastral line
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- Towns
- Coordinate entered

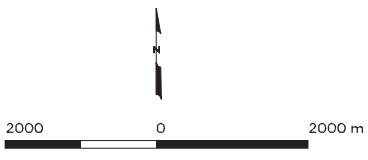
Requested By: JBYRD@AARC.NET.AU
Date: 06 May 10 Time: 12.59.19

Centered on point position:
Latitude: -20.597 Longitude: 140.34 (decimal degrees)

Queensland Government

LOCALITY DIAGRAM





Horizontal Datum: Geocentric Datum of Australia 1994 (GDA94)

Labels for the Vegetation Management Act Essential Habitat are centred on the subject lot (1.1km surrounding and including a Lot on Plan). Labels correlate to the label field in the attached essential habitat database.

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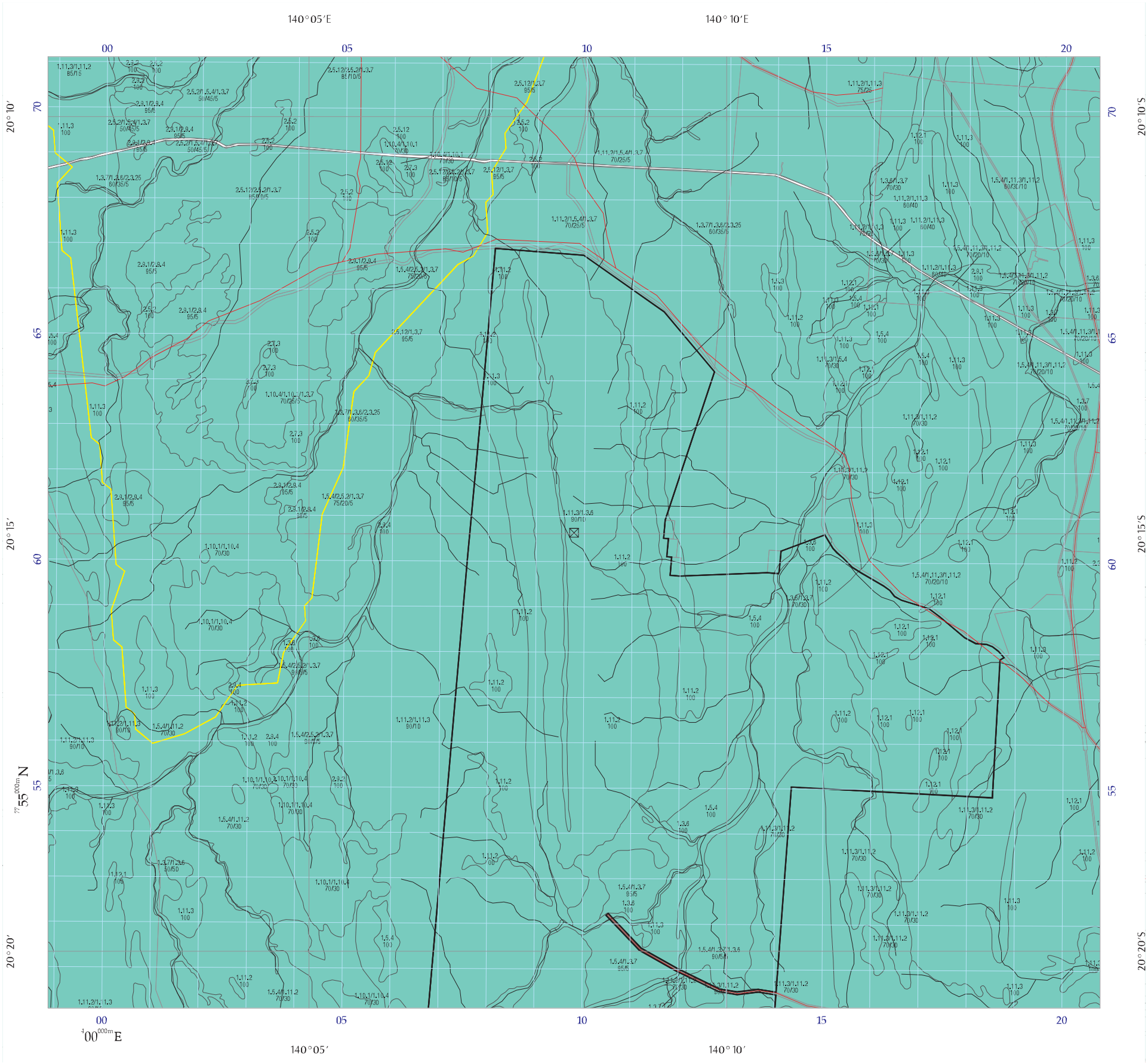
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Vegetation Management Act Regional Ecosystem and Remnant Map-Version 6

Remnant vegetation containing endangered regional ecosystems
- Dominant
- Sub-dominant

Remnant vegetation containing of concern regional ecosystems
- Dominant
- Sub-dominant

- Remnant vegetation that is a least concern regional ecosystem
- Remnant vegetation under Section 20AH of the VMA
- Non-remnant
- Plantation Forest
- Dam or Reservoir
- Remnant Vegetation
- PMAV Category X area
- Great Barrier Reef Wetlands
- Vegetation Management Act Essential Habitat
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- Watercourse (Stream order shown as black number against stream where available)
- Bioregion boundary
- Roads © MapInfo Australia Pty Ltd 2009
- National Park, Conservation Area State Forest and other reserves
- Cadastral line
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- Towns
- ☒ Coordinate entered

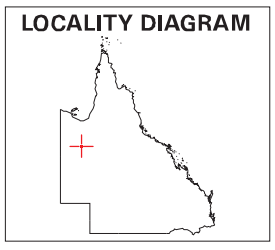
Based on 2006 Landsat TM imagery

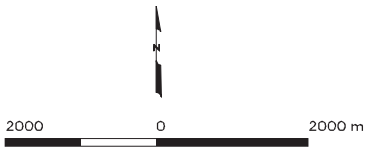
Requested By: JBYRD@AARC.NET.AU
Date: 06 May 10 Time: 12.58.13

Centered on point position:
Latitude: -20.2497 Longitude: 140.1362 (decimal degrees)
Bioregion: North West Highlands

Queensland Government

LOCALITY DIAGRAM





Horizontal Datum: Geocentric Datum of Australia 1994 (GDA94)

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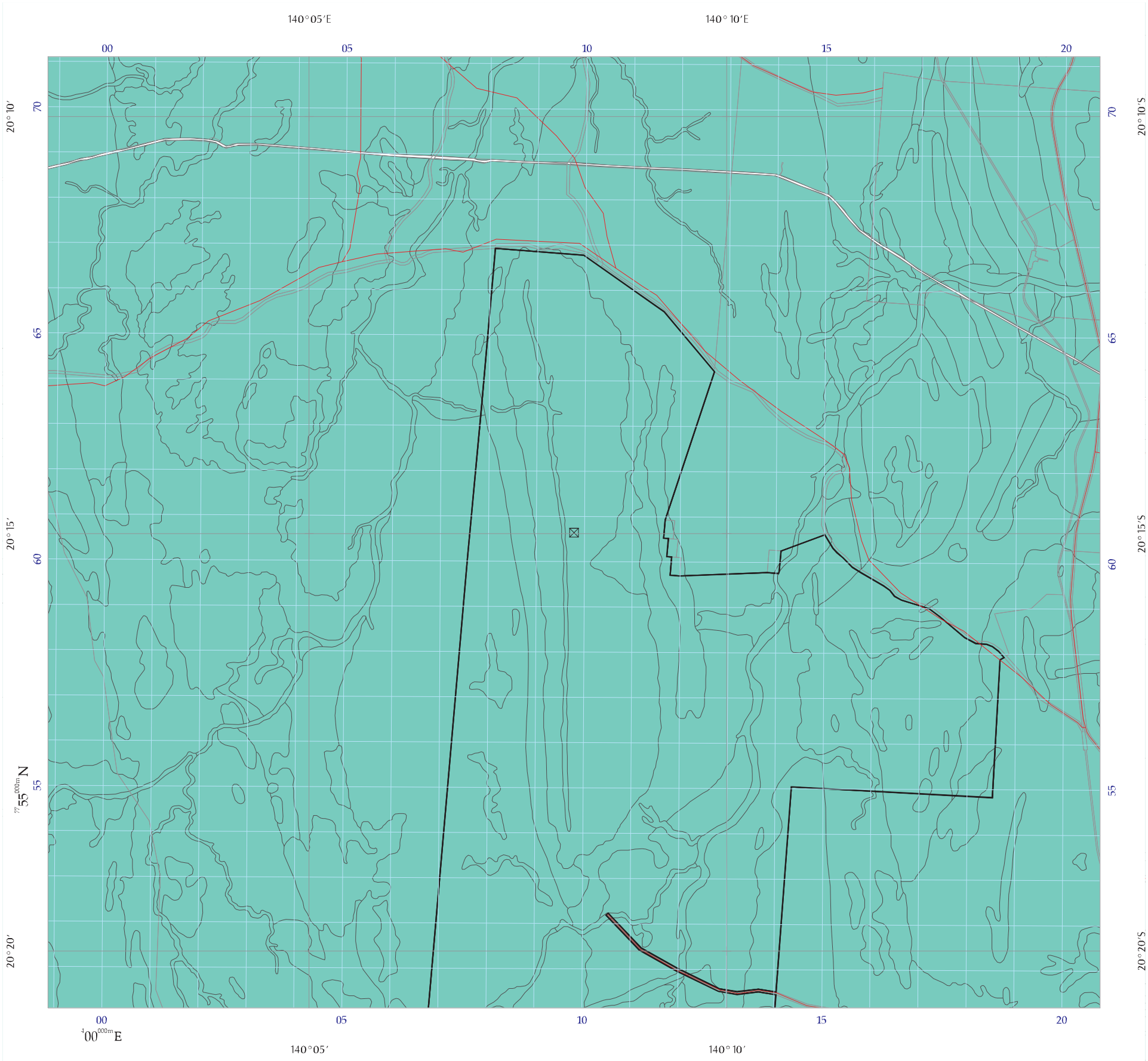
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Vegetation Management Act Essential Habitat Map Version 3.0

Remnant vegetation containing endangered regional ecosystems
- Dominant
- Sub-dominant

Remnant vegetation containing of concern regional ecosystems
- Dominant
- Sub-dominant

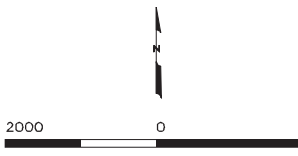
- Remnant vegetation that is a least concern regional ecosystem
- Remnant vegetation under Section 20AH of the VMA
- Non-remnant
- Plantation Forest
- Dam or Reservoir
- Remnant Vegetation
- PMAV Category X area
- Vegetation Management Act Essential Habitat
- Vegetation Management Act Essential Habitat Species Records
- Subject Lot
- Roads © MapInfo Australia Pty Ltd 2009
- National Park, Conservation Area State Forest and other reserves
- Cadastral line
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- Towns
- ⊠ Coordinate entered

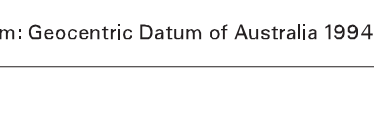
Requested By: JBYRD@AARC.NET.AU
Date: 06 May 10 Time: 12.58.16

Centered on point position:
Latitude: -20.2497 Longitude: 140.1362 (decimal degrees)

Queensland Government

LOCALITY DIAGRAM





Horizontal Datum: Geocentric Datum of Australia 1994 (GDA94)

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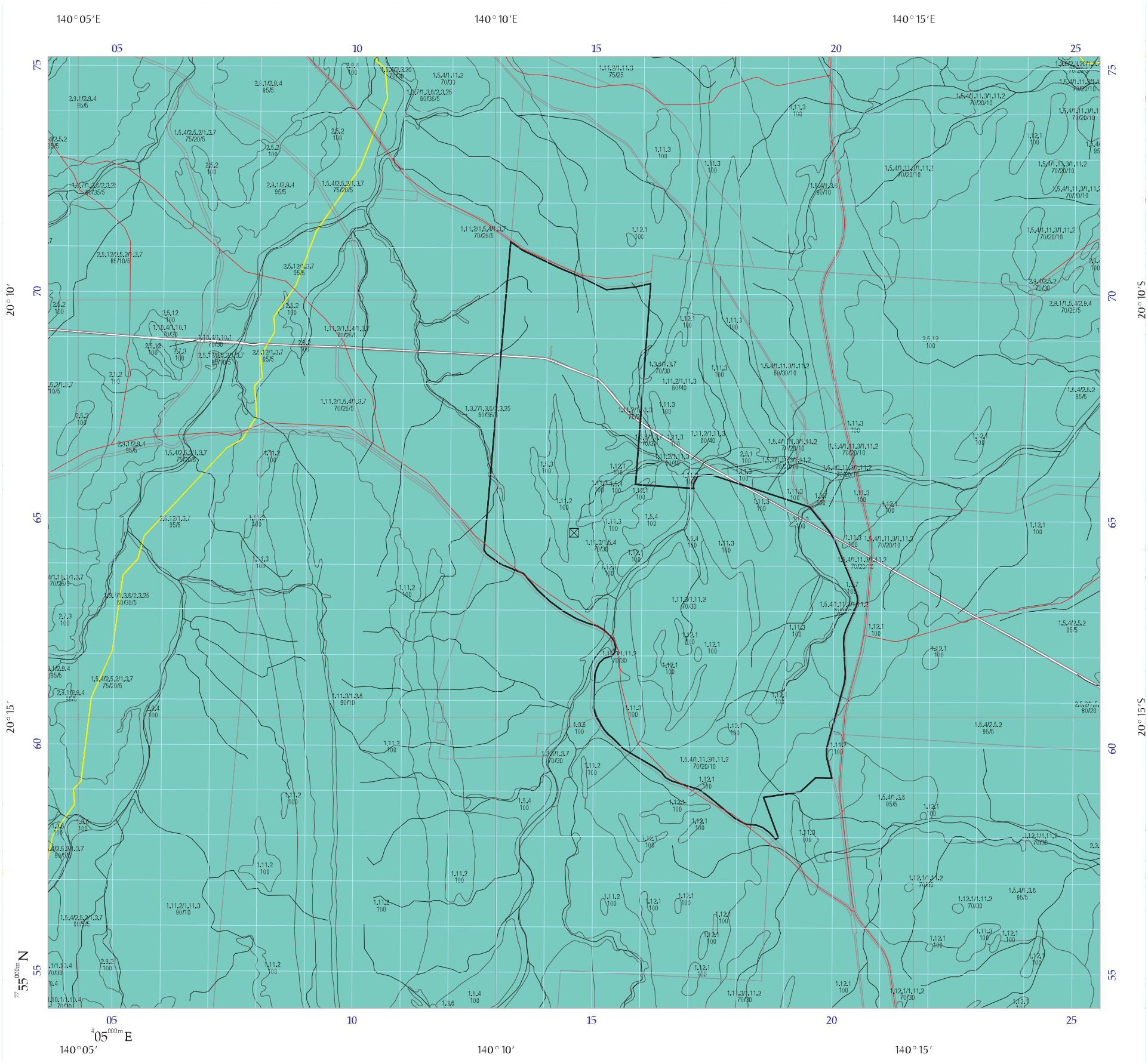
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Vegetation Management Act Regional Ecosystem and Remnant Map-Version 6

Remnant vegetation containing endangered regional ecosystems
- Dominant
- Sub-dominant

Remnant vegetation containing of concern regional ecosystems
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- Towns
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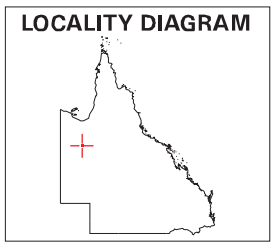
Based on 2006 Landsat TM imagery

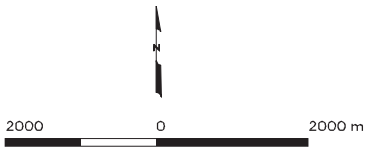
Requested By: JBYRD@AARC.NET.AU
Date: 06 May 10 Time: 12.58.32

Centered on point position:
Latitude: -20.2131 Longitude: 140.1823 (decimal degrees)
Bioregion: North West Highlands

Queensland Government

LOCALITY DIAGRAM





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A remnant map covers areas not covered by a regional ecosystem map.

Defined map areas are labelled with the regional ecosystem (RE) code along with the percentage breakdown if more than one RE occurs within the area. Detailed definitions of regional ecosystems are available from www.derm.qld.gov.au/REDD. Defined map areas smaller than 5ha may not be labelled.

Regional ecosystem linework has been compiled at a scale of 1:100 000, except in designated areas where a compilation scale of 1:50 000 is available. Linework should be used as a guide only. The positional accuracy of RE data mapped at a scale of 1:100 000 is +/-100 metres. The extent of remnant regional ecosystems as of 2006, depicted on this map is based on rectified 2006 Landsat TM imagery (supplied by the Statewide Landcover and Trees Study (SLATS), Department of Environment and Resource Management (DERM)).

Some watercourse lines are derived from GeoScience Australia 1:250 000 mapping.

Disclaimer:
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All datasets are updated as they become available to provide the most current information as of the date shown on this map.

Additional information is required for the purposes of land clearing or assessment of a regional ecosystem map or PMAV applications. For further information go to the web site: www.derm.qld.gov.au/vegetation or contact the Department of Environment and Resource Management.

Digital regional ecosystem data is available in shapefile format, for Lot on Plans from www.derm.qld.gov.au/REDATA or from DERM for larger areas.

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Vegetation Management Act Essential Habitat Map Version 3.0

Remnant vegetation containing endangered regional ecosystems
- Dominant
- Sub-dominant

Remnant vegetation containing of concern regional ecosystems
- Dominant
- Sub-dominant

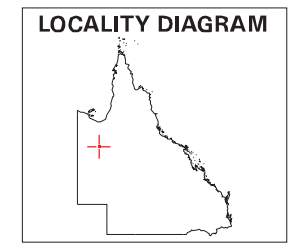
- Remnant vegetation that is a least concern regional ecosystem
- Remnant vegetation under Section 20AH of the VMA
- Non-remnant
- Plantation Forest
- Dam or Reservoir
- Remnant Vegetation
- PMAV Category X area
- Vegetation Management Act Essential Habitat
- Vegetation Management Act Essential Habitat Species Records
- Subject Lot
- Roads © MapInfo Australia Pty Ltd 2009
- National Park, Conservation Area State Forest and other reserves
- Cadastral line
  The maximum spatial error of parcels extracted for this map from the Digital Cadastral Data Base(DCDB) range from: 14m to 251m at a 95% confidence level. Property boundaries shown are provided as a locational aid only.
- Towns
- Coordinate entered

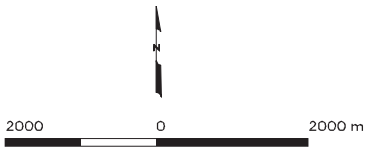
Requested By: JBYRD@AARC.NET.AU
Date: 06 May 10 Time: 12.58.35

Centered on point position:
Latitude: -20.2131 Longitude: 140.1823 (decimal degrees)

Queensland Government

LOCALITY DIAGRAM





Horizontal Datum: Geocentric Datum of Australia 1994 (GDA94)

Labels for the Vegetation Management Act Essential Habitat are centred on the subject lot (1.1km surrounding and including a Lot on Plan). Labels correlate to the label field in the attached essential habitat database.

Regional ecosystem linework has been compiled at a scale of 1:100 000, except in designated areas where a compilation scale of 1:50 000 is available. Linework should be used as a guide only. The positional accuracy of RE data mapped at a scale of 1:100 000 is +/-100 metres. The extent of remnant regional ecosystems as of 2006, depicted on this map is based on rectified 2006 Landsat TM imagery (supplied by SLATS, Department of Environment and Resource Management).

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Wildlife Online Extract

Search Criteria: Species List for a Specified Point
Species: All
Type: All
Status: All
Records: All
Date: All
Latitude: 20.2509
Longitude: 140.1369
Distance: 25
Email: jbyrd@aarc.net.au
Date submitted: Monday 28 Feb 2011 18:20:13
Date extracted: Monday 28 Feb 2011 18:31:01

The number of records retrieved = 364

Disclaimer

As the DERM is still in a process of collating and vetting data, it is possible the information given is not complete. The information provided should only be used for the project for which it was requested and it should be appropriately acknowledged as being derived from Wildlife Online when it is used.

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Kingdom	Class	Family	Scientific Name	Common Name	I	Q	A	Records
animals	amphibians	Bufonidae	*Rhinella marina*	cane toad	Y			2
animals	amphibians	Hylidae	*Litoria rothii*	northern laughing treefrog		C		2
animals	amphibians	Hylidae	*Litoria inermis*	bumpy rocketfrog		C		3
animals	amphibians	Hylidae	*Litoria pallida*	pallid rocketfrog		C		3
animals	amphibians	Hylidae	*Cyclorana australis*	northern snapping frog		C		7
animals	amphibians	Hylidae	*Litoria caerulea*	common green treefrog		C		6
animals	amphibians	Hylidae	*Litoria rubella*	ruddy treefrog		C		6
animals	amphibians	Limnodynastidae	*Platyplectrum ornatum*	ornate burrowing frog		C		3
animals	birds	Acanthizidae	*Gerygone fusca*	western gerygone		C		2
animals	birds	Acanthizidae	*Smicrornis brevirostris*	weebill		C		39
animals	birds	Acanthizidae	*Acanthiza chrysorrhoa*	yellow-rumped thornbill		C		3
animals	birds	Accipitridae	*Aquila audax*	wedge-tailed eagle		C		6
animals	birds	Accipitridae	*Accipiter fasciatus*	brown goshawk		C		9
animals	birds	Accipitridae	*Haliaeetus leucogaster*	white-bellied sea-eagle		C		1
animals	birds	Accipitridae	*Hamirostra melanosternon*	black-breasted buzzard		C		5
animals	birds	Accipitridae	*Accipiter cirrocephalus*	collared sparrowhawk		C		4
animals	birds	Accipitridae	*Haliastur sphenurus*	whistling kite		C		20
animals	birds	Accipitridae	*Circus assimilis*	spotted harrier		C		2
animals	birds	Accipitridae	*Milvus migrans*	black kite		C		26
animals	birds	Aegothelidae	*Aegotheles cristatus*	Australian owlet-nightjar		C		7
animals	birds	Alcedinidae	*Ceyx azureus*	azure kingfisher		C		2
animals	birds	Anatidae	*Anas gracilis*	grey teal		C		1
animals	birds	Anatidae	*Anas superciliosa*	Pacific black duck		C		1
animals	birds	Anatidae	*Dendrocygna eytoni*	plumed whistling-duck		C		4
animals	birds	Anatidae	*Nettapus coromandelianus*	cotton pygmy-goose		NT		1
animals	birds	Anatidae	*Aythya australis*	hardhead		C		1
animals	birds	Anhingidae	*Anhinga novaehollandiae*	Australasian darter		C		7
animals	birds	Ardeidae	*Ardea modesta*	eastern great egret		C		5
animals	birds	Ardeidae	*Ardea pacifica*	white-necked heron		C		12
animals	birds	Ardeidae	*Egretta garzetta*	little egret		C		2
animals	birds	Ardeidae	*Egretta novaehollandiae*	white-faced heron		C		12
animals	birds	Ardeidae	*Nycticorax caledonicus*	Nankeen night-heron		C		5
animals	birds	Ardeidae	*Ixobrychus flavicollis*	black bittern		C		5
animals	birds	Ardeidae	*Ardea intermedia*	intermediate egret		C		1
animals	birds	Artamidae	*Artamus minor*	little woodswallow		C		11
animals	birds	Artamidae	*Cracticus nigrogularis*	pied butcherbird		C		16
animals	birds	Artamidae	*Artamus superciliosus*	white-browed woodswallow		C		2
animals	birds	Artamidae	*Artamus leucorynchus*	white-breasted woodswallow		C		3
animals	birds	Artamidae	*Cracticus torquatus*	grey butcherbird		C		1
animals	birds	Artamidae	*Artamus personatus*	masked woodswallow		C		3
animals	birds	Artamidae	*Cracticus tibicen*	Australian magpie		C		10
animals	birds	Artamidae	*Artamus cinereus*	black-faced woodswallow		C		22
animals	birds	Burhinidae	*Burhinus grallarius*	bush stone-curlew		C		6
animals	birds	Cacatuidae	*Cacatua galerita*	sulphur-crested cockatoo		C		18
animals	birds	Cacatuidae	*Nymphicus hollandicus*	cockatiel		C		22
animals	birds	Cacatuidae	*Eolophus roseicapillus*	galah		C		20

Kingdom	Class	Family	Scientific Name	Common Name	I	Q	A	Records
animals	birds	Cacatuidae	*Cacatua sanguinea*	little corella		C		6
animals	birds	Campephagidae	*Lalage sueurii*	white-winged triller		C		8
animals	birds	Campephagidae	*Coracina novaehollandiae*	black-faced cuckoo-shrike		C		19
animals	birds	Campephagidae	*Coracina papuensis*	white-bellied cuckoo-shrike		C		2
animals	birds	Casuariidae	*Dromaius novaehollandiae*	emu		C		2
animals	birds	Charadriidae	*Vanellus miles*	masked lapwing		C		3
animals	birds	Charadriidae	*Vanellus miles miles*	masked lapwing (northern subspecies)		C		7
animals	birds	Charadriidae	*Elseyornis melanops*	black-fronted dotterel		C		13
animals	birds	Ciconiidae	*Ephippiorhynchus asiaticus*	black-necked stork		NT		5
animals	birds	Climacteridae	*Climacteris melanura*	black-tailed treecreeper		C		11
animals	birds	Columbidae	*Geopelia cuneata*	diamond dove		C		18
animals	birds	Columbidae	*Geopelia striata*	peaceful dove		C		32
animals	birds	Columbidae	*Phaps chalcoptera*	common bronzewing		C		11
animals	birds	Columbidae	*Geophaps plumifera*	spinifex pigeon		C		13
animals	birds	Columbidae	*Geopelia humeralis*	bar-shouldered dove		C		7
animals	birds	Columbidae	*Ocyphaps lophotes*	crested pigeon		C		13
animals	birds	Coraciidae	*Eurystomus orientalis*	dollarbird		C		5
animals	birds	Corcoracidae	*Struthidea cinerea*	apostlebird		C		17
animals	birds	Corvidae	*Corvus sp.*					9
animals	birds	Corvidae	*Corvus orru*	Torresian crow		C		9
animals	birds	Corvidae	*Corvus coronoides*	Australian raven		C		18
animals	birds	Cuculidae	*Chalcites basalis*	Horsfield's bronze-cuckoo		C		2
animals	birds	Cuculidae	*Chalcites osculans*	black-eared cuckoo		C		1
animals	birds	Cuculidae	*Eudynamys orientalis*	eastern koel		C		4
animals	birds	Cuculidae	*Scythrops novaehollandiae*	channel-billed cuckoo		C		3
animals	birds	Cuculidae	*Cacomantis variolosus*	brush cuckoo		C		3
animals	birds	Cuculidae	*Cacomantis pallidus*	pallid cuckoo		C		1
animals	birds	Estrildidae	*Emblema pictum*	painted finch		C		2
animals	birds	Estrildidae	*Heteromunia pectoralis*	pictorella mannikin		NT		2
animals	birds	Estrildidae	*Taeniopygia bichenovii*	double-barred finch		C		9
animals	birds	Estrildidae	*Taeniopygia guttata*	zebra finch		C		28
animals	birds	Estrildidae	*Poephila acuticauda*	long-tailed finch		C		9
animals	birds	Eurostopodidae	*Eurostopodus argus*	spotted nightjar		C		8/1
animals	birds	Falconidae	*Falco berigora*	brown falcon		C		7
animals	birds	Falconidae	*Falco longipennis*	Australian hobby		C		7
animals	birds	Falconidae	*Falco cenchroides*	nankeen kestrel		C		5
animals	birds	Gruidae	*Grus rubicunda*	brolga		C		9
animals	birds	Halcyonidae	*Dacelo leachii*	blue-winged kookaburra		C		23
animals	birds	Halcyonidae	*Todiramphus pyrrhopygius*	red-backed kingfisher		C		8
animals	birds	Halcyonidae	*Todiramphus sanctus*	sacred kingfisher		C		8
animals	birds	Hirundinidae	*Petrochelidon ariel*	fairy martin		C		9
animals	birds	Maluridae	*Amytornis ballarae*	Kalkadoon grasswren		C		4
animals	birds	Maluridae	*Malurus melanocephalus*	red-backed fairy-wren		C		5
animals	birds	Maluridae	*Malurus lamberti*	variegated fairy-wren		C		13
animals	birds	Megaluridae	*Eremiornis carteri*	spinifexbird		C		2
animals	birds	Megaluridae	*Cincloramphus mathewsi*	rufous songlark		C		5

Kingdom	Class	Family	Scientific Name	Common Name	I	Q	A	Records
animals	birds	Meliphagidae	*Conopophila rufogularis*	rufous-throated honeyeater		C		16
animals	birds	Meliphagidae	*Philemon citreogularis*	little friarbird		C		23
animals	birds	Meliphagidae	*Lichenostomus unicolor*	white-gaped honeyeater		C		2
animals	birds	Meliphagidae	*Lichenostomus plumulus*	grey-fronted honeyeater		C		15
animals	birds	Meliphagidae	*Certhionyx variegatus*	pied honeyeater		C		1
animals	birds	Meliphagidae	*Philemon argenticeps*	silver-crowned friarbird		C		2
animals	birds	Meliphagidae	*Melithreptus gularis*	black-chinned honeyeater		NT		3
animals	birds	Meliphagidae	*Lichmera indistincta*	brown honeyeater		C		26
animals	birds	Meliphagidae	*Cissomela pectoralis*	banded honeyeater		C		2
animals	birds	Meliphagidae	*Epthianura tricolor*	crimson chat		C		4
animals	birds	Meliphagidae	*Phylidonyris niger*	white-cheeked honeyeater		C		1
animals	birds	Meliphagidae	*Manorina flavigula*	yellow-throated miner		C		20
animals	birds	Meliphagidae	*Sugomel niger*	black honeyeater		C		1
animals	birds	Meliphagidae	*Lichenostomus penicillatus*	white-plumed honeyeater		C		31/1
animals	birds	Meliphagidae	*Melithreptus brevirostris*	brown-headed honeyeater		C		1
animals	birds	Meliphagidae	*Lichenostomus keartlandi*	grey-headed honeyeater		C		10
animals	birds	Meliphagidae	*Lichenostomus flavescens*	yellow-tinted honeyeater		C		9
animals	birds	Meliphagidae	*Acanthagenys rufogularis*	spiny-cheeked honeyeater		C		3
animals	birds	Meliphagidae	*Lichenostomus virescens*	singing honeyeater		C		3
animals	birds	Meropidae	*Merops ornatus*	rainbow bee-eater		C		20
animals	birds	Monarchidae	*Myiagra inquieta*	restless flycatcher		C		10
animals	birds	Monarchidae	*Grallina cyanoleuca*	magpie-lark		C		29
animals	birds	Nectariniidae	*Dicaeum hirundinaceum*	mistletoebird		C		12
animals	birds	Neosittidae	*Daphoenositta chrysoptera*	varied sittella		C		1
animals	birds	Oriolidae	*Oriolus sagittatus*	olive-backed oriole		C		10
animals	birds	Otididae	*Ardeotis australis*	Australian bustard		C		4
animals	birds	Pachycephalidae	*Oreoica gutturalis*	crested bellbird		C		5
animals	birds	Pachycephalidae	*Pachycephala rufiventris*	rufous whistler		C		16
animals	birds	Pachycephalidae	*Colluricincla harmonica*	grey shrike-thrush		C		21/2
animals	birds	Pardalotidae	*Pardalotus striatus*	striated pardalote		C		18
animals	birds	Pardalotidae	*Pardalotus rubricatus*	red-browed pardalote		C		4
animals	birds	Passeridae	*Passer domesticus*	house sparrow	Y			1
animals	birds	Pelecanidae	*Pelecanus conspicillatus*	Australian pelican		C		1
animals	birds	Petroicidae	*Microeca fascinans*	jacky winter		C		2
animals	birds	Petroicidae	*Melanodryas cucullata*	hooded robin		C		3
animals	birds	Phalacrocoracidae	*Phalacrocorax carbo*	great cormorant		C		1
animals	birds	Phalacrocoracidae	*Microcarbo melanoleucos*	little pied cormorant		C		3
animals	birds	Phalacrocoracidae	*Phalacrocorax varius*	pied cormorant		C		2
animals	birds	Phalacrocoracidae	*Phalacrocorax sulcirostris*	little black cormorant		C		2
animals	birds	Phasianidae	*Coturnix ypsilophora*	brown quail		C		3
animals	birds	Podargidae	*Podargus strigoides*	tawny frogmouth		C		4
animals	birds	Podicipedidae	*Poliocephalus poliocephalus*	hoary-headed grebe		C		1
animals	birds	Pomatostomidae	*Pomatostomus temporalis*	grey-crowned babbler		C		26/1
animals	birds	Psittacidae	*Barnardius zonarius*	Australian ringneck		C		10
animals	birds	Psittacidae	*Aprosmictus erythropterus*	red-winged parrot		C		18
animals	birds	Psittacidae	*Trichoglossus haematodus moluccanus*	rainbow lorikeet		C		1

Kingdom	Class	Family	Scientific Name	Common Name	I	Q	A	Records
animals	birds	Psittacidae	*Barnardius zonarius macgillivrayi*	Cloncurry parrot		C		8/1
animals	birds	Psittacidae	*Psitteuteles versicolor*	varied lorikeet		C		24
animals	birds	Psittacidae	*Melopsittacus undulatus*	budgerigar		C		24
animals	birds	Ptilonorhynchidae	*Ptilonorhynchus nuchalis*	great bowerbird		C		7
animals	birds	Ptilonorhynchidae	*Ptilonorhynchus maculatus*	spotted bowerbird		C		3
animals	birds	Rallidae	*Tribonyx ventralis*	black-tailed native-hen		C		1
animals	birds	Recurvirostridae	*Himantopus himantopus*	black-winged stilt		C		1
animals	birds	Rhipiduridae	*Rhipidura albiscapa*	grey fantail		C		2
animals	birds	Rhipiduridae	*Rhipidura leucophrys*	willie wagtail		C		31
animals	birds	Strigidae	*Ninox boobook*	southern boobook		C		7
animals	birds	Strigidae	*Ninox connivens*	barking owl		C		1
animals	birds	Threskiornithidae	*Platalea regia*	royal spoonbill		C		2
animals	birds	Threskiornithidae	*Threskiornis spinicollis*	straw-necked ibis		C		3
animals	birds	Threskiornithidae	*Threskiornis molucca*	Australian white ibis		C		1
animals	birds	Turnicidae	*Turnix velox*	little button-quail		C		1
animals	birds	Tytonidae	*Tyto javanica*	eastern barn owl		C		2
animals	bony fish	Ambassidae	*Ambassis species*	northwest glassfish				1
animals	bony fish	Clupeidae	*Nematalosa erebi*	bony bream				2
animals	bony fish	Melanotaeniidae	*Melanotaenia splendida splendida*	eastern rainbowfish				1
animals	bony fish	Terapontidae	*Amniataba percoides*	barred grunter				1
animals	bony fish	Terapontidae	*Leiopotherapon unicolor*	spangled perch				3
animals	insects	Nymphalidae	*Euploea core corinna*	common crow				2
animals	insects	Nymphalidae	*Danaus chrysippus petilia*	lesser wanderer				2
animals	insects	Nymphalidae	*Hypolimnas bolina nerina*	varied eggfly				5
animals	insects	Nymphalidae	*Junonia villida calybe*	meadow argus				1
animals	insects	Papilionidae	*Papilio demoleus sthenelus*	chequered swallowtail				3
animals	insects	Pieridae	*Eurema smilax*	small grass-yellow				1
animals	insects	Pieridae	*Catopsilia pomona pomona*	lemon migrant				1
animals	insects	Pieridae	*Catopsilia pyranthe crokera*	white migrant				1
animals	insects	Pieridae	*Belenois java teutonia*	caper white				1
animals	mammals	Emballonuridae	*Taphozous sp.*					1
animals	mammals	Macropodidae	*Macropus rufus*	red kangaroo		C		4
animals	mammals	Macropodidae	*Onychogalea unguifera*	northern nailtail wallaby		C		3
animals	mammals	Macropodidae	*Macropus agilis*	agile wallaby		C		2
animals	mammals	Macropodidae	*Macropus robustus*	common wallaroo		C		3
animals	mammals	Macropodidae	*Petrogale purpureicollis*	purple-necked rock-wallaby		V		4
animals	mammals	Molossidae	*Chaerephon jobensis*	northern freetail bat		C		1
animals	mammals	Molossidae	*Mormopterus beccarii*	Beccari's freetail bat		C		1
animals	mammals	Muridae	*Pseudomys desertor*	desert mouse		C		1
animals	mammals	Muridae	*Hydromys chrysogaster*	water rat		C		1
animals	mammals	Muridae	*Pseudomys johnsoni*			C		1
animals	mammals	Pteropodidae	*Pteropus scapulatus*	little red flying-fox		C		1
animals	mammals	Tachyglossidae	*Tachyglossus aculeatus*	short-beaked echidna		C		1
animals	mammals	Vespertilionidae	*Vespadelus sp.*					1/1
animals	mammals	Vespertilionidae	*Chalinolobus gouldii*	Gould's wattled bat		C		3
animals	mammals	Vespertilionidae	*Scotorepens balstoni*	inland broad-nosed bat		C		4/3

Kingdom	Class	Family	Scientific Name	Common Name	I	Q	A	Records
animals	mammals	Vespertilionidae	*Vespadelus finlaysoni*	Finlayson's cave bat		C		1
animals	mammals	Vespertilionidae	*Chalinolobus nigrogriseus*	hoary wattled bat		C		1
animals	mammals	Vespertilionidae	*Scotorepens greyii*	little broad-nosed bat		C		14/2
animals	reptiles	Agamidae	*Pogona vitticeps*			C		4/1
animals	reptiles	Agamidae	*Amphibolurus temporalis*			C		2
animals	reptiles	Agamidae	*Ctenophorus caudicinctus*	ring-tailed dragon		C		1
animals	reptiles	Agamidae	*Diporiphora bilineata*	two-lined dragon		C		1
animals	reptiles	Agamidae	*Diporiphora magna*			C		3
animals	reptiles	Agamidae	*Amphibolurus gilberti*	Gilbert's dragon		C		7
animals	reptiles	Agamidae	*Chlamydosaurus kingii*	frilled lizard		C		1
animals	reptiles	Boidae	*Aspidites melanocephalus*	black-headed python		C		2
animals	reptiles	Crocodylidae	*Crocodylus johnstoni*	Australian freshwater crocodile		C		1
animals	reptiles	Elapidae	*Furina ornata*	orange-naped snake		C		1
animals	reptiles	Elapidae	*Vermicella annulata*	bandy-bandy		C		1
animals	reptiles	Elapidae	*Pseudonaja textilis*	eastern brown snake		C		1
animals	reptiles	Gekkonidae	*Gehyra sp.*					1
animals	reptiles	Gekkonidae	*Gehyra nana*			C		1
animals	reptiles	Gekkonidae	*Gehyra dubia*			C		2
animals	reptiles	Gekkonidae	*Gehyra variegata*	tree dtella		C		2
animals	reptiles	Gekkonidae	*Lucasium immaculatum*			C		2
animals	reptiles	Gekkonidae	*Rhynchoedura ornata*	beaked gecko		C		1/1
animals	reptiles	Gekkonidae	*Heteronotia binoei*	Bynoe's gecko		C		4/1
animals	reptiles	Gekkonidae	*Gehyra robusta*			C		2
animals	reptiles	Gekkonidae	*Lucasium stenodactylum*	crowned gecko		C		4
animals	reptiles	Gekkonidae	*Diplodactylus conspicillatus*	fat-tailed diplodactylus		C		3
animals	reptiles	Pygopodidae	*Delma nasuta*	sharp-snouted legless lizard		C		1
animals	reptiles	Pygopodidae	*Lialis burtonis*	Burton's legless lizard		C		2
animals	reptiles	Scincidae	*Tiliqua multifasciata*	Centralian blue-tongued lizard		C		2
animals	reptiles	Scincidae	*Cryptoblepharus zoticus*	agile snake-eyed skink		C		1
animals	reptiles	Scincidae	*Cryptoblepharus pannosus*	ragged snake-eyed skink		C		1
animals	reptiles	Scincidae	*Menetia maini*			C		1
animals	reptiles	Scincidae	*Ctenotus hebetior*			C		1
animals	reptiles	Scincidae	*Ctenotus striaticeps*			C		2
animals	reptiles	Scincidae	*Ctenotus pantherinus*			C		6
animals	reptiles	Scincidae	*Ctenotus pulchellus*			C		2/2
animals	reptiles	Scincidae	*Ctenotus decaneurus*			C		1
animals	reptiles	Scincidae	*Ctenotus lateralis*			C		8
animals	reptiles	Scincidae	*Egernia hosmeri*	Hosmer's skink		C		2
animals	reptiles	Scincidae	*Carlia amax*			C		2
animals	reptiles	Scincidae	*Cryptoblepharus plagiocephalus sensu lato*			C		1
animals	reptiles	Typhlopidae	*Ramphotyphlops diversus*			C		2
animals	reptiles	Varanidae	*Varanus mertensi*	Mertens' water monitor		C		5
animals	reptiles	Varanidae	*Varanus panoptes*	yellow-spotted monitor		C		2
animals	reptiles	Varanidae	*Varanus acanthurus*	ridge-tailed monitor		C		3/1
fungi	sac fungi	Lecideaceae	*Lecidea*			C		1/1
fungi	sac fungi	Teloschistaceae	*Caloplaca*			C		1/1

Kingdom	Class	Family	Scientific Name	Common Name	I	Q	A	Records
plants	higher dicots	Amaranthaceae	*Gomphrena lanata*			C		2/2
plants	higher dicots	Amaranthaceae	*Alternanthera denticulata*	lesser joyweed		C		1/1
plants	higher dicots	Amaranthaceae	*Gomphrena leptophylla*			C		1/1
plants	higher dicots	Amaranthaceae	*Achyranthes aspera*			C		1/1
plants	higher dicots	Apocynaceae	*Calotropis procera*		Y			3/3
plants	higher dicots	Apocynaceae	*Calotropis gigantea*		Y			1/1
plants	higher dicots	Apocynaceae	*Carissa lanceolata*			C		1/1
plants	higher dicots	Asteraceae	*Pluchea rubelliflora*			C		1/1
plants	higher dicots	Asteraceae	*Pterocaulon sphacelatum*	applebush		C		1/1
plants	higher dicots	Asteraceae	*Pterocaulon serrulatum var. serrulatum*			C		1/1
plants	higher dicots	Boraginaceae	*Heliotropium tanythrix*			C		1/1
plants	higher dicots	Boraginaceae	*Heliotropium cunninghamii*			C		1/1
plants	higher dicots	Boraginaceae	*Trichodesma zeylanicum var. zeylanicum*			C		1/1
plants	higher dicots	Boraginaceae	*Heliotropium tenuifolium*			C		1/1
plants	higher dicots	Byttneriaceae	*Waltheria indica*			C		1/1
plants	higher dicots	Caesalpiniaceae	*Senna notabilis*			C		1/1
plants	higher dicots	Caesalpiniaceae	*Senna artemisioides subsp. oligophylla*			C		1/1
plants	higher dicots	Caryophyllaceae	*Polycarpaea breviflora*			C		1/1
plants	higher dicots	Caryophyllaceae	*Polycarpaea spirostylis subsp. glabra*			C		1/1
plants	higher dicots	Caryophyllaceae	*Polycarpaea spirostylis subsp. spirostylis*			C		1/1
plants	higher dicots	Caryophyllaceae	*Polycarpaea corymbosa var. corymbosa*			C		1/1
plants	higher dicots	Chenopodiaceae	*Maireana georgei*			C		1/1
plants	higher dicots	Cleomaceae	*Cleome viscosa*	tick-weed		C		2/2
plants	higher dicots	Cleomaceae	*Cleome gynandra*		Y			1/1
plants	higher dicots	Combretaceae	*Terminalia aridicola subsp. aridicola*			C		2/2
plants	higher dicots	Convolvulaceae	*Bonamia pannosa*			C		2/2
plants	higher dicots	Convolvulaceae	*Ipomoea plebeia*	bellvine		C		1/1
plants	higher dicots	Cucurbitaceae	*Cucumis melo*			C		1/1
plants	higher dicots	Cucurbitaceae	*Momordica balsamina*	balsam apple	Y			1/1
plants	higher dicots	Cucurbitaceae	*Cucumis maderaspatanus*			C		1/1
plants	higher dicots	Euphorbiaceae	*Chamaesyce hirta*	asthma plant	Y			1/1
plants	higher dicots	Euphorbiaceae	*Chamaesyce australis*			C		1/1
plants	higher dicots	Fabaceae	*Vigna*			C		1/1
plants	higher dicots	Fabaceae	*Indigofera linnaei*	Birdsville indigo		C		1/1
plants	higher dicots	Fabaceae	*Tephrosia virens*			C		4/4
plants	higher dicots	Fabaceae	*Indigofera colutea*	sticky indigo		C		1/1
plants	higher dicots	Fabaceae	*Cajanus acutifolius*			C		1/1
plants	higher dicots	Fabaceae	*Sesbania benthamiana*			C		1/1
plants	higher dicots	Fabaceae	*Crotalaria novae-hollandiae subsp. novae-hollandiae*			C		1/1
plants	higher dicots	Fabaceae	*Tephrosia sp. (Magazine Hill P.Jones 365)*			C		1/1
plants	higher dicots	Fabaceae	*Tephrosia brachyodon var. longifolia*			C		1/1
plants	higher dicots	Fabaceae	*Crotalaria medicaginea var. neglecta*			C		1/1
plants	higher dicots	Fabaceae	*Vigna lanceolata var. lanceolata*			C		1/1
plants	higher dicots	Fabaceae	*Crotalaria novae-hollandiae*			C		1/1
plants	higher dicots	Fabaceae	*Macroptilium atropurpureum*	siratro	Y			1/1
plants	higher dicots	Fabaceae	*Indigastrum parviflorum*			C		1/1

Kingdom	Class	Family	Scientific Name	Common Name	I	Q	A	Records
plants	higher dicots	Fabaceae	*Tephrosia lasiochlaena*			C		1/1
plants	higher dicots	Fabaceae	*Indigofera linifolia*			C		2/2
plants	higher dicots	Goodeniaceae	*Scaevola*			C		2/2
plants	higher dicots	Goodeniaceae	*Goodenia vilmoriniae*			C		1/1
plants	higher dicots	Lamiaceae	*Hyptis suaveolens*	hyptis	Y			1/1
plants	higher dicots	Lamiaceae	*Vitex benthamiana*			C		2/2
plants	higher dicots	Lamiaceae	*Ocimum tenuiflorum*			C		1/1
plants	higher dicots	Loranthaceae	*Diplatia grandibractea*			C		1/1
plants	higher dicots	Malvaceae	*Abutilon hannii*			C		1/1
plants	higher dicots	Malvaceae	*Sida rohlenae subsp. rohlenae*			C		1/1
plants	higher dicots	Malvaceae	*Hibiscus sturtii var. grandiflorus*			C		1/1
plants	higher dicots	Malvaceae	*Abutilon arenarium*			C		1/1
plants	higher dicots	Mimosaceae	*Acacia chisholmii*			C		2/2
plants	higher dicots	Mimosaceae	*Acacia elachantha*			C		1/1
plants	higher dicots	Mimosaceae	*Acacia farnesiana*	mimosa bush	Y			2/2
plants	higher dicots	Mimosaceae	*Acacia tenuissima*			C		1/1
plants	higher dicots	Mimosaceae	*Acacia gonoclada*			C		1/1
plants	higher dicots	Mimosaceae	*Acacia acradenia*			C		5/5
plants	higher dicots	Mimosaceae	*Acacia cambagei*	gidgee		C		1/1
plants	higher dicots	Mimosaceae	*Acacia retivenea subsp. retivenea*			C		3/3
plants	higher dicots	Myoporaceae	*Eremophila latrobei subsp. latrobei*			C		1/1
plants	higher dicots	Myrtaceae	*Melaleuca argentea*	silver tea-tree		C		3/3
plants	higher dicots	Myrtaceae	*Corymbia capricornia*			C		1/1
plants	higher dicots	Myrtaceae	*Melaleuca fluviatilis*			C		1/1
plants	higher dicots	Myrtaceae	*Eucalyptus leucophylla*			C		1/1
plants	higher dicots	Myrtaceae	*Eucalyptus leucophylla x E.pruinosa*			C		1/1
plants	higher dicots	Myrtaceae	*Melaleuca viridiflora var. viridiflora*			C		1/1
plants	higher dicots	Myrtaceae	*Eucalyptus pruinosa subsp. pruinosa*			C		1/1
plants	higher dicots	Myrtaceae	*Eucalyptus leucophloia subsp. euroa*			C		2/2
plants	higher dicots	Nyctaginaceae	*Boerhavia burbidgeana*			C		1/1
plants	higher dicots	Portulacaceae	*Portulaca*			C		1/1
plants	higher dicots	Portulacaceae	*Sedopsis armitii*			C		1/1
plants	higher dicots	Proteaceae	*Grevillea dryandri subsp. dryandri*			C		1/1
plants	higher dicots	Sapindaceae	*Dodonaea stenophylla*			C		1/1
plants	higher dicots	Solanaceae	*Datura inoxia*		Y			3/3
plants	higher dicots	Solanaceae	*Solanum esuriale*	quena		C		1/1
plants	higher dicots	Solanaceae	*Solanum succosum*			C		1/1
plants	higher dicots	Solanaceae	*Solanum echinatum*			C		1/1
plants	higher dicots	Solanaceae	*Solanum quadriloculatum*			C		2/2
plants	higher dicots	Sparrmanniaceae	*Corchorus pumilio*			C		1/1
plants	higher dicots	Sparrmanniaceae	*Corchorus tridens*			C		2/2
plants	higher dicots	Sparrmanniaceae	*Triumfetta rupestris*			C		1/1
plants	higher dicots	Sparrmanniaceae	*Corchorus sericeus subsp. densiflorus*			C		1/1
plants	higher dicots	Sparrmanniaceae	*Corchorus sidoides subsp. vermicularis*			C		1/1
plants	higher dicots	Violaceae	*Hybanthus enneaspermus*			C		1/1
plants	monocots	Arecaceae	*Livistona rigida*			C		1/1

Kingdom	Class	Family	Scientific Name	Common Name	I	Q	A	Records
plants	monocots	Cyperaceae	*Cyperus iria*			C		3/3
plants	monocots	Cyperaceae	*Cyperus squarrosus*	bearded flatsedge		C		1/1
plants	monocots	Cyperaceae	*Cyperus carinatus*			C		1/1
plants	monocots	Cyperaceae	*Cyperus dactylotes*			C		1/1
plants	monocots	Cyperaceae	*Bulbostylis barbata*			C		3/3
plants	monocots	Cyperaceae	*Fimbristylis microcarya*			C		2/2
plants	monocots	Cyperaceae	*Fimbristylis sp. (Thargomindah D.E.Boyland 3094)*			C		1/1
plants	monocots	Cyperaceae	*Cyperus microcephalus subsp. microcephalus*			C		1/1
plants	monocots	Cyperaceae	*Cyperus cunninghamii subsp. cheradicus*			C		1/1
plants	monocots	Cyperaceae	*Fimbristylis corynocarya*			C		1/1
plants	monocots	Cyperaceae	*Lipocarpha microcephala*			C		1/1
plants	monocots	Cyperaceae	*Fimbristylis littoralis*			C		1/1
plants	monocots	Poaceae	*Tragus australianus*	small burr grass		C		1/1
plants	monocots	Poaceae	*Dichanthium fecundum*	curly bluegrass		C		1/1
plants	monocots	Poaceae	*Aristida hygrometrica*			C		1/1
plants	monocots	Poaceae	*Dichanthium annulatum*	sheda grass	Y			1/1
plants	monocots	Poaceae	*Heteropogon contortus*	black speargrass		C		1/1
plants	monocots	Poaceae	*Bothriochloa ewartiana*	desert bluegrass		C		1/1
plants	monocots	Poaceae	*Brachyachne convergens*	common native couch		C		2/2
plants	monocots	Poaceae	*Enneapogon cylindricus*	jointed nineawn		C		1/1
plants	monocots	Poaceae	*Enneapogon polyphyllus*	leafy nineawn		C		2/2
plants	monocots	Poaceae	*Sporobolus australasicus*			C		1/1
plants	monocots	Poaceae	*Pennisetum pennisetiforme*		Y			1/1
plants	monocots	Poaceae	*Aristida holathera var. holathera*			C		2/2
plants	monocots	Poaceae	*Eriachne pulchella subsp. dominii*			C		1/1
plants	monocots	Poaceae	*Bothriochloa bladhii subsp. bladhii*			C		1/1
plants	monocots	Poaceae	*Eriachne sp. (Dugald River B.K.Simon+ 3007)*			C		1/1
plants	monocots	Poaceae	*Oxychloris scariosa*	winged chloris		C		1/1
plants	monocots	Poaceae	*Echinochloa colona*	awnless barnyard grass	Y			1/1
plants	monocots	Poaceae	*Chrysopogon fallax*			C		1/1
plants	monocots	Poaceae	*Aristida latifolia*	feathertop wiregrass		C		1/1
plants	monocots	Poaceae	*Urochloa piligera*			C		2/2
plants	monocots	Poaceae	*Paspalidium rarum*			C		1/1
plants	monocots	Poaceae	*Mnesithea formosa*			C		1/1
plants	monocots	Poaceae	*Chloris pectinata*	comb chloris		C		1/1
plants	monocots	Poaceae	*Aristida pruinosa*			C		1/1
plants	monocots	Poaceae	*Aristida contorta*	bunched kerosene grass		C		1/1
plants	monocots	Poaceae	*Themeda triandra*	kangaroo grass		C		1/1
plants	monocots	Poaceae	*Themeda avenacea*			C		1/1
plants	monocots	Poaceae	*Sehima nervosum*			C		1/1
plants	monocots	Poaceae	*Eulalia aurea*	silky browntop		C		1/1
plants	monocots	Poaceae	*Eriachne mucronata forma (Alpha C.E.Hubbard 7882)*			C		1/1

CODES

I - Y indicates that the taxon is introduced to Queensland and has naturalised.

Q - Indicates the Queensland conservation status of each taxon under the *Nature Conservation Act 1992.* The codes are Extinct in the Wild (PE), Endangered (E), Vulnerable (V), Near Threatened (NT), Least Concern (C) or Not Protected ( ).

A - Indicates the Australian conservation status of each taxon under the *Environment Protection and Biodiversity Conservation Act 1999.* The values of EPBC are Conservation Dependent (CD), Critically Endangered (CE), Endangered (E), Extinct (EX), Extinct in the Wild (XW) and Vulnerable (V).

Records – The first number indicates the total number of records of the taxon for the record option selected (i.e. All, Confirmed or Specimens).
This number is output as 99999 if it equals or exceeds this value. The second number located after the / indicates the number of specimen records for the taxon.
This number is output as 999 if it equals or exceeds this value.

Appendix B: AARC Flora Species List

Species Name	Common Name	River Red Gum Riparian Woodland	Ghost Gum / Bloodwood Riparian Woodland	Gidgee Open Woodland	Cloncurry Box Open Woodland	Snappy Gum Open Woodland	Silver Box Open Woodland
Abutilon hannii	Andrews' Lantern Flower	x	x			x	
Acacia acradenia						x	
Acacia bidwillii	Corkwood Wattle	x	x		x	x	
Acacia cambagei	Gidgee			x			
Acacia chippendalei						x	x
Acacia chisholmii	Chisholm's Wattle, Turpentine				x	x	x
Acacia elachantha	Cowle's Wattle					x	
*Acacia farnesiana**	Mimosa	x	x	x	x		x
Acacia gonoclada						x	
Acacia hemignosta	Club-leaf Wattle	x		x			
Acacia holosericea	Soap Bush	x	x		x	x	x
Acacia lysiphloia	Turpentine	x	x		x	x	x
Acacia monticola	Turpentine	x	x			x	
Acacia retivenea	Net-Veined Wattle	x	x			x	
Acacia tenuissima	Narrow-Leaved Wattle				x	x	
Acacia torulosa		x	x				
Acacia victoriae					x		
Achyranthes aspera	Chaff Flower	x		x	x		
Aeschynomene indica	Budda Pea	x	x				
*Aerva javanica**	Kapok Bush		x	x	x	x	
Alternanthera denticulata	Lesser Joyweed	x	x				
*Alternanthera pungens**	Khaki Weed	x	x				
Alternanthera sp. (Mt Isa R.L.Specht+ 49)	Joyweed	x	x				
Anisomeles malabarica	Chodhava	x					
Aristida contorta	Bunched Kerosene Grass	x	x	x	x	x	x

Aristida inaequiglumis	Feathertop Three-Awn	x		x	x		
Aristida latifolia	Feathertop Grass	x				x	
Astrebla squarrosa	Bull Mitchell Grass		x		x		
Atalaya hemiglauca	Whitewood	x	x		x	x	x
*Boerhavia paludosa**	Tarvine					x	
Boerhavia schomburgkiana	Tar Vine	x		x	x	x	
Bonamia media	Conmmon Bonamia	x	x	x		x	
Bulbostylis barbata	Watergrass	x				x	
Cajanus acutifolius						x	
*Calotropis procera**	Calotrope, Cabbage Tree	x					
Capparis lasiantha	Wait-A-While	x	x	x		x	x
Carissa lanceolata	Conkerberry, Currant Bush	x	x	x	x		
Cassytha filiformis	Dodder Laurel, Spaghetti plant	x		x			
Chamaecrista symonii	Dwarf Cassia					x	
Chamaesyce coghlanii			x		x		
Chamaesyce drummondii	Caustic Weed	x		x			
Cheilanthes brownii						x	
Chloris virgata	Feathertop Rhodes Grass				x		
Chrysopogon fallax	Golden Beard Grass				x	x	
*Citrullus colocynthis**	Colocynth					x	
*Cleome viscosa**	Tick Weed	x				x	
Clerodendrum floribundum			x			x	x
Corchorus pascuorum	Native Jute	x	x				
Corchorus pumilio	Jute					x	
Corchorus tridens			x		x	x	x
Corymbia aparrerinja	North-west Ghost Gum		x		x		x
Corymbia aspera	Rough-leaved Ghost Gum					x	
Corymbia capricornia	Small-fruited Bloodwood		x		x	x	x
Corymbia terminalis	Western Bloodwood	x	x		x	x	
Crotalaria aridicola	Chillagoe Horse Poison	x			x	x	x
Crotalaria dissitiflora	Grey Rattlepod	x	x		x	x	

Crotalaria medicaginea	Treefoil rattlepod				x	x	
Crotalaria novae-hollandiae	New Holland Rattlepod	x		x	x	x	
Cucumis melo subsp. a*gretis*	Native Cucumber	x	x			x	
Cullen leucanthum	Native Cullen	x	x				
Cyanotis axillaris	Blue Ears	x					
Cymbopogon bombycinus	Silky Oil Grass	x	x			x	x
Cyperus conicus var. *conicus*		x	x			x	
Cyperus cunninghamii subsp. *cheradicus*		x	x			x	
Cyperus dactylotes		x	x				
Cyperus difformis	Dirty Dora	x	x		x	x	
Cyperus exaltatus	Giant Sedge	x					
Cyperus iria	Variable Sedge	x					
Cyperus javanicus	Java Sedge	x					
Cyperus microcephalus		x					
Cyperus pulchellus		x	x			x	
Cyperus vaginatus	Stiff Flat-sedge	x					
Dactyloctenium radulans	Button Grass			x			
*Datura inoxia**	Downy Thornapple			x			
Datura leichhardtii	Native Thornapple	x					
Dichantium fecundum	Curly Bluegrass	x					
Dichanthium sericeum	Queensland Bluegrass	x			x		x
Digitaria bicornis	Silky Arm Grass	x					
*Echinochloa colona**	Awnless Barnyard Grass	x					x
Echinochloa obtusa			x			x	
Enneapogon oblongus	Purple-Head Nineawn	x	x	x		x	
Enneapogon polyphyllus	Leafy Nineawn			x	x	x	
Eragrostis basedowii	Neat Lovegrass	x	x				
Eragrostis elongata	Clustered Lovegrass	x	x				
Eragrostis fallax		x	x		x		

Eragrostis lacunaria	Purple Lovegrass	x	x				
Eragrostis leptocarpa	Drooping Lovegrass				x	x	x
*Eragrostis minor**	Small Stinkgrass	x					
Eremophila latrobei	Crimson Turkey Bush		x	x	x		
Eremophila longifolia	Emu Bush	x			x		
Eriachne ciliata	Slender Wandarrie Grass	x	x		x	x	
Eriachne mucronata	Mountain Wandarrie Grass					x	
Eriachne obtusa	Northern Wandarrie Grass	x					
Eriochloa crebra	Cup Grass	x					
Eucalyptus camaldulensis	River Red Gum	x			x	x	x
Eucalyptus herbertiana						x	
Eucalyptus leucophloia	Snappy Gum	x	x		x	x	x
Eucalyptus leucophylla	Cloncurry Box	x				x	x
Eucalyptus pruinosa	Silver-leaved Box		x				
Eulalia aurea	Silky Browntop	x	x		x		
Euphorbia tannensis subsp. eremophila	Desert Spurge					x	
Evolvulus alsinoides	Tropical Speedwell	x	x	x	x	x	
Ficus aculeata	Sandpaper Fig	x	x				
Fimbristylis dichotoma	Common Fringerush	x	x		x	x	
Fimbristylis littoralis	Lesser Fringerush	x					
Fimbristylis microcarya	Fringerush	x	x		x	x	
Fimbristylis signata	Fringerush	x				x	
Fimbristylis tetragona	Single-head Fringerush					x	
Flueggea virosa subsp melanthesoides	White Currant	x	x				
Glycine tomentella	Wooly Glycine	x					
Gomphrena flaccida	Gomphrena	x		x	x	x	
Gossypium australe	Rose Cottonbush, Native Cotton				x	x	
Gossypium nelsoni			x		x	x	
Grevillea dryandri	Dryander's Grevillea					x	

Grevillea striata	Beefwood		x		x	x	x
Hakea aborescens	Tree Hakea	x				x	x
Hakea cordophylla	Bull Oak, Bootlace Oak	x	x		x		
Heliotropium cunninghamii	Heliotrope					x	
Heteropogon contortus	Black Speargrass	x					
Hibiscus meraukensis	Merauke Hibiscus	x					
Hibiscus pentaphyllus	Five-Leaflet Hibiscus		x				
Hybanthus aurantiacus	Orange Spadeflower		x				
Hybanthus enneaspermus	Blue Spadeflower	x	x		x	x	
Indigofera colutea	Sticky Indigo, Rusty Indigo	x	x		x		
Indigofera linifolia	Narrow-Leaved Indigo	x	x	x	x		
Indigofera linnaei		x		x	x	x	
Iphigenia indica	Indian Grass Lily	x					
Ipomoea diamantinensis	Desert Cow-vine	x	x				
Ipomoea lonchophylla	Cow Vine		x				
Ipomoea muelleri	Poison Morning Glory	x	x	x			
Iseilema vaginiflorum	Red Flinders Grass	x					
Iseilema sp.			x				
Jacquemontia browniana	Clustervine	x					
Leptochloa digitata	Cane Grass	x					
Lipocarpha microcephala	Button Rush	x	x				
Livistona rigida		x	x				
riparius	Northern Swamp Box	x	x				x
Ludwigia octovalvis	Willow Primrose	x					
Lysiphyllum cunninghamii	Bauhinia, Bean Tree	x					
Malvastrum americanum var. *americanum**	Spiked Malvastrum	x	x	x			x
Marsilea hirsuta	Hairy Nardoo		x				
Melaleuca argentea	Silvery Weeping River Teatree	x					
Melaleuca bracteata	River Teatree	x					
Melaleuca leucadendra	Weeping River Teatree	x					

Melinis repens	Red Natal Grass	x				x	
Mukia maderaspatensis	Desert Cucumber			x	x		x
Neptunia dimorphantha	Sensitive Plant				x	x	
Neptunia gracilis	Low Sensitive Plant	x	x	x	x		x
Ocimum tenuiflorum	Native Basil	x					
Operculina aequisepala	Paper Rose, Onion Vine		x				
Panicum decompositum	Native Panic	x		x			
Paratephrosia lantana	Velvet Bush	x	x	x		x	
Paspalidium rarum	Paspalidium	x	x	x	x	x	
*Pennisetum ciliare**	Buffel Grass	x	x	x	x	x	
*Pennisetum pennisetiforme**	Cloncurry Buffel	x	x	x	x	x	
Perotis rara	Comet Grass	x	x		x		
Phyllanthus maderaspatensis	Spurge	x	x	x		x	
Pluchea rubelliflora	Daisy	x					
Plumbago zeylanica	Plumbago		x				
Polycarpaea corymbosa	Copper Bush			x	x	x	
Polygala rhinanthoides		x					
Polygala wightiana		x	x				
Polymeria ambigua	Clumped Bindweed	x	x		x	x	
Polymeria longifolia	Polymeria				x		
Portulaca filifolia	Pigweed	x	x				
Pterocaulon serrulatum				x	x		
Pterocaulon serrulatum var. velutinum					x		
Pterocaulon sphacelatum	Fruit Salad Plant				x	x	
Ptilotus fusiformis	Pom-Pom Bottlebrush	x	x				
Rostellularia adscendens	Pinktongues	x				x	
Rhynchosia minima	Rhynchosia	x	x	x			
Rhynchospora pterochaeta	Rusty Heads				x	x	
Salsola kali	Soft Roly Poly			x	x	x	x
Santalum lanceolatum	Sandalwood	x		x			

Sarcostemma viminale subsp. *australe*	Pencil Caustic, Caustic Vine			x			
Sclerolaena bicornis	Goathead Burr		x	x			
Schizachyrium fragile	Firegrass				x		
Senna artemisioides subsp. o*ligophylla*	Limestone Cassia		x	x			
*Senna notabilis**	Cockroach Bush	x	x		x		
Sesbania campylocarpa	Sesbania Pea		x		x		
Sesbania javacina	Tall Sesbania Pea	x	x				
Setaria surgens	Annual Pigeon Grass	x	x				
*Sida cordifolia**	Flannel Weed	x	x		x		x
Sida fibulifera	Pin sida	x	x				x
*Sida spinosa**	Spiny Sida	x					
Sida subspicata	Spiked Sida	x		x	x	x	
Solanum echinatum	Wild Tomato				x	x	
Solanum ellipticum	Potato Bush		x	x	x		
Spermacoce auriculata	False Buttonwood	x	x			x	
Sporobolus actinocladus	Katoora, Ray Grass	x	x				
Sporobolus australasicus	Australian Dropseed				x		
Sporobolus caroli	Fairy Grass			x	x	x	
Stackhousia intermedia						x	
Stemodia lythrifolia		x					
Stemodia viscosa	Sticky Blue Rod	x			x		
Swainsona burkei	Desert Pea	x				x	
Tephrosia brachyodon var longifolia	Narrow-leaved Tephrosia	x				x	
Tephrosia flagellaris			x		x		
Tephrosia rosea var rosea	Flinders River Poison	x	x		x	x	x
Tephrosia varians		x				x	
Tephrosia virens	Green Tephrosia	x					
Terminalia aridicola subsp. *aridicola*	Arid Peach	x	x			x	

Terminalia canescens	Winged Nut Tree		x				
Terminalia oblongata subsp. *volcuris*	Rosewood, Yellow Wood		x				
Themeda triandra	Kangaroo Grass	x				x	
Tinospora smilacina	Snake Vine		x				
Trema tomentosa var aspera	Poison Peach	x	x	x	x	x	x
Trichodesma zeylanicum	Camelbush	x	x		x	x	
Trigonella suavissima	Coppers Clover	x	x		x		
Triodia pungens	Soft Spinifex, Gummy Spinifex	x	x	x	x	x	x
Triumfetta rupestris		x	x			x	
Vigna lanceolata	Maloga Bean	x			x	x	
Vigna radiata var sublobata	Mung Bean	x			x		
Vitex benthamiana	Vitex	x					
Vitex trifolia var. *trifolia*	Simple-leaf Chastetree	x					
Wahlenbergia gracilis	Australian Bluebell	x	x				
Waltheria indica	Walthera					x	
Xanthium strumarium	Noogoora Burr	x					
Xenostegia tridentata	Arrow-leaf Morning-glory					x	
Yakkira majuscula		x	x				
Zornia muriculata	Zornia	x	x		x	x	
Zornia prostrata	Prostrate Zornia	x			x		

Appendix C: AARC Fauna Species List

FAUNA SPECIES CATALOGUE				
REPTILES				
FAMILY				
Scientific Name	**Common Name**	**Status**	**Dry Season**	**Wet Season**
Agamidae				
Amphibolurus gilberti	Gilbert's Dragon	Least Concern		X
Diporiphora bilineata	Two-lined Dragon	Least Concern		X
Diporiphora magna	Yellow-sided Two-lined Dragon	Least Concern		X
Elapidae				
Furnia ornata	Orange-naped Snake	Least Concern		X
Gekkonidae				
Diplodactylus conspiculatus	Fat-tailed Gecko	Least Concern		X
Gehyra nana	Spotted Gecko	Least Concern		X
Gehyra variegata	Tree Dtella	Least Concern		X
Heteronotia binoei	Bynoes Gecko	Least Concern		X
Pythonidae				
Aspidites melanocephalus	Black-headed Python	Least Concern		X
Antaresia stimsoni	Stimpson's Python	Least Concern		X
Scincidae				
Cryptoblepharus plagiocephalus sensu lato		Least Concern		
Ctenotus herbetior	Stout Ctenotus	Least Concern		X
Ctenotus lateralis	Gravelly-soil Ctenotus	Least Concern		X
Ctenotus pantherinus	Leopard Ctenotus	Least Concern		X
Proablepharus tenuis	Northern Soil-crevice Skink	Least Concern		X
Tiliqua multifasciata	Centralian Blue-tongue	Least Concern		X
BIRDS				
FAMILY				
Scientific Name	**Common Name**	**Status**	**Dry Season**	**Wet Season**
Acanthizidae				
Smicrornis brevirostris race *flavescens*	Weebill	Least Concern	X	X
Accipitridae				
Aquila audax	Wedge-tail Eagle	Least Concern	X	X
Falco subniger	Black Falcon	Least Concern	X	
Haliastur sphenurus	Whistling Kite	Marine - EPBC ACT	X	X
Milvus migrans	Black Kite	Least Concern		X
Aegothelidae				
Aegotheles cristatus	Australian Owlet-nightjar	Least Concern		X
Alcedinidae				
Alcedo azurea	Azure Kingfisher	Least Concern		X
Ardeidae				
Egretta novaehollandiae	White-faced Heron	Least Concern		X
Artamidae				
Artamus cinereus	Black-faced Woodswallow	Least Concern	X	X
Cracticus nigrogularis	Pied Butcherbird	Least Concern		X
Gymnorhina tibicen	Australian Magpie	Least Concern	X	X
Burhinidae				
Burhinus grallarius	Bush-stone Curlew	Least Concern		X
Cacatuidae				

Cacatua galerita	Sulphur-crested Cockatoo	Least Concern		X
Cacatua roseicapilla	Galah	Least Concern		X
Nymphicus hollandicus	Cockatiel	Least Concern		X
Campephagidae				
Coracina novaehollindiae	Black-faced Cuckoo-shrike	Least Concern		X
Lalage sueurii	White-winged Triller	Least Concern		X
Casuariidae				
Dromaius novaehollandiae	Emu	Least Concern	X	
Charadriidae				
Elseyornis melanops	Black-fronted Dotterel	Least Concern		X
Vanellus miles miles	Masked Lapwing	Least Concern		X
Columbidae				
Geopelia cuneata	Diamond Dove	Least Concern	X	X
Geopelia striata	Peaceful Dove	Least Concern	X	X
Geophaps plumifera	Spinifex Pigeon	Least Concern	X	X
Ocyphaps lophotes	Crested Pigeon	Least Concern	X	X
Phaps chalcoptera	Common Bronzewing	Least Concern	X	X
Corvidae				
Corvus coronoides	Australian Raven	Least Concern	X	
Corvus orru	Torresian Crow	Least Concern		X
Cuculidae				
Centropus phasianinus	Pheasant Coucal	Least Concern	X	X
Chalcites basalis	Horsfield's Bronze-cuckoo	Least Concern		X
Chalcites oscularis	Black-eared Cuckoo	Least Concern		X
Dicruridae				
Grallina cyanoleuca	Magpie-lark	Least Concern	X	X
Rhipidura leucophrys	Willie Wagtail	Least Concern	X	X
Estrildidae				
Emblema pictum	Painted Finch	Least Concern		X
Taeniopygia guttata	Zebra Finch	Least Concern	X	X
Eurostopodidae				
Eurostopodus argus	Spotted Nightjar	Least Concern		X
Gruidae				
Grus rubicundus	Brolga	Least Concern		X
Halcyonidae				
Dacelo leachii	Blue-winged Kookaburra	Least Concern	X	X
Todiramphus sanctus	Sacred Kingfisher	Marine - EPBC ACT		X
Maluridae				
Malurus lamberti	Variegated Fairy-wren	Least Concern		X
Malurus melanocephalus	Red-backed Fairy-wren	Least Concern		X
Meliphagidae				
Entomyzon cyanotis	Blue-faced Honeyeater	Least Concern		X
Lichenostomus virescens	Singing Honeyeater	Least Concern		X
Lichmera indistincta	Brown Honeyeater	Least Concern		X
Marorina flavigula	Yellow-throated Miner	Least Concern		X
Philemon argenticeps	Silver-crowned Friarbird	Least Concern		X
Meropidae				
Merops ornatus	Rainbow Bee-eater	Marine, Migratory-EPBC		X
Otididae				
Ardeotis australis	Australian Bustard	Least Concern	X	X

Pachycephalidae				
Colluricincia harmonica	Grey Shrike-thrush	Least Concern		X
Pachycephala rufiventris	Rufous Whistler	Least Concern		X
Passeridae				
Emblema pictum	Painted Finch	Least Concern		X
Taeniopygia bichenovii	Double-barred Finch	Least Concern		X
Taeniopygia guttata	Zebra Finch	Least Concern		X
Pelecanidae				
Pelecanus conspicillatus	Australian Pelican	Marine - EPBC ACT		X
Petroicidae				
Melanodryas cucullata	Hooded Robin	Least Concern		X
Microeca fascinans	Jacky Winter	Least Concern	X	X
Phasianidae				
Coturnix pectoralis	Stubble Quail	Least Concern		X
Podargidae				
Podargus strigoides	Tawny Frogmouth	Least Concern		X
Pomatostomidae				
Pomatostomus temporalis	Grey-crowned Babbler	Least Concern		X
Psittacidae				
Aprosmictus erythropterus	Red-winged Parrot	Least Concern		X
Barnardius barnardi race *macgillivrayi*	Eastern Ringneck (Cloncurry Parrot)	Least Concern	X	X
Melopsittacus undulatus	Budgerigar	Least Concern		X
Platycercus adscitus	Pale-headed Rosella	Least Concern		X
Psitteuteles versicolor	Varied Lorikeet	Least Concern		X
Ptilonorhynchidae				
Ptilonorhynchus nuchalis	Great Bowerbird	Least Concern		X
Rhipiduridae				
Rhipidura leucophrys	Willy Wagtail	Least Concern	X	X
MAMMALS				
FAMILY				
Scientific Name	**Common Name**	**Status**	**Dry Season**	**Wet Season**
Canidae				
Canis familiaris dingo	Dingo	Class 2 - LP Act		X
Dasyuridae				
Sminthopsis crassicaudata	Fat-tailed Dunnart	Least Concern	X	
Emballonuridae				
Saccolaimus flaviventris	Yellow-bellied Sheathtail Bat	Least Concern		X
Taphozous georianus	Common Sheathtail Bat	Least Concern		X
Taphozous troughtoni	Troughton's Sheathtail Bat	Least Concern		X
Felidae				
Felis catus	Feral Cat	Class 2 - LP Act		X
Macropodidae				
Macropus giganteus	Grey Kangaroo	Least Concern		X
Macropus robustus	Common Wallaroo	Least Concern		X
Macropus rufus	Red Kangaroo	Least Concern	X	X
Petrogale purpureicollis	Purple-necked Rock Wallaby	Vulnerable - NC Act		X
Muridae				
Mus musculus	House Mouse	Class 1 - LP Act	X	
Pseudomys desertor	Desert Mouse	Lease Concern		X

Pseudomys sp	unidentified Mouse			X
Zyzomys argurus	Common Rock Rat	Least Concern	X	
Molossidae				
Mormopterus beccarii	Beccari's Freetail Bat	Least Concern		X
Mormopterus loriae ridei	Eastern Little Freetail Bat	Least Concern		X
Mormopterus sp.	unknown Freetail Bat	Least Concern		X
Chalinolobus gouldii	Gould's Wattled Bat	Least Concern		X
Suidae				
Sus scrofa	Pig	Class 2 - LP Act		X
Vespertilionidae				
Charephon jobensis	Northern Free-tailed Bat	Least Concern		X
Chalinolobus nigrogriseus	Hoary Wattled Bat	Least Concern		X
Nyctophilus sp.	unknown Long-eared Bat	Least Concern		X
Scotorepens balstoni	Inland Broad-nosed Bat	Least Concern		X
Scotorepens greyii	Little Broad-nosed Bat	Least Concern		X
Vespadelus baverstocki	Inland Forest Bat	Least Concern		X
Vespadelus courinus	Northern Cave Bat	Least Concern		X
AMPHIBIANS				
FAMILY				
Scientific Name	**Common Name**	**Status**	**Dry Season**	**Wet Season**
Bufonidae				
Rhinella marina	Cane Toad	Least Concern	X	X
Hylidae				
Cyclorana australis	Giant Frog	Least Concern		X
Litoria caerulea	Green Tree Frog	Least Concern		X
Litoria pallida	Pale Tree Frog	Least Concern		X
Litoria rubella	Red Tree Frog	Least Concern		X
Limnidynstidae				
Platyplectrum ornatum	Ornate Burrowing Frog	Least Concern		X

Appendix D: ANABAT Results

Anabat echolocation data interpretation summary

Client: AARC (Julie Byrd; Townsville) **Balance Job no.:** AARC1104

Project name/location: Dugald River, NW of Cloncurry (March 2011)

Data summary tables

Numbers in columns indicate number of calls attributed to species/group for given night

	Anabat 2						Total Calls
Species	21-Mar	22-Mar	23-Mar	24-Mar	26-Mar	27-Mar	
Species positively identified (i.e. species definitely present)							
Chalinolobus gouldii	11	13	6	9		11	50
Chalinolobus nigrogriseus	1	13		1		1	16
Nyctophilus species	1	28	1				30
Scotorepens balstoni	22	20	9	19		21	91
Scotorepens greyii		7		4		11	22
Vespadelus baverstocki	24	40	2	14		15	95
Vespadelus caurinus / V. finlaysoni	2		8	20		28	58
Chaerephon jobensis	4	5	7	6		7	29
Mormopterus beccarii	1	2	3	2		12	20
Mormopterus species	3	9	1			6	19
Saccolaimus flaviventris	22	46	27	51	2	97	245
Taphozous georgianus							0
Taphozous troughtoni	1	1					2
Total calls positively identified	92	184	64	126	2	209	677
Calls NOT positively identified *							
Chalinolobus gouldii / Scotorepens balstoni	7	3	10	54		7	81
C. gouldii / S. balstoni / Mormopterus species	21	24	11	12		8	76
Scotorepens balstoni / S. greyii	2	4					6
Scotorepens greyii / Vespadelus baverstocki	10	48	9	48		17	132
Scotorepens greyii / Chalinolobus nigrogriseus	22	38	12	47	2	23	144
Vespadelus baverstocki / Nyctophilus sp		2					2
Chaerephon jobensis / Saccolaimus flaviventris	1	5	9	2		9	26
Mormopterus beccarii / Saccolaimus flaviventris			4	39		3	46
Mormopterus beccarii / Taphozous troughtoni	2	3	3			3	11
Saccolaimus flaviventris / Taphozous georgianus	2		1				3
UNIDENTIFIED BAT CALLS	14	28	10	5		2	59
Total calls not positively identified	81	155	69	207	2	72	586
Total calls for site/night	**173**	**339**	**133**	**333**	**4**	**281**	**1,263**

***** A species listed in the bottom section of the table that is not also listed in the top section should be considered as possibly present. Likelihood of occurrence and call identification issues for these species are discussed in the 'Reliability of species ID' section on the following pages.

Notes:

No bat calls recorded on night of 25th March and no Anabat data beyond morning of 28th March

Total number of sequence files recorded on this Anabat	10,464
Total number of sequence files that passed a generic bat-call filter	2,187
Total number of calls identified from filtered sequence files	1,263

Anabat echolocation data interpretation summary

Client: AARC (Julie Byrd; Townsville) **Balance Job no.:** AARC1104

Project name/location: Dugald River, NW of Cloncurry (March 2011)

Data summary tables

Numbers in columns indicate number of calls attributed to species/group for given night

	Un-named Anabat								Total Calls
Species	**21-Mar**	**22-Mar**	**24-Mar**	**25-Mar**	**26-Mar**	**27-Mar**	**29-Mar**	**30-Mar**	
Species positively identified (i.e. species definitely present)									
Chalinolobus gouldii	18	13	4	13		7	1	9	65
Chalinolobus nigrogriseus	3			2			4	1	10
Nyctophilus species		1				3		7	11
Scotorepens balstoni	10	8	2	17		13	13	83	146
Scotorepens greyii	1	2	3	6	1	3	1	6	23
Vespadelus baverstocki	5	19	6	4	2	6	11	52	105
Vespadelus caurinus / V. finlaysoni	2	6	7	4	2	3	4	7	35
Chaerephon jobensis	3	1	4	2		9	8	5	32
Mormopterus beccarii	1	6	2	5		5	12	13	44
Mormopterus species							1		1
Saccolaimus flaviventris	6	9	27	21	4	60	102	63	292
Taphozous georgianus							3		3
Taphozous troughtoni						1		1	2
Total calls positively identified	49	65	55	74	9	110	160	247	769
Calls NOT positively identified *									0
Chalinolobus gouldii / Scotorepens balstoni	13	23	1	5		85	31	42	200
C. gouldii / S. balstoni / Mormopterus species	14	8	10	4		14	35	5	90
Scotorepens balstoni / S. greyii	1						3	5	9
Scotorepens greyii / Vespadelus baverstocki	6	15	8	5	1	25	56	65	181
Scotorepens greyii / Chalinolobus nigrogriseus	6	5	2	2		4	55	23	97
Vespadelus baverstocki / Nyctophilus sp	3	15	1				4	4	27
Chaerephon jobensis / Saccolaimus flaviventris		1	7	4		22	28	7	69
Mormopterus beccarii / Saccolaimus flaviventris	1	4	1	3		8	67	85	169
Mormopterus beccarii / Taphozous troughtoni		2		1		7	3	1	14
Saccolaimus flaviventris / Taphozous georgianus			4			1		4	9
UNIDENTIFIED BAT CALLS		2	1			3	10	1	17
Total calls not positively identified	44	75	35	24	1	169	292	242	882
Total calls for site/night	**93**	**140**	**90**	**98**	**10**	**279**	**452**	**489**	**1,651**

***** A species listed in the bottom section of the table that is not also listed in the top section should be considered as possibly present. Likelihood of occurrence and call identification issues for these species are discussed in the 'Reliability of species ID' section on the following pages.

Notes:

No bat calls recorded on nights of 23rd, 28th and 31st March and no Anabat data beyond morning of 1st April.

Total number of sequence files recorded on this Anabat	3,455
Total number of sequence files that passed a generic bat-call filter	2,259
Total number of calls identified from filtered sequence files	1,651

Anabat echolocation data interpretation summary

Client: AARC (Julie Byrd; Townsville) **Balance Job no.:** AARC1104

Project name/location: Dugald River, NW of Cloncurry (March 2011)

Species nomenclature:

Species names used in this summary follow Churchill (2008), except for the free-tailed bats (Molossidae), which follow van Dyck & Strahan (2008) and Adams *et al.* (1988).

Call identification & reporting standard:

No bat call identification guide or key exists for the region from which these data were collected.

Call identification was based on published call descriptions (Milne 2001; Reinhold *et al* 2001; and Pennay *et al.* 2004); and on reference calls collected from various locations in Queensland, New South Wales & the Northern Territory.

Determination of species' identification was further refined by considering probability of occurrence based on distributional information presented in Churchill (2008) and van Dyck & Strahan (2008).

The format and content of this report complies with nationally accepted standards for the interpretation and reporting of Anabat data (Reardon 2003); latest version available from the Australasian Bat Society on-line at http://www.ausbats.org.au/.

Reliability of species ID

***Nyctophilus* species**

Nyctophilus bats generally produce distinctive calls, but the species cannot be reliably differentiated from call data. The species most likey to be present in the Dugald River area is *N. geoffroyi* . Three other species (*N. arnhemensis* , *N. daedelus* and *N. walkeri*) also occur in the far north-west of Queensland but are primarily restricted to moist habitats such as watercourses lined with pandanus and paperbark.

Vespadelus caurinus / V. finlaysoni

These species produce distinctive calls with hooked pulses at higher frequency (>50kHz) than any other species (with similar pulse shape) that would occur in the area. Most calls attributed to this species pair were in the range 54-56kHz, with a handful of sequences having slightly higher frequency (*ca.* 58kHz). The higher frequency is most likely to represent *V. caurinus* and the lower frequency *V. finlaysoni* ; however, the full range of both species is poorly known, so all calls were attributed to the pair rather than attempting an unreliable species split.

***Mormopterus* species**

Mormopterus calls generally sweep through a narrow frequency band, compared with vespertilionids in the same frequency range, and pulse shape is either flat or shallow-curved (rather than steep or sharply curved). A number of calls with typical *Mormopterus*- type pulses around 32-33kHz were recorded during this survey. These are likely to be from one of the un-named species in the *M. 'loriae'* complex, presumably *M.* 'species 5' (Adams *et al.* 1988).

***Chalinolobus gouldii / Scotorepens balstoni / Mormopterus* species**

C. gouldii (28-34kHz) has steep and curved pulses that usually alternate in frequency by 2-3kHz. *S. balstoni* (30-36kHz) pulses are also steep and curved but do not alternate in frequency. *Mormopterus* sp (30-34kHz) pulses are generally much flatter; however, pulses sometimes steepen when flying close to vegetation and brief calls may be confused with calls from the other two spp. Similarly, *C. gouldii* and *S. balstoni* pulses sometimes lack steep initial broad-band frequency sweeps when flying in open space and these calls can appear similar to those of *Mormopterus* .

A number of calls steep-pulsed calls at 30-34kHz were listed as either *C. gouldii* or *S. balstoni* because they were brief and/or weak and/or showed inconclusive evidence of frequency alternation and could not be reliably distinguished. Numerous calls with similarly low quality but obviously less steep pulses could have been from any of these three species.

Scotorepens balstoni / S. greyii

These species have very similar pulse shapes and overlap slightly with characteristic frequency (Fc) around 35kHz. Differentiation is based on the frequency at which the first abrupt change in slope ("knee") occurs in the pulse curve . If Fk<37kHz, then identity is attributable to *S. balstoni.* However, in a few calls with Fc around 35kHz, this feature was marginal, so identity was unclear.

Scotorepens greyii / Chalinolobus nigrogriseus

Signficant frequency overlap occurs in the range 36-39kHz, but pulse shape is sometimes diagnostic. Some *C. nigrogriseus* have flatter body of longer duration (2/3 of total pulse duration) compared with cup-shaped body of shorter duration in *S. greyii* . A high proportion of calls, however, exhibit pulses with intermediate features or a mixture of pulse types and cannot be reliably differentiated.

Anabat echolocation data interpretation summary

Client: AARC (Julie Byrd; Townsville) **Balance Job no.:** AARC1104

Project name/location: Dugald River, NW of Cloncurry (March 2011)

Reliability of species ID

Scotorepens greyii / Vespadelus baverstocki
S. greyii (35-40kHz) calls overlap in frequency with and have very similar pulse shapes to *V. baverstocki* (39-46kHz). A number of calls within the frequency overlap zone (39-40kHz) could have been from either of these species.

Vespadelus baverstocki / Nyctophilus sp
These species are generally easy to distinguish due to different search-phase pulse shapes (linear in *Nyctophilus cf.* curved in *V. baverstocki*). A few weak and brief calls in the relevant frequency range (44±3kHz), however, were not reliably identifed and could have been *V. baverstocki* attack-phase calls or *Nyctophilus* calls.

Cherephon jobensis / Saccolaimus flaviventris / Taphozous georgianus / T. troughtoni / Mormopterus beccarii
Frequency overlap occurs between these spp across a range of about 12kHz: *C. jobensis* (15-21kHz); *S. flaviventris* (17-22kHz); *T. georgianus* (21-23kHz); *T. roughtoni* (23-25kHz); *M. beccarii* (21-27kHz). Where good quality signals are recorded (i.e. long duration call sequence with numerous clearly defined pulses) species identity is usually discernible due to the shape and uniformity of pulses within the sequence. About 70% of the calls from this survey were of sufficient quality to be reliably attributed to one or other of these species. The remaining 30% of calls in this frequency range were too brief and/or weak and/or noisy to be reliably identified.

References:

Adams, M., Reardon, T., Baverstock, P.R. and Watts, C.H.S. (1988). Electrophoretic resolution of species boundaries in Australian Microchiroptera. IV. The Molossidae (Chiroptera). *Australian Journal of Biological Sciences* **41**, 315-326.

Churchill, S. (2008). *Australian Bats* . Jacana Books, Allen & Unwin; Sydney.

Milne, D.J. (2002). *Key to the Bat Calls of the Top End of the Northern Territory.* Technical Report No. 71, Parks and Wildlife Commission of the Northern Territory, Darwin.

Pennay, M., Law, B. and Reinhold, L. (2004). *Bat Calls of New South Wales.* Department of Environment and Conservation, Hurstville.

Reardon, T. (2003). Standards in bat detector based surveys. *Australasian Bat Society Newsletter* **20**, 41-43.

Reinhold, L., Law, B., Ford, G. and Pennay, M. (2001). *Key to the bat calls of south-east Queensland and north-east New South Wales.* Department of Natural Resources and Mines, Brisbane.

van Dyck, S. and Strahan, R. (ed.) (2008). *The Mammals of Australia* (Third Edition); New Holland; Sydney.

Anabat Data Analysis Summary

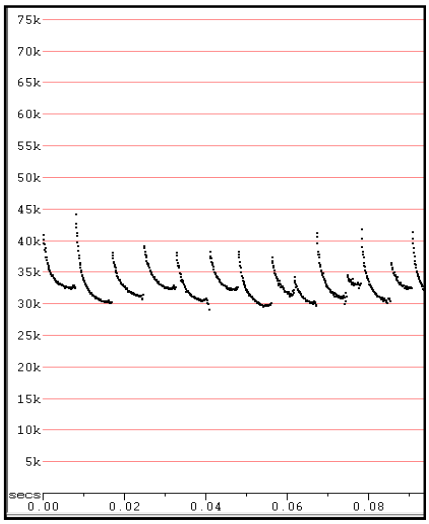
Client: AARC (Julie Byrd; Townsville) **Balance Job no.:** AARC1104

Project name/location: Dugald River, NW of Cloncurry (March 2011)

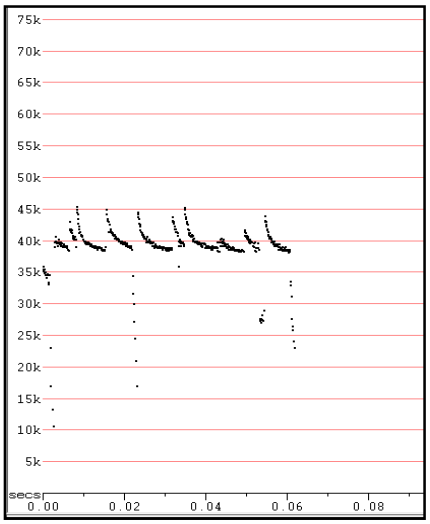
Sample calls extracted from the survey data.

Scale: 10 msec per tick; time between pulses removed (AnalookW F7 compressed mode)

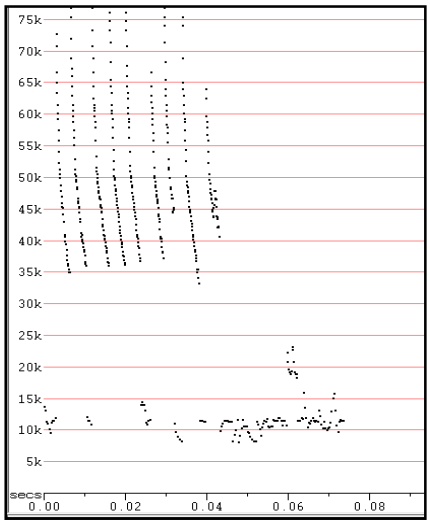
Species positively identified



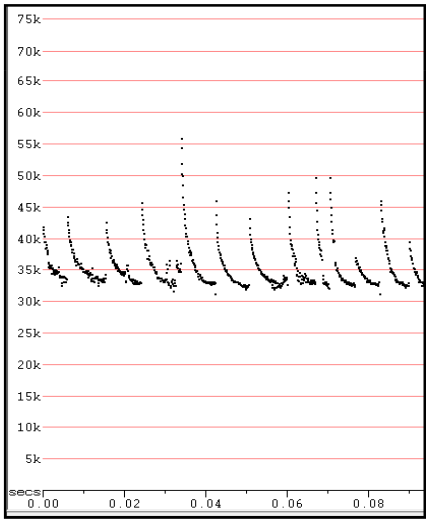
Chalinolobus gouldii



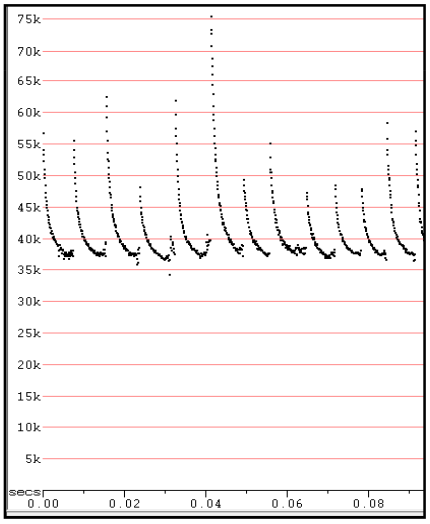
Chalinolobus nigrogriseus



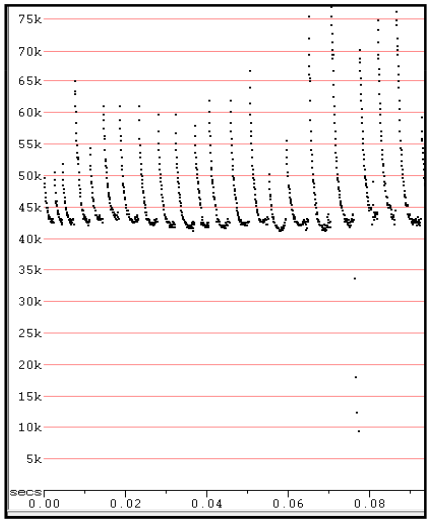
Nyctophilus species



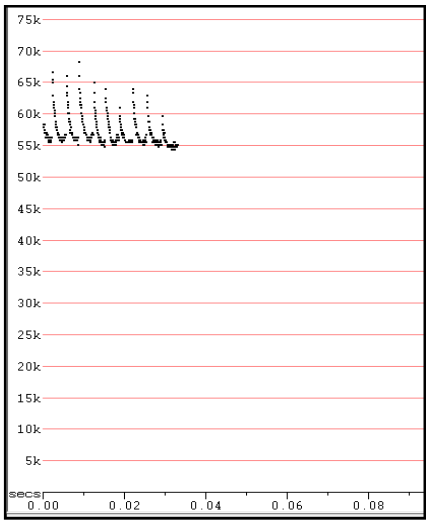
Scotorepens balstoni



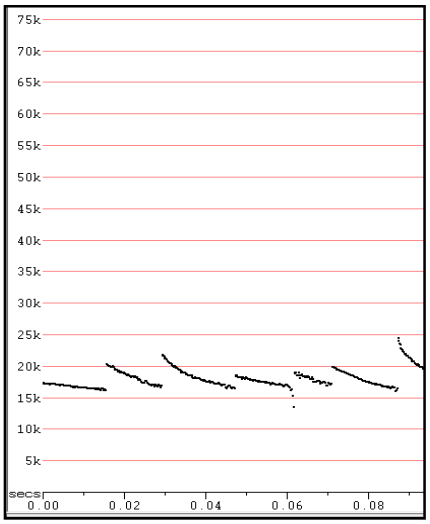
Scotorepens greyii



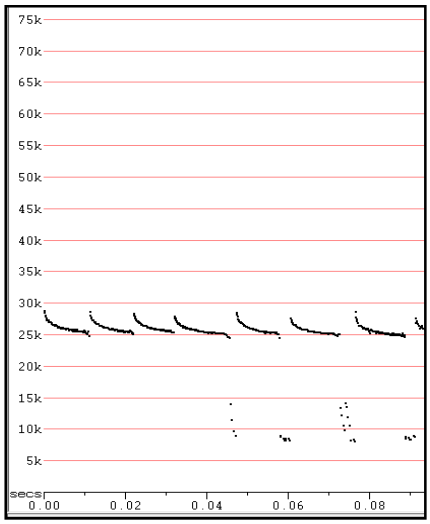
Vespadelus baverstocki



V. caurinus / V. finlaysoni



Chaerephon jobensis



Mormopterus beccarii

PO Box 1744, Toowoomba Qld 4350

Anabat Data Analysis Summary

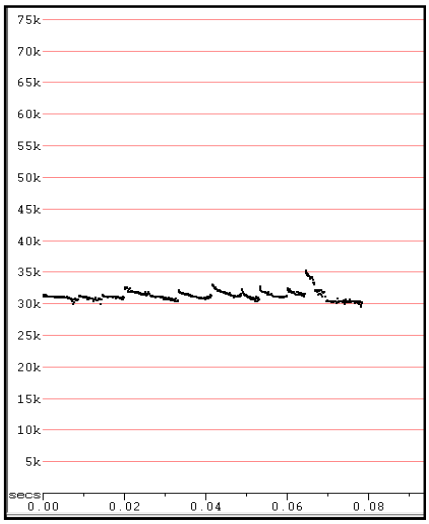
Client: AARC (Julie Byrd; Townsville) **Balance Job no.:** AARC1104

Project name/location: Dugald River, NW of Cloncurry (March 2011)

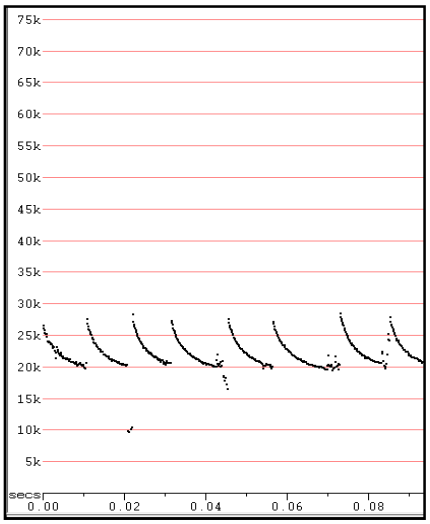
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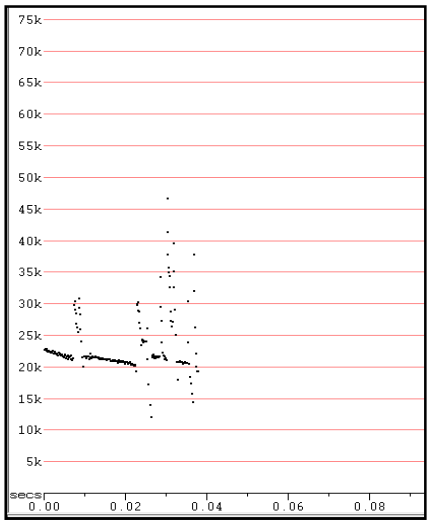
Species positively identified



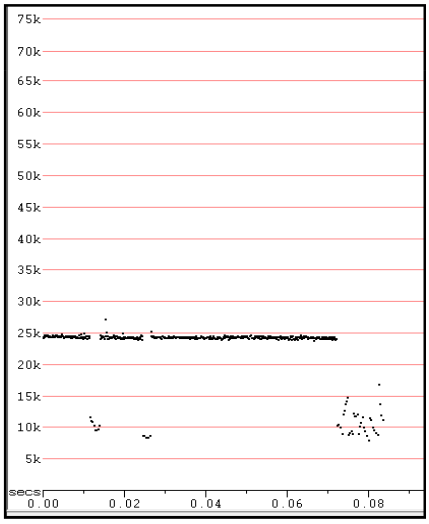
Mormopterus sp



Saccolaimus flaviventris



Taphozous georgianus



Taphozous troughtoni

Data received – quantity and quality

A single compressed data file was received via email (zinifex anabt.zip); said folder containing six folders of Anabat data recorded on the nights of 28th March to 2nd April 2008.

All folders contained a very low number of Anabat sequence files (maximum 16 files on 2nd April); and only two nights yielded bat echolocation calls (31/3 and 2/4).

Call identification standard

No keys or descriptions have been published for bat calls of north-west Queensland, and access to reliable locally recorded reference calls is limited. However, most of the species likely to be present are covered in keys and descriptions published for southern Queensland (Reinhold *et al.* 2001) and the Northern Territory (Milne 2002)

The extent of geographic variation in call characteristics is poorly known, but available evidence suggests that calls of most species do not vary significantly between regions. Therefore, it is deemed sufficient to refer to the above-named keys and reference calls collected from central- and south-western Queensland in determining the identity of calls recorded in the present survey.

Results

Bat calls were recorded only on 31st March (2 sequence files) and 2nd April (14 sequence files). All other files contained only environmental noise.

At least four species were recorded, with up to three other species also present but not reliably identified.

In the following species summary (Table 1), species presence is coded according to highest level of confidence achieved in call identification. Reliability of identification is coded as follows:

A	Definite	absolutely no doubt about identification of bat making call
B	Probable	most likely the species named but low probability of confusion with species with similar calls
C	Possible	call is comparable with the listed species, but moderate to high probability of confusion with species with similar calls

Table 1. Summary of species recorded for Zinifex survey,31st March and 2nd April 2008.

SPECIES	COMMON NAME	Recording date:	
		31/3	2/4
Saccolaimus flaviventris	Yellow-bellied Sheath-tailed Bat		B
Chaerephon jobensis	Northern Free-tailed Bat		A
Mormopterus loriae ridei	Eastern Little Free-tailed Bat		B
Chalinolobus gouldii	Gould's Wattled Bat	B	
Chalinolobus nigrogriseus	Hoary Wattled Bat	A	A
Nyctophilus species	unknown long-eared bat		C
Scotorepens greyii	Little Broad-nosed Bat		A

Species Notes

Saccolaimus flaviventris and *Chaerephon jobensis*

Calls overlap in frequency and often exhibit similar pulse shape; frequency overlaps also with *Taphozous georgianus* and *Mormopterus beccarii*. *S. flaviventris* differentiated from *C. jobensis* on consistent vs. erratic pulse frequency and shape; *T. georgianus* and *M. beccarii* are usually higher in frequency, and have subtle differences in pulse shape in frequency overlap zone.

C. jobensis was definitely present, with positive identification made for a number of calls; and several brief sequences with uniform frequency and pulse shape were very likely from *S. flaviventris*.

Mormopterus loriae ridei

A couple of calls on 2/4 were almost certainly from this species. These calls were definitely of *Mormopterus* type, and this species is likely to be the only one present in the survey area (Churchill 1998; van Dyck & Strahan 2008). No reference calls are available, although Milne's (2002) key shows the closely related *M. l. coburgiana* having similar calls to those observed in the Zinifex data.

Chalinolobus gouldii

Calls are readily recognised, typically exhibiting a steep curve with alternating frequency between successive pulses. Very likely responsible for one of the two calls recorded on 31/3, but very brief sequence and pulses not well-defined so cannot be certain of identity.

Chalinolobus nigrogriseus

This species calls overlap in frequency with those of *Scotorepens greyii* (see below), but pulse shape is diagnostic where long duration calls with good recording quality are available.

One of the calls from 31/3 was definitely attributable to *C. nigrogriseus*, along with a number of calls recorded on 2/4. Several poorer quality calls on 2/4 could not be reliably differentiated between *C. nigrogriseus* and *S. greyii*.

Nyctophilus species

Long-eared bats produce low intensity calls that are often poorly recorded. Pulse shape is distinctive and they are readily distinguished from other bats, but the species within *Nyctophilus* cannot be reliably differentiated from call data.

A single, very brief call on 2/4 may have emanated from a *Nyctophilus* species bat, although the brevity and poor quality of the call means it was not possible to discount the likelihood of *C. nigrogriseus* or *S. greyii* being responsible for the call.

Scotorepens greyii

This species' calls are often very similar to those of *C. nigrogriseus* (see above), although pulse shape is usually distinctive in better quality recordings.

A number of the calls recorded on 2/4 were definitely attributable to *S. greyii*.

References

Churchill, S. (1998). *Australian Bats*. New Holland, Sydney.

Milne, D.J. (2002). *Key to the Bat Calls of the Top End of the Northern Territory*. Technical Report No. 71, Parks and Wildlife Commission of the Northern Territory, Darwin.

Reinhold, L., Law, B., Ford, G. and Pennay, M. (2001). *Key to the bat calls of south-east Queensland and north-east New South Wales*. Department of Natural Resources and Mines, Brisbane.

van Dyck, S. and Strahan, R. (ed.) (2008). *The Mammals of Australia*. New Holland, Sydney.

Appendix E: DEEDI Pest Fact Sheets

Queensland Government

Department of **Primary Industries and Fisheries**

Dingo



Dingo (*Canis familiaris dingo*)



Dingoes can carry canid diseases and parasites

General information

The dingo (*Canis familiaris dingo*) is a primitive canid related to wolves and coyote. The dingo was not a part of the ancestral fauna of Australia. Though its origins are not clear, it is thought to have arrived in Australia 3500-4000 years ago.

It is the largest mammalian carnivore remaining in mainland Australia, and as such fills an important ecological niche. The dingo has been regarded as a serious domestic stock predator since early European settlement in Australia.

The dingo is a Class 2 declared animal under Queensland legislation. It is the responsibility of landholders to control dingoes on their land.

Scientific name	*Canis familiaris dingo*
Impacts	■ can carry diseases such as distemper and parvovirus as well as parasites ■ can harass and kill large numbers of sheep without feeding on the carcasses ■ could pose serious risk if rabies was introduced into Australia
Description	■ predominantly red, ginger and sandy-yellow, though dingoes can also be pure white, black and tan or solid black ■ adults reach up to 60 cm in height ■ heavily-boned skull and larger teeth than domestic dogs ■ females weigh about 12 kg and males 15 kg ■ naturally lean with large ears pricked and a white tip on their tails
Habitat and life cycle	■ found throughout Queensland ■ in far western area most dingoes are purebred

- close to settled areas there is a greater number of dingoes crossed with feral domestic dogs
- breed once a year (usually April to June)
- nine-week gestation
- usually 4-6 pups in a litter

Control

- different control methods including shooting, poisoning, trapping and fencing with land management practices is most effective
- can be controlled outside national parks and other protected areas
- see the wild dog control fact sheet for further information

Declaration details

- a declared Class 2 species under the *Land Protection (Pest and Stock Route Management) Act 2002*
- landholders are required to control declared pests on their land

Further information

- local government animal control/environmental staff
- Biosecurity Queensland, Ph: 13 25 23
- Dingoes in Queensland: distribution and ecology fact sheet (PDF, 158 kB)
- Queensland Pest Animal Strategy 2002-06 (PDF, 383 kB)
- Wild dogs
- Control methods
- Frequently asked questions
- Environmental Protection Agency

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Last reviewed 21 May 2008
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Queensland Government

Department of **Primary Industries and Fisheries**

House mouse



House mouse (*Mus domesticus)*



Dalby mouse plague, 1995

General information

Mice (*Mus domesticus)* are considered pests because of their diet, reproductive capacity and gnawing behaviour. When seasonal conditions are favourable, their numbers can increase to a level where they become a serious pest, causing damage to crops, stored products and equipment.

Although mice are not a declared animal under Queensland legislation, its control is recommended.

Scientific name

Mus domesticus

Impacts

- cause serious damage to crops during plagues
- can transmit Salmonella (which causes food poisoning) to human food stuffs

Description

- brown, grey or black short-haired pelt and may appear white, pale yellow or grey underneath
- notched upper incisors distinguish them from other species
- omnivorous and opportunistic feeders

Habitat and life cycle

- present in agricultural areas around long grass and crops
- may be found in and around sheds and homes
- field breeding occurs mostly in spring and early summer however, breeding may occur at any time
- females can produce a litter each month during the breeding season
- litters consist of up to six pups
- gestation lasts from 19-20 days
- first breeding commences from five weeks

Control

- a combined approach of different control methods including chemical, baiting, trapping, barrier fencing, habitat modification, ultrasonic devices, repellents, biological control integrated with land management practices is most effective

Declaration details

- not a declared animal under Queensland legislation but may be declared under local government law

Further information

- local government animal control/environmental staff
- Biosecurity Queensland, Ph: 13 25 23
- Mouse bait card (PDF, 97 kB)
- House mouse in Queensland pests status review (PDF, 155 kB)
- Zinc phosphide fact sheet (PDF, 54 kB)
- Mouse Strategy (PDF, 114 kB)
- Queensland Pest Animal Strategy 2002-06 (PDF, 383 kB)
- see the control methods page
- *Land Protection (Pest and Stock Route Management) Act 2002*

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Queensland Government

Department of **Primary Industries and Fisheries**

Feral pig



Feral pig (*Sus scrofa*)



Feral pigs can damage sugar cane, wheat, banana and strawberry crops

General information

The feral pig (*Sus scrofa*) is one of the most widespread and damaging pest animals in Queensland. Feral pigs in Australia are descendants of various subspecies of the domestic pig. Accidental and deliberate releases of domestic and semi-feral pigs have resulted in a large feral pig population.

The feral pig is a declared Class 2 pest under Queensland legislation. It is the responsibility of landholders to control feral pigs on their land.

Scientific name

Sus scrofa

Impacts

- can damage almost all crops from sowing to harvest
- feeds on seed, grain, fruit and vegetable crops
- lamb predation
- damages pastures by grazing and rooting
- can also spread weeds
- can carry many diseases and parasites

Description

- smaller, leaner and more muscular than domestic pigs with well-developed shoulders and necks and smaller, shorter hindquarters
- sparse, coarse hair
- longer, larger snouts and tusks, straighter tails, smaller mostly pricked ears and much narrower backs than domestic pigs
- mostly black, buff-coloured or spotted black and white
- juveniles may be striped
- old boars (razorbacks) have massive heads and shoulders and a raised, prominent backbone

Habitat and life cycle

- generally shy and nocturnal
- inhabit about 40% of Australia from subalpine grasslands to monsoonal floodplains
- found in all areas of Queensland
- greatest concentrations on the larger drainage basins and swamp areas of the coast and inland
- females and juveniles usually live in small family groups
- adult males are typically solitary
- in ideal conditions sows can produce two litters of 4-10 piglets a year
- weaning occurs after 2-3 months
- in good conditions feral pig populations may increase fivefold in 12 months

Control

- difficult to control in some situations
- different control methods including shooting, poisoning, trapping and fencing with land management practices is most effective
- see the control of feral pigs fact sheet for further information

Declaration details

- a declared Class 2 species under the *Land Protection (Pest and Stock Route Management) Act 2002*
- landholders are required to control its numbers on their land

Further information

- local government animal control/environmental staff
- Biosecurity Queensland, Ph: 13 25 23
- Feral pigs in Queensland fact sheet (PDF, 212 kB)
- Control of feral pigs fact sheet (PDF, 246 kB)
- Feral pig control in the wet tropics fact sheet (PDF, 221 kB)
- Sodium fluroacetate (1080) fact sheet (PDF, 148 kB)
- Feral Pig Management Strategy (PDF, 250 kB)
- Queensland Pest Animal Strategy 2002-06 (PDF, 383 kB)
- Feral pig pest status review (PDF, 152 kB)
- Control methods
- Frequently asked questions
- Model code of practice for welfare of animals: feral animal control
- Codes of practice and standard operating procedures for humane vertebrate pest control
- *Land Protection (Pest and Stock Route Management) Act 2002*

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Invasive plants and animals

Feral cat ecology and control

DECLARED CLASS 2



A descendant of the African wild cat (*Felis silvestris lybica*), the common 'house' cat (*Felis catus*) has now been domesticated for about 4 000 years. Although the domestic cat has a long history of association with man, it retains a strong hunting instinct and can easily revert to a wild (feral) state when abandoned or having strayed from a domestic situation.

Semi-feral cats live around dump sites, alleys or abandoned buildings, relying on humans by scavenging rubbish scraps and sheltering in abandoned structures. The true feral cat does not rely on humans at all, obtaining its food and shelter from the natural environment.

Declaration details

The feral cat is declared as a Class 2 species under the *Land Protection (Pest and Stock Route Management) Act 2002*. Declared species represent a threat to primary industries and natural resources, and have a social impact on other human activities.

Legislation describes a feral cat as one that is not fed and kept by someone. The word ‘kept’ specifically means that the cat is housed in a domestic situation.

Produced by: Land Protection (Invasive Plants and Animals)

Queensland the Smart State

Queensland Government
Department of Primary Industries and Fisheries

Description

The feral cat differs little in appearance from its domestic counterpart; however, when in good condition, the feral cat displays increased overall muscle development, which is especially noticeable around the head, neck and shoulders, thus giving the animal a more robust appearance. The average body weight of male feral cats is from 3 kg to 6 kg, while that of females varies from 2 kg to 4 kg. Body weights vary with condition, with some extremely large specimens having been documented.

Australian feral cats are predominantly short-haired, with coat colours that range between ginger, tabby, tortoiseshell, grey and black. White markings may be present on the feet, belly, chest and throat; completely white feral cats are extremely rare. In established populations coat colours are the result of a natural, genetically selective process. Terrain, predators and the ability to capture prey limit coat colours to those that provide the most suitable camouflage and cause a predominance of these colours in subsequent offspring. Ginger cats are more likely to be found in the semi-arid and desert areas, while grey and black specimens generally predominate in scrub and more heavily timbered habitats.

The feral cat is most active at night, with peak hunting activity occurring soon after sunset and in the early hours before sunrise. At night the cat displays a distinctive green eyeshine under spotlight, making it easily distinguishable from other animals. During the day it will rest in any number of den sites, which may include hollow logs, dense clumps of grass, piles of debris, rabbit burrows, and even the hollow limbs of standing trees.

The most obvious and characteristic field signs of feral cats are their scats (droppings). Unlike the domestic cat, the feral cat does not bury its scats, but leaves them exposed at prominent sites to warn other cats of its territorial boundary.

History of introduction and dispersal

There is some evidence to suggest that the cat was present in Australia long before European settlement. This may have occurred as a result of Dutch shipwrecks and regular visits to northern Australia by early South-East Asian vessels as long as 500 years ago.

Post-settlement dispersal resulted from cats straying from areas of early colonisation. In the late 19th and early 20th centuries, large numbers of cats were purposely released in many rural areas to combat plague numbers of rabbits.
Unwanted cats continue to be released into urban and rural areas by irresponsible pet owners.

The feral cat is now present Australia-wide, thriving under all climatic extremes and in vastly different types of terrain.

Population dynamics

Male cats attain sexual maturity at about 12 months of age, whereas females are capable of reproduction at approximately 7 months. Annually, and under ideal conditions, an adult female can produce up to three litters—each of usually four kittens, but varying from two to seven.

As the breeding instinct is triggered by the increasing length of daylight, litters are less frequent in winter. Most reproduction occurs during the spring and summer months, and is generally limited to two litters per year. Birth follows a gestation period of 65 days, and kittens may be reared in a single den site or may be frequently shifted to other sites within the female's home range. Family and litter bonding begin to break down when the kittens are approximately seven-months old. The female's ability to bear litters does not decrease with age, so reproduction continues for the course of her life.

Social organisation and behaviour

Feral cats maintain stable home ranges, the sizes of which depend upon the relative abundance of food and the availability of suitable den sites. Dominant male cats may have territories of up to 8 square kilometres, while the territories of females are smaller and may even be halved when kittens are being reared. Scent glands are present on the chin, at the corners of the mouth, and in the anal region. Territorial boundaries are maintained by scent marking with the cheek glands, pole-clawing, urinating and exposed faecal deposits.

Although feral cats are often thought of as being solitary animals, studies have revealed that such behaviour is generally limited to hunting activities. At other times feral cats display a degree of social interaction that peaks during the breeding season. Group behaviour has been observed in semi-feral populations, and it has been suggested that such behaviour is exhibited also in feral populations. Groups usually comprise several related adult females, their young of both sexes, and an adult male—whose range may include other groups of females. Young females usually remain in a group, while young males either leave or are driven from the group as they reach sexual maturity.

Effects on wildlife

The energy expended by an adult male cat requires it to consume 5% to 8% of its body weight in prey per day, while females raising kittens require 20%. Based on these figures, one study concluded that 375 feral cats on Macquarie Island would consume 56 000 rabbits and 58 000 sea-birds per year. Where present on the mainland, rabbits may comprise up to 40% of the diet of feral cats. Cats are successful as a control mechanism only when rabbit densities are low. At other times cat predation does little to halt the build-up or spread of rabbit

populations; rabbits merely help to support a larger number of cats. When seasonal shortages of rabbits occur there is a corresponding rise in the number of native animals taken by cats.

The feral cat is an opportunistic predator, and dietary studies have shown that small mammals, birds, reptiles, amphibians, insects and even fish can be taken as prey. Cat predation is particularly harmful in island situations, and a number of species have become extinct due to the introduction of cats by early sealers and lighthouse keepers. On the mainland, native animals—which already suffer due to the destruction of their habitats by man and other introduced animals—may be endangered further by cat predation. Actual competition for prey can cause a decline in the numbers of native predatory species such as quolls, eagles, hawks and reptiles.

Not only do native animals bear the brunt of predation, but they also suffer the effects of a parasite which reproduces only in the intestine of the cat. This disease (toxoplasmosis) is particularly harmful to marsupials, which may develop blindness, respiratory disorders, paralysis, and suffer the loss of offspring through abortion and stillbirths.

Exotic disease—rabies

Due to their widespread distribution, feral cats may prove to be a major vector for this fatal viral disease should it ever enter Australia. Overseas studies have revealed that wounds inflicted by rabid cats are more dangerous than those caused by rabid dogs. While the bites of rabid dog bites are generally inflicted on the arms and legs, the cat attacks the head of its victim, biting and clawing viciously. These head and facial bites reduce the time taken for the virus to enter the central nervous system, lessening the chance of success from subsequent remedial treatment.

Methods of control

Exclusion

Fencing is the only feasible method of control when special areas need protection from cats. Feral cats have been successfully prevented from climbing over netted fences by the use of an electrified wire mounted 15 cm from the top and 10 cm outward from the fence. Non-electrified fencing should incorporate a netted ceiling, or a curved overhang, which prevents the cat from climbing straight up and over the fence.

Shooting

Night shooting is assisted by the cat's distinctive, green eyeshine. Cats have been successfully attracted by the use of a fox whistle.

Poisoning

Registration of the vertebrate pesticide sodium fluoroacetate (1080) is currently being sought for the control of feral cats where conditions for its use are suitable.

Audible recorded lures for feral cats and other predators are available through a number of sources. These recordings mimic the distress call of a small animal and can be use to draw a predator to a bait or trap site.

Trapping

Rubber-jawed, leg-hold traps (see below) can be laid in the same manner as they are laid for dingoes and foxes. Leg-hold traps can work well with true feral cats, which would normally avoid the live-capture box traps. Ideal sites are those where territorial markers, such as faecal deposits and pole-clawing, are noticed. Tuna fish oil has shown some success as an attractant; however, feral cats seem more readily attracted to a site by some visual stimulus such as a bunch of bird feathers hung from a bush or stick.

Cats are easily trapped in wire 'treadle-type' box traps (see diagram). This method is most practical for semi-feral urban cats. Attractants/lures may be of meat or fish and should be placed so that they cannot be reached through the wire and be retrieved by clawing.



Rubber-jawed leg-hold trap



Treadle box trap

A number of local governments lend cat traps for the purpose of removing stray and feral cats in urban situations.

Further information

Further information is available from animal control/environmental staff at your local government or, if your council does not have animal control staff, from your local Department of Primary Industries and Fisheries land protection officer. Contact details are available through 13 25 23.

Fact sheets are available from DPI&F service centres and the DPI&F Information Centre phone (13 25 23). Check our web site <www.dpi.qld.gov.au> to ensure you have the latest version of this fact sheet. The control methods referred to in this Pest Fact should be used in accordance with the restrictions (federal and state legislation and local government laws) directly or indirectly related to each control method. These restrictions may prevent the utilisation of one or more of the methods referred to, depending on individual circumstances. While every care is taken to ensure the accuracy of this information, the Department of Primary Industries and Fisheries does not invite reliance upon it, nor accept responsibility for any loss or damage caused by actions based on it.
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Appendix F: Fauna Study Sites

Descriptions of each terrestrial study site are detailed below, together with Photo Plate 39 - Photo Plate 55.

Study Site 1 was located in a drainage area within a valley surrounded by steep slopes.



Photo Plate 39 The Pitfall-line at Study Site 1 (Wet Season)



Photo Plate 40 The Pitfall-line at Study Site 1 (Dry Season)

Study Site 2 was located in open woodland on flat plains at the base of the Knapdale Range.



Photo Plate 41 The Pitfall-line at Study Site 2 (Wet Season)



Photo Plate 42 The Pitfall-line at Study Site 2 (Dry Season)

Study Site 3 was located along a drainage area with an open woodland context.



Photo Plate 43 Study Site 3 (Wet Season)



Photo Plate 44 The Pitfall-line at Study Site 3 (Dry Season)

Study Site 4 was located along a drainage area associated with low lying hills at the foot of the Knapdale Ranges.



Photo Plate 45 The Pitfall-line at Study Site 4 (Wet Season)



Photo Plate 46 The Pitfall-line at Study Site 4 (Dry Season)

Study Site 5 was located in low open woodland with rocky outcrops and exposed faces.



Photo Plate 47 The Pitfall-line at Study Site 5 (Wet Season)



Photo Plate 48 The Pitfall-line at Study Site 5 (Dry Season)

Study Site 6 was located in an open woodland floodplain tending towards a drainage line.



Photo Plate 49 The Pitfall-line at Study Site 6 (Wet Season)



Photo Plate 50 The Pitfall-line at Study Site 6 (Dry Season)

Secondary Study Site 1 was located in open woodland associated with a drainage area.



Photo Plate 51 Secondary Study Site 1 (Wet Season)

Secondary Study Site 2 was located on a rocky outcrop. Evidence of a recent grass-fire was evident.



Photo Plate 52 Secondary Study Site 2 (Wet Season)

Secondary Study Site 3 was located along the unnamed creek downstream of the Tailings Storage Facility (TSF);

Secondary Study Site 4 was located along the unnamed creek downstream of the TSF, in between two large sections of the Knapdale Range;



Photo Plate 53 Secondary Study Site 4 (Wet Season)

Secondary Study Site 5 was located along Silvermine Creek, with scattered sections of rocky outcrops present on creek banks;



Photo Plate 54 Secondary Study Site 5 (Wet Season)

Secondary Study Site 6 was located along the downstream reaches of Silvermine Creek, with open sandy plains and riverine terracing adjacent to the watercourse;

Secondary Study Site 7 was located along the banks of North Creek, will hilly sections adjacent to the creek;



Photo Plate 55 Secondary Study Site 7 (Wet Season)

Secondary Study Site 8 was located along the banks of North Creek, with an open sand plain adjacent to the watercourse.

Appendix G: Flora Secondary and Quaternary Transect Pro-formas

AARC FLORA SURVEY PROFORMA
Secondary Transect

Project	
Date	
Recorder	
Site No.	
GPS Coordinates	
Site Photo No.	

Locality	
Site Context	
RE	
General Notes	

Altitude	**Erosion Pattern**	**Slope (º)**	**Aspect**

Soil Description	
Geology	
Additional Soil Notes	

Disturbance Severity (1 = minor 2 = moderate 3 = severe)	
Storm Damage	
Road Works	
Fire	
Clearing	
Grazing	
Weeds	
Other	

Height	**Emergent**	**T1**	**T2**	**T3**	**S1**	**S2**	**Ground**

(m)							

Stem Cover (Bitterlich Method)	

Species Stem Cover (50x10m) – count all woody stems	
Emergent	
T1	
T2	
T3	
S1	
S2	
S3	

Additional Notes (sketch if required)

Crown Cover Calc.	0m	5m	10m	15m	20m	25m	30m	35m	40m	45m

D = Dominant, CD = Co-Dominant, A = Associated, O = Occasional

Dominance (D, CD, A, O or ✓)							Species	Sample #	Photo #	Q1	Q2	Q3	Q4	Q5
E	T1	T2	T3	S1	S2	G								
							Bare							
							Litter							
							Rock							

Dominance (D, CD, A, O or ✓)							Species	Sample #	Photo #	Q1	Q2	Q3	Q4	Q5
E	T1	T2	T3	S1	S2	G								

AARC FLORA SURVEY PROFORMA
Quaternary Transect

Project	
Date	
Recorder	
Site No.	
GPS Coordinates	
Site Photo No.	
RE	
Notes	

Dominance (D, CD, O, A)	Species	Sample No.	Photo No.

Appendix H: Queensland Herbarium Identifications

Queensland Herbarium
Brisbane Botanic Gardens Mt Coot-tha • Toowong 4066 Queensland • Australia
Telephone +61 7 3896 9326 • Facsimile +61 7 3896 9624
e-mail Queensland.Herbarium@derm.qld.gov.au • www.derm.qld.gov.au

Enquiries Tony Bean/ Jian Wang
Telephone 07 3896 9318
Your reference
Our reference ARB:JW:mh 3/11

11 January 2011

Julie Byrd
AARC
PO Box 675
TOWNSVILLE Qld 4810

Dear Julie

The botanical specimens received by the Queensland Herbarium on 4 January 2011, have been identified as:

DV3 *Triumfetta rupestris*
DV9 *Stemodia lythrifolia*
DV2 *Stemodia viscosa*
DR2 *Stemodia viscosa*
DV8 *Vigna radiata* var. *sublobata*
DV1 *#Tephrosia rosea* var. *rosea*
DR8 *Vigna radiata* var. *sublobata*
DR8 *Acrostichum speciosum*
DR3 *Cleome viscosa*
DR7 *Pluchea rubelliflora*
DV13 *Trema tomentosa* var. *aspera*
DR6 *Flueggea virosa* subsp. *melanthesoides*
DR1 *Vitex benthamiana*
DV12 *Cyperus microcephalus*
DR5 *Cyperus dactylotes*
DR4 *Cyperus javanicus*
DV14 *Acacia hemignosta*

This specimen has been retained for incorporation into the Herbarium collection, with thanks.

There is a charge of $407.60 (4 hrs @ $101.90 per hr incl GST) for these identifications and a tax invoice will be sent separately.

Yours sincerely

G.P.Guymer
Director

Queensland Herbarium
Brisbane Botanic Gardens Mt Coot-tha • Toowong 4066 Queensland • Australia
Telephone +61 7 3896 9326 • Facsimile +61 7 3896 9624
e-mail Queensland.Herbarium@derm.qld.gov.au • www.derm.qld.gov.au/herbarium

Enquiries Tony Bean
Telephone 07 3896 9318
Your reference
Our reference ARB:mh 355/11

3 May 2011

Julie Byrd
AARC
PO Box 675
TOWNSVILLE Qld 4810

Dear Julie

The botanical specimens received by the Queensland Herbarium on 18 April 2011 have been identified as:

D 1 *Anisomeles malabarica*
D 2 *#Polygala wightiana*
D 3 *#Polygala rhinanthoides*
D 4 *Fimbristylis dichotoma*
D 5 *Cymbopogon bombycinus*
D 7 *Xenostegia tridentata*
D 8 *Spermacoce auriculata*
D 9 *Corchorus pumilio*
D 10 *Cajanus acutifolius*
D 11 *Cyperus conicus* var. *conicus*
D 12 *Cyperus cunninghamii* subsp. *cheradicus*
D 13 *Cyperus pulchellus*
D 14 *Cyanotis axillaris*
D 15 *Lipocarpha microcephala*
D 16 *Hibiscus* sp., insufficient material for species identification
D 16 *#Fimbristylis signata*
D 17 *Vigna radiata* var. *sublobata*
D 18 *Iphigenia indica*
D 19 *Cheilanthes brownii*
D 20 *Eucalyptus herbertiana*
D 21 *Schizachyrium fragile*
D 22 *Eremophila latrobei*
D 24 *Stackhousia intermedia*
D 25 *Euphorbia tannensis* subsp. *eremophila*
D 27 *Sida* sp., fruits required for species identification

D 28 *Chamaecrista symonii*
D 30 *Fimbristylis microcarya*
D 31 *Aristida contorta*
D 32 *Jacquemontia browniana*
D 33 *Glycine tomentella*
D 34 **Eragrostis minor*
D 35 *Cyperus vaginatus*
D 36 *Eragrostis* sp., inflorescence too immature to allow species identification
D 37 **Sida spinosa*
D 38 *Fimbristylis littoralis*

These specimens have been retained for incorporation into the Herbarium collection, with thanks.

* Naturalised, usually non-native species

There is a charge of $815.20 (8 hrs @ $101.90 per hr incl GST) for these identifications and a tax invoice and receipt are enclosed.

Yours sincerely

G.P.Guymer
Director

APPENDIX J: EcoSmart PMAV Report



PROPERTY MAP OF ASSESSABLE VEGETATION (PMAV)

Dugald River Project

PREPARED FOR MMG AUSTRALIA LTD
December 2021

Property Map of Assessable Vegetation (PMAV)

Dugald River Project

Prepared for MMG Australia Ltd

December 2021

ECOSMART ECOLOGY
48 Streeton Parade
Everton Park QLD 4053 Australia

Tel: +61 7 3162 1161

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Name of Project:	Dugald River Property Map of Assessable Vegetation (PMAV)
Project Number:	MMG_2104
Project Manager:	Mark Sanders
Document Author(s):	David Stanton
Name of Document:	Dugald River PMAV Report
File Name:	S:\Project Files\Active Projects\MMG\MMG_2104 (PMAV)\Report\DR_PMAV_Dec 21.docx
Last saved:	8/12/2021 12:58 PM
Document Version:	Version 1.0

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Name of Project:	Dugald River Property Map of Assessable Vegetation (PMAV)
Project Number:	MMG_2104
Project Manager:	Mark Sanders
Document Author(s):	David Stanton
Name of Document:	Dugald River PMAV Report
File Name:	S:\Project Files\Active Projects\MMG\MMG_2104 (PMAV)\Report\DR_PMAV_Dec 21.docx
Last saved:	8/12/2021 12:58 PM
Document Version:	Version 1.0

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1.0 INTRODUCTION AND PURPOSE

1.1 Introduction

This assessment provides revised mapping of vegetation across Lots 3692 PH2168, 36 B15753, 35 B15753, and 27 B15753 to support an application for a Property Map of Assessable Vegetation (PMAV) as per the Queensland Vegetation Management Act, 1999 (VM Act). Supporting information includes:

- Description of survey method
- Compilation of field survey data
- Interpretation of the field survey data and proposed updates to regulated vegetation on the property.

The location of the survey area relative to property boundaries is shown in Figure 1.1.

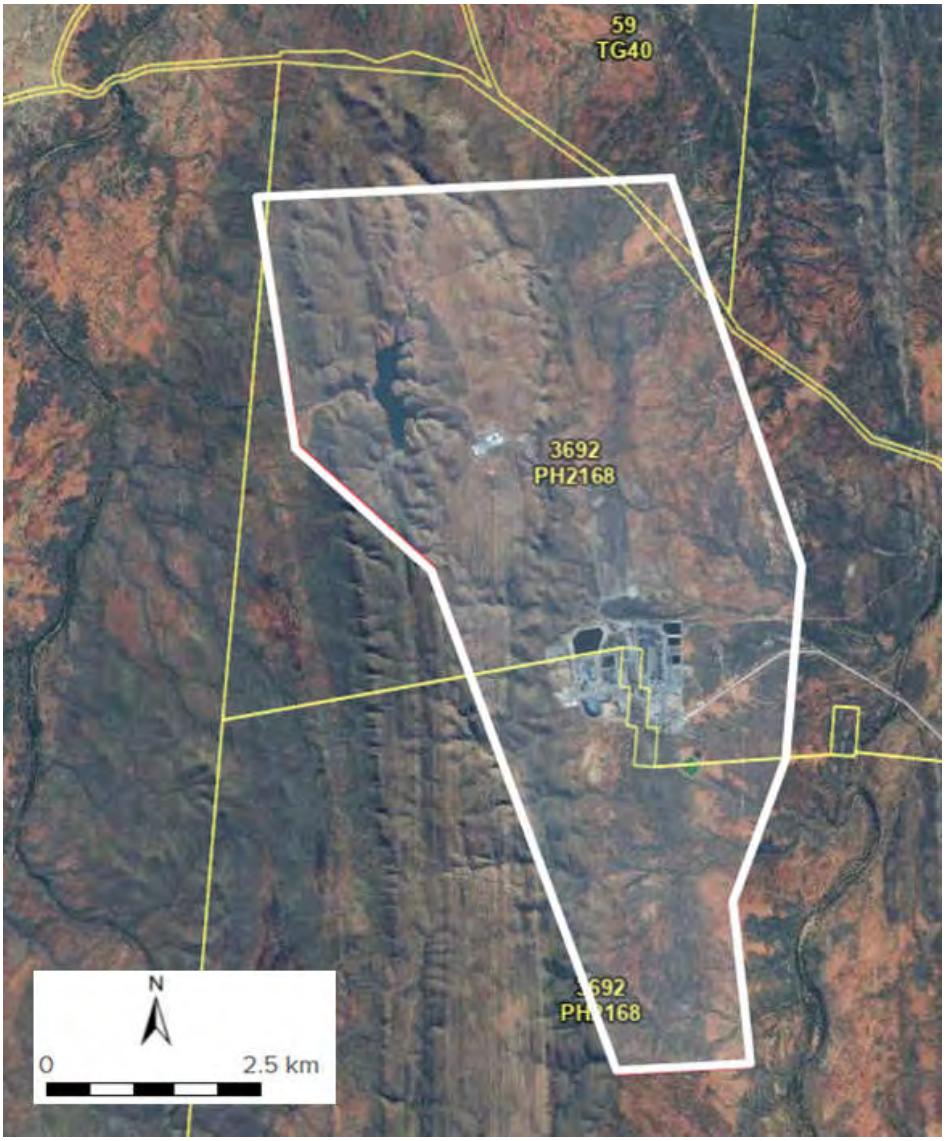


Figure 1.1. Property boundaries from Queensland Globe.

1.2 Purpose of Assessment

The assessment aims to provide a specific assessment of native vegetation in respect to its remnant status as defined under the VM Act (herein referred to as 'The Act') with the version current as at 29th March 2019. Remnant vegetation is defined under The Act as vegetation which is a regional ecosystem (RE) (endangered, of concern and least concern) where the predominant canopy of the vegetation:

- Covers more than 50% of the undisturbed predominant canopy,
- Averages more than 70% of the vegetation's undisturbed height; and is
- Composed of species characteristic of the vegetations undisturbed predominant canopy.

The assessment provides the necessary information to support an application for a PMAV providing specific information on the distribution of Category X (Non-remnant) and Category B (Remnant Vegetation).

Of primary importance in this assessment is the mapping of vegetation associated with watercourses, particularly the riparian vegetation community RE1.3.7, which occurs throughout the study area as narrow / restricted linear features. Outside these riparian habitats, regional ecosystem distribution as per certified regional ecosystem mapping (DNRM Version 11.0) is applied.

2.0 METHODS

The assessment applied a review of publicly available vegetation mapping databases and aerial photography which was supported by field survey and mapping at an appropriate scale.

Desktop Review

To provide context for the assessment, a review of current RE mapping (DNRM Version 11.0; 2021) for the property was undertaken to provide a basis for the assessment and provide a list of REs mapped as occurring in the assessment area.

Field Assessment

Field assessment was completed in August. Survey methods followed a modified version of floristic data collection protocols as described in Nelder et al (2020) targeted to describe vegetation associated with watercourses, allowing riparian regional ecosystems to be accurately described to support revised vegetation mapping. Quaternary vegetation sites were utilized during field assessment as these were sufficient to describe vegetation structure, composition, and floristics to fulfil the intent of this assessment. At each Quaternary site, the maximum height of vegetation in each structural layer was recorded coupled with a subjective assessment of canopy cover in each structural layer, along with notes on site disturbance and condition of groundcovers. Floristic composition, including species dominance, as also described. A summary of survey sites is provided in Attachment A. In total, 32 vegetation survey sites were completed across the assessment area with the location of survey sites is shown in Attachment B.

Mapping Process and Scale:

Based on results of field assessment, vegetation boundaries were marked in google earth imagery (Qld Globe 2017) and imported into ArcGIS for generation of polygons and editing. The aim was to capture polygon boundaries at >1:10 000 scale (+/- 10m accuracy). The following methods and protocols were applied throughout the mapping assessment:

- The minimum patch size for remnant vegetation is defined as 1 ha where the patch is discrete and isolated from broader areas of remnant vegetation.
- Narrow linear belts of RE1.3.7 were mapped to a minimum width of 10m except where they attenuated upstream and pinched out at their origin. Some narrow drainage features were not associated with specialist riparian vegetation and hence were not distinguished from the broader areas of remnant woodland.
- The mapping of non-remnant vegetation relied on recognition of areas of vegetation disturbance / clearance in available aerial imagery. Due to proximity to the Dugald River mining site and presence of numerous access tracks, non-remnant vegetation was relatively obvious in aerial imagery and readily delineated.
- Away from drainage features and associated belts of RE1.3.7, certified RE mapping (Version 11.0) was accepted as correct and representative of REs in the broader assessment area. Relative proportions of REs within heterogenous polygons were adjusted to account for the delineation or RE1.3.7b.

3.0 RESULTS

The resulting vegetation map is shown in Attachment B and delineates the riparian vegetation (RE1.3.7b). Outside these, the certified vegetation mapping has been adopted including the following heterogenous polygons:

- RE1.11.2a / 1.11.2x1 (70/30) – Least Concern Vegetation
- RE1.11.2a (100) – Least Concern Vegetation
- RE1.11.2e / 1.5.4x3 (70/30) – Least Concern Vegetation
- 1.11.3a (100) – Least Concern Vegetation
- 1.11.2a / 1.5.13 (70/30) – Least Concern Vegetation
- 1.11.3x1b (100) – Least Concern Vegetation

4.0 ACCOMPANYING DATA

This PMAV assessment is accompanied with the following attachments:

- Vegetation Mapping spatial files delineating proposed vegetation boundaries, REs and Vegetation Management Status.
- Spatial files of floristic assessment locations.

5.0 REFERENCES

Neldner, V.J., Wilson, B.A., Dillewaard, H.A., Ryan, T.S. and Butler, D.W. (2020) Methodology for Survey and Mapping of Regional Ecosystems and Vegetation Communities in Queensland. Version 5.1. Queensland Herbarium, Queensland Department of Science, Information Technology and Innovation, Brisbane. 124 pp.

Appendix A.
Vegetation Survey Data

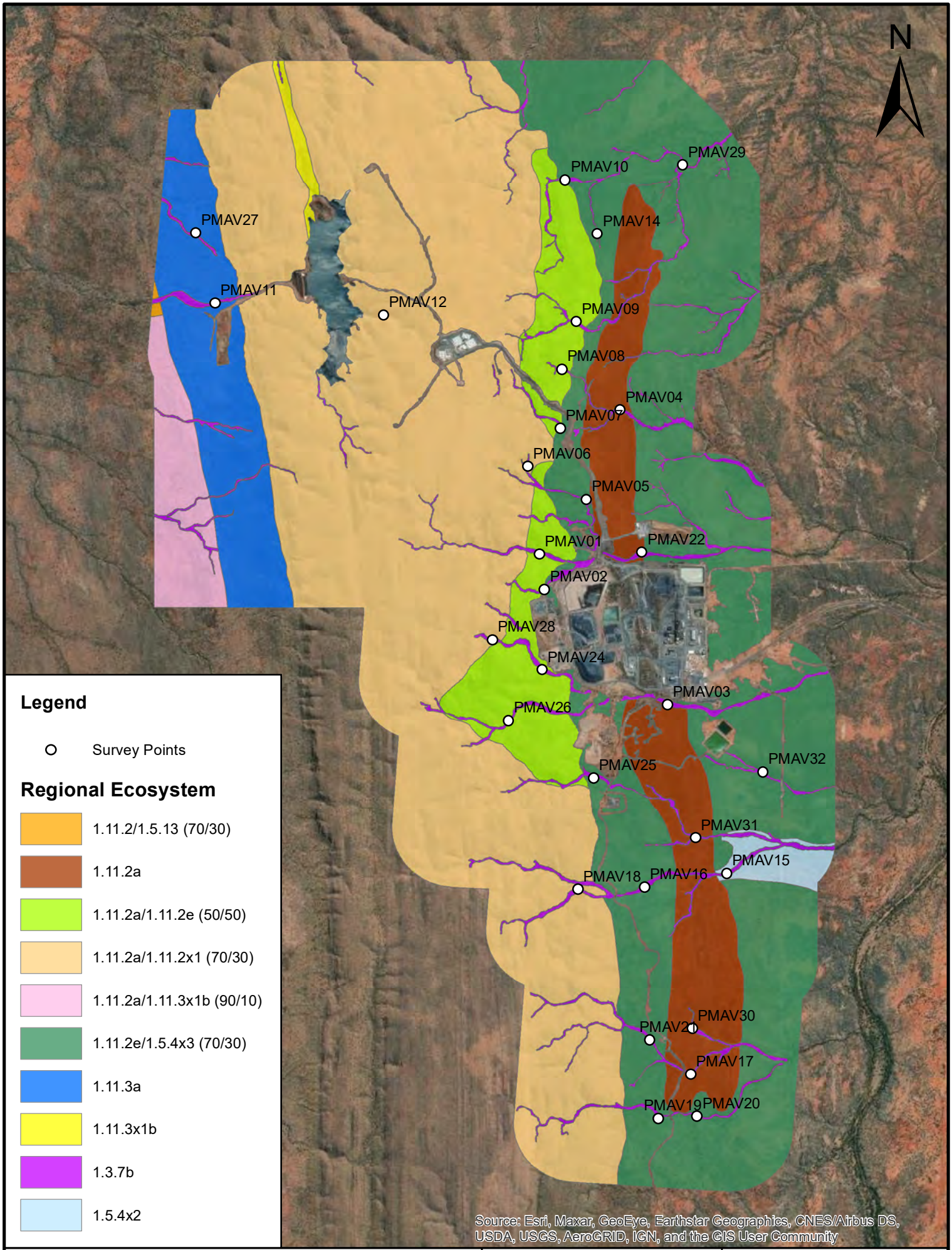
Appendix A. Vegetation Survey Data

Site	Lat_deg	Long_deg	canopy height (m)	Shrub height (m)	Canopy cover (%)	t1	t2	t3	s1	s2	ground
PMAV01	-20.2444412	140.1470789	5 - 10	2	40	*Lophostemon grandiflorus*	*Terminalia aridicola*		*Flueggea virosa*		*Eriachne sp., Triodia pungens, Poaceae No2.*
PMAV02	-20.247135	140.1474567	6 - 10	4	10	*Corymbia sp. aff. terminalis*	*Terminalia aridicola*		*Acacia monticola*	*Acacia lysiphloia, Acacia chisholmii, Acacia colei*	*Triodia pungens*
PMAV03	-20.2558731	140.1568016	5-10	2	45	*Lophostemon grandiflorus*	*Eucalyptus camaldulensis*	*Corymbia sp. aff. terminalis*	*Acacia holosericea*		*Cenchrus ciliaris*, Triodia pungens*
PMAV04	-20.2334834	140.1531889			25	*Lophostemon grandiflorus*	*Corymbia sp. aff. terminalis*	*Terminalia aridicola*	*Acacia chisholmii*	*Acacia holosericea*	*Cenchrus ciliaris*, Triodia pungens*
PMAV05	-20.2403021	140.1506436	6 - 14	3 - 4	45	*Lophostemon grandiflorus*	*Bauhinia cunninghamii*	*Terminalia aridicola, Corymbia aparrerinja*	*Flueggea virosa*	*Acacia holosericea*	*Triodia pungens, Cenchrus ciliaris**
PMAV06	-20.2377777	140.1462057	4 - 10	3	35	*Lophostemon grandiflorus*	*Terminalia aridicola*	*Eucalyptus leucophloia*	*Acacia monticola*		*Triodia pungens*
PMAV07	-20.2348891	140.1486531	5 - 10	2	30	*Terminalia aridicola*	*Eucalyptus leucophloia*	*Lophostemon grandifloras, Vachellia sutherlandi, Atalaya hemiglauca*	*Flueggea virosa*	*Sesbania sp.*	*Triodia pungens, native grass*
PMAV08	-20.2303990	140.1487924	12	4	15	*Terminalia aridicola*	*Eucalyptus leucophloia*	*Corymbia aparrerinja*	*Acacia monticola*	*Flueggea virosa, Acacia lysiphloia, Acacia holosericea*	*Triodia pungens, mixed grassy understorey*
PMAV09	-20.2267811	140.1498843	10	2	10	*Lophostemon grandiflorus*	*Terminalia aridicola*	*Eucalyptus leucophloia*	*Acacia holosericea*	*Acacia monticola, Sesbania sp.*	*Triodia pungens*

Site	Lat_deg	Long_deg	canopy height (m)	Shrub height (m)	Canopy cover (%)	t1	t2	t3	s1	s2	ground
PMAV10	-20.2160064	140.149043	12	2	15	*Lophostemon grandiflorus*	*Terminalia aridicola*	*Eucalyptus camaldulensis, Eucalyptus leucophloia*	*Flueggea virosa*		*Triodia pungens, Cenchrus ciliaris**
PMAV11	-20.2253811	140.1224663	18	3	40	*Lophostemon grandiflorus*	*Eucalyptus camaldulensis*	*Terminalia aridicola*	*Flueggea virosa*	*Carissa lanceolata*	*Cenchrus ciliaris*, Poaceae No2.*
PMAV12	-20.2262758	140.1352503	3 - 5	2	10	*Terminalia aridicola*	*Corymbia aspera*		*Sesbania sp.*		*mixed native grass and forbs, Triodia pungens*
PMAV14	-20.2201113	140.1514808	5	4	5	*Eucalyptus leucophylla*	*Corymbia sp. aff. terminalis*		*Acacia chisholmii*		*Triodia pungens*
PMAV15	-20.268698	140.1613093	5 - 10	0.5 - 2	35	*Lophostemon grandiflorus*	*Eucalyptus camaldulensis*	*Bauhinia cunninghamii*	*Acacia chisholmii*	*Vachellia farnesiana*	*Poaceae No1., Cenchrus ciliaris*, Poaceae No2.*
PMAV16	-20.2697255	140.1550511	8 - 14	N/A	45	*Lophostemon grandiflorus*	*Eucalyptus camaldulensis*		*Acacia hemsleyi*	*Tephrosia sp.*	*Cyperus sp., Poaceae No2., Themeda triandra, Grass4*
PMAV17	-20.2839736	140.1585649	6 - 10	1 - 2	30	*Lophostemon grandiflorus*	*Corymbia sp. aff. terminalis*	*Bauhinia cunninghamii*	*Acacia chisholmii*	*Carissa lanceolata*	*Poaceae No1., Cenchrus ciliaris**
PMAV18	-20.2698910	140.150002	4 - 10	1 - 3	35	*Lophostemon grandiflorus*	*"Grevillea sp."*	*Corymbia sp. aff. terminalis*	*Flueggea virosa*	*Acacia holosericea*	*Cymbopogon obtectus, Poaceae No2., Poaceae No1.*
PMAV19	-20.2873138	140.1560858	4 - 8	1 - 3	15	*Lophostemon grandiflorus*	*Terminalia aridicola*		*Acacia chisholmii*	*Acacia monticola*	*Cenchrus ciliaris**
PMAV20	-20.2871473	140.1590363	4 - 10	3 - 4	15	*Lophostemon grandiflorus*	*Bauhinia cunninghamii*	*Eucalyptus leucophloia*	*Acacia chisholmii*		*Poaceae No2., Triodia pungens, Cenchrus ciliaris**
PMAV21	-20.281338	140.155467	4 - 8	1 - 2	35	*Lophostemon grandiflorus*	*Eucalyptus leucophyllla*		*Acacia chisholmii*		*Cenchrus ciliaris**

Site	Lat_deg	Long_deg	canopy height (m)	Shrub height (m)	Canopy cover (%)	t1	t2	t3	s1	s2	ground
PMAV22	-20.2443072	140.1548631	6 - 12	N/A	50	*Lophostemon grandiflorus*	*Eucalyptus camaldulensis*	*Bauhinia cunninghamii*			*Cenchrus ciliaris**
PMAV24	-20.2532339	140.1472798	4 - 10	2 - 4	15	*Eucalyptus leucophloia*	*Terminalia aridicola*	*Lophostemon grandiflorus*	*Acacia monticola*		*Triodia pungens, Poaceae No2.*
PMAV25	-20.2614572	140.1511797	6 - 8	1 - 2	45	*Lophostemon grandiflorus*	*Terminalia aridicola*	*Eucalyptus leucophloia, Corymbia sp. aff. Terminalis, Eucalyptus leucophylla*	*Flueggea virosa*	*Acacia holosericea*	*Poaceae No2., Poaceae No1., Triodia pungens*
PMAV26	-20.2570797	140.1447311	4 - 7	1	30	*Lophostemon grandiflorus*	*Terminalia aridicola*		*Flueggea virosa*		*Eriachne sp., Poaceae No2., Triodia pungens*
PMAV27	-20.2200427	140.1209838	18	3	25	*Terminalia aridicola*	*Lophostemon grandiflorus*	*Eucalyptus camaldulensis*	*Flueggea virosa*		*Cenchrus ciliaris*, Poaceae No2.*
PMAV30	-20.2804680	140.158696	6 - 12	2 - 3	15	*Eucalyptus leucophloia*	*Eucalyptus leucophyllla*	*Lophostemon, Corymbia aparrerinja grandiflorus*	*Acacia chisholmii*		*small section of Lophostemon only ~20m*
PMAV28	-20.2509656	140.1435007	4 - 12	2 - 3	35	*Eucalyptus leucophloia*	*Terminalia aridicola*	*Lophostemon grandifloras, Corymbia sp. aff. terminalis*	*Acacia monticola*		*Poaceae No2., Triodia pungens*
PMAV29	-20.2148659	140.157941	6 - 8	2 - 3	20	*Lophostemon grandiflorus*	*Bauhinia cunninghamii*	*Eucalyptus leucophylla, Corymbia sp. aff. terminalis*	*Acacia chisholmii*		*Cenchrus ciliaris*, Triodia pungens*
PMAV31	-20.265995	140.158941	6 - 10	1	50	*Lophostemon grandiflorus*	*Eucalyptus leucophylla*	*Corymbia sp. aff. terminalis*	*Acacia chisholmii*		*Cyperus sp., Cenchrus ciliaris*, Poaceae No1.*
PMAV32	-20.260978	140.164062	5 - 7	2 - 3	15	*Eucalyptus leucophylla*			*Acacia chisholmii*		*Cenchrus ciliaris*, Triodia pungens, Themeda triandra*

Appendix B.
Proposed Vegetation Boundaries



Appendix B

Proposed Vegetation Boundaries

Scale: 1:40,013

0 0.225 0.45 0.9 1.35 1.8

Kilometers

Client: MMG Australia Ltd

Project: Dugald River PMAV

ecosmart ECOLOGY

APPENDIX L: Bird and Bat Management Program (WTS, 2024b)



Bird and Bat Management Plan

DUGALD RIVER WINDFARM

MMG DUGALD RIVER PTY LTD

May 2024

WULGURU TECHNICAL SERVICES

Contact Details	
Company	Wulguru Technical Services Pty Ltd
Project Manager	Glyn Thomas
Email	glyn@wulgurutechservices.com.au
Mail	PO Box 2553 IDALIA QLD 4810
ABN	79 644 301 655

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Document Control and History

Version	Date	Description	Prepared By	Reviewed By
V0.1	22/04/2024	Draft for internal review	Harry Bonnell	Dylan Case
V0.2	07/05/2024	Second Draft	Dylan Case	Glyn Thomas, Haley Harding
V0.3	13/05/2024	Third Draft	Dylan Case	Harry Bonnell
V0.4	15/05/2024	Draft for client review	Harry Bonnell	Gemma Green
V1.0	21/05/2024	Final draft	Harry Bonnell	Dylan Case

WTS acknowledge the work of EcoSmart Ecology for their ongoing commitment to ecological survey and monitoring at MMGs Dugald River Mine and for the preparation of a summary of survey effort since 2013 to support this report.

Citation

Wulguru Technical Services, 2024, *MMG - Dugald River Windfarm Bird and Bat Management Plan*, Prepared by Wulguru Technical Services Pty Ltd for MMG Dugald River Pty Ltd.

1. Introduction

The objective of the Bird and Bat Management Plan (BBMP) is to provide a plan for monitoring potential impacts of the windfarm on bird and bat species and to provide a strategy to manage and mitigate significant impacts.

The BBMP uses an adaptive management approach. Monitoring will indicate compliance or non-compliance under approval conditions and management strategies. It also informs where management strategies are effective and where they need to be reviewed and altered. The proposed conditions also align with the conditioning precedent in EA EPML00731213.

1.1. Background

MMG are seeking to develop a windfarm at the Dugald River Mine (DRM) on the Knapdale Range to provide a sustainable energy source for mine related activities.

The DRM is located approximately 70 km northwest of Cloncurry in western Queensland and situated adjacent to the Knapdale Range. Other infrastructure such as the mine camp are located on the range itself along with the valley fill tailings dam which is situated in the northern one-third of the range.

The rocky habitat of the Knapdale Range supports populations of Purple-necked Rock-wallaby (PNRW) (*Petrogale purpuriecolis*) which is considered a vulnerable species under the *Nature Conservation Act 1992* (NCA). Local populations are currently monitored under the MMG DRM PNRW Monitoring Program and reported annually to the Department of Environment, Science and Innovation (DESI) in accordance with the EA.

Nine locations across the Knapdale Range were selected for geotechnical investigations with the intended purpose of installation of wind turbines. Construction of turbine pads, access tracks, powerlines, and laydown areas requires 75 ha of land clearing within the lease footprint. There will be eight turbines. The Rotor-swept Area (RSA, i.e. referring to the height range within which the blades of operating wind turbines move (Brett Lane & Associates Pty Ltd, 2005) was considered at the largest dimensions possible to allow for design adjustments. The Goldwind GW 165-5.2/5.6/6.0MW (or equivalent) with a 130m hub height and 165m rotor blade diameter calculates to an RSA between 47.5m - 212.5m height above ground level, with blade rotation area of 21,382m^2. This assessment has been based on these criteria in consideration of the Precautionary Principle and in accordance with accepted methodology and conditioning style adopted through Planning guidance State Code 23: Wind farm development.

The project will consist of a clearing phase, a construction phase, an operation phase, and a decommissioning phase following mine closure.

2. Pre-construction Bird and Bat Information

2.1. Desktop analysis

A review of available information was undertaken to provide insight on the potential occurrence of bird and bat species surrounding and within the windfarm area.

A comprehensive desktop analysis was undertaken as part of the Ecological Assessment Report (WTS, 2023) to identify potential environmental values, constraints, and potential impacts within the Project area and to enhance understanding of the ecology of the area and its relationship to and connectivity with the surrounding landscape.

2.2. Survey Effort

Two rounds of Bird and Bat Utilisation surveys (BBUS) were undertaken by EcoSmart Ecology in May and September 2023 at eight survey sites, four of which are proposed turbine locations that will become impact sites upon commencement of construction and operation.

A subsequent BBUS was performed by Wulguru Technical Services (WTS) in April 2024. Four additional survey sites were included during this campaign to provide a more comprehensive coverage of the Project area, bringing the total to 12 survey sites.

Prior to commencement of construction and operation, impact and control sites are to be monitored twice yearly, once in the post-wet season and once in the pre-wet season.

2.3. Bird Survey

2.3.1. Bird Survey Methodology

Level one bird surveys are conducted as per the approved method outlined in *Wind Farms and Birds: Interim Standards For Risk Assessment* by Brett Lane & Associates (Brett Lane & Associates Pty Ltd, 2005). Level one surveys are considered to be a minimum requirement to assess the potential impacts of a wind farm on birds during the pre-construction phase.

BBUS were performed to collect quantitative data on bird use of the potential windfarm site. This can be used to estimate potential collision rates and provide a ranked abundance of species use of the site at varying heights. The BBUS involved a “Fixed-point Count” methodology where an observer is stationed at a fixed survey point for 20 minutes. During the 20 minutes, all bird species and number of birds observed were recorded. Observations of birds (and theoretically diurnally flying bats) during the survey periods were broken into BBUS and incidental observations. BBUS observations are those which include individuals observed to be flying above the predominant canopy. These observations do not include individuals that briefly fly out of the canopy layer at a low height. All other observation not conforming to BBUS records, including positively identified bird calls were recorded as incidental observations. The BBUS method provides the following information:

- Species
- Number of individuals
- Estimated distance from observer

- Estimated height above observer
- Bearing to record
- Direction of flight
- Behaviour
- Any additional notes on the observation

2.3.2. Bird Survey Results

Birds recorded during the BBUS surveys were characterised as either occurring within or outside of the RSA. These records are shown below in Table 1. An additional 76 species of bird have been historically recorded from the site. These are recorded as incidental observations and are shown in Appendix A. Bird species commonly entering RSA height can be broken into two main groups, raptors and aerial insectivores. Raptors include all species within the Accipitriformes and Falconiformes Orders, while aerial insectivores include woodswallows, martins and the rainbow bee-eater. One listed Marine species, the rainbow bee-eater was recorded during BBUS surveys. A single listed Migratory species, the glossy ibis, has historically been recorded from the Dugald River Project Area.

2.3.3. Bird Collision Likelihood Risk

Collision Risk Susceptibility of birds previously identified on site, as well as potentially occurring NCA or EPBC listed species was determined through the results of the surveys and the ecology of each species.

To determine collision risk susceptibility, a number of characteristics of bird behaviours were considered including:

- Foraging, dispersal and territorial behaviours;
- Flight manoeuvrability;
- General flight patterns;
- Size of birds; and
- Distribution, and biology.

A review of approvals issued by the State and Federal Governments informed the development of a Collision Risk Assessment. A BBMP from Base Consulting (2022) formed the basis of the assessment. Of the key collision risk characteristics, flight height pattern was given the larger weighting over distribution and biology. Flight manoeuvrability was given the lowest weighting. Table 2 below outlines the criteria evaluated for each species or group of birds assessed.

For the purposes of this report, flight height is presented as below, at or above RSA height:

A = Below RSA (< 47.5 metres above ground)

B = At RSA (40 – 212.5 metres above ground)

C = Above RSA (> 212.5 metres above ground).

Table 1. Collision Risk Assessment Table

Risk Characteristics	Criteria	Score
Flight height Expected frequency a species enters the RSA.	Never – Species not expected to enter RSA	0 – Negligible
	Occasional – Species is typically present outside of RSA but may enter infrequently.	5 – Low
	Regular – Species enters RSA, but majority of records are outside RSA.	10 – Medium
	Predominant – Species within RSA most of the time while in flight.	15 – High
Movements and biology Annual presence of a species within the Project Area.	Rare – Present once or twice per year	0 – Negligible
	Intermittent – Present <1 month of the year	2 – Low
	Seasonal/migration – Present for 1-5 months of the year	5 – Medium
	Resident – Present throughout most of the year (>5 months)	10 – High
Manoeuvrability Size and relative manoeuvrability of the bird species	Small size, highly manoeuvrable	0 – Negligible
	Small size, constrained manoeuvrability or medium size, highly manoeuvrable	2 – Low
	Medium size, constrained manoeuvrability or large size, highly manoeuvrable	4 – Medium
	Large size, constrained manoeuvrability	6 – High

Scores for each of the criteria in the above table were combined to produce an overall value for the Collision Risk Susceptibility in Table 3. Species expected to never fly in the RSA are all considered to have a low Collision Risk Susceptibility regardless of other criteria.

Threatened birds including migratory species identified from the desktop EPBC, PMST, and WildNet searches with the potential to occur within the Project Area were also considered during the risk assessment process.

Table 2. Collision Risk Susceptibility

Collision Risk Scoring	Overall Collision Risk Susceptibility
Risk score 0-10	Low
Risk score 11-20	Moderate
Risk score 21+	High

2.3.4. Bird Collision Consequence Criteria

Using the collision risk susceptibility assessment and the relative abundance of species within the Project area, potential collision consequences were able to be estimated. An evaluation of the potential collision consequences for birds is outlined in Table 4.

Table 3. Collision Consequence

Collision Consequence	Collision Consequence Criteria
No loss of individuals	• Not previously identified on site or, • Low abundance with low collision risk susceptibility
Rare loss of individuals	• Low abundance with moderate collision risk susceptibility or, • Moderate abundance with low collision risk susceptibility
Occasional loss of individuals	• Low abundance with high collision risk susceptibility or, • Moderate abundance with moderate collision risk susceptibility or, • High abundance with low collision risk susceptibility
Repeated loss of individuals	• Moderate abundance with high collision risk susceptibility or, • High abundance with moderate collision risk susceptibility
Significant loss of individuals	• High abundant with high collision risk susceptibility

2.3.5. Bird Collision Risk Assessment

2.3.5.1. General Order Risk Assessment

General risk assessments have been made at the Order or Family (for some passerine birds) level for all species found on site, this assessment can be found in Appendix B. The most at risk Orders of birds known to occur within the project area are the Accipitriformes, the Coraciiformes (in part), the Falconiformes, and the Families *Artamidae* and *Hirundinidae* of the Passeriformes Order. Many of these species of birds have been recorded within the proposed RSA of the Project area.

2.3.5.2. Listed Species Risk Assessment

NCA/EPBC listed species deemed as having a 'possible' likelihood of occurrence in WTS's Ecological Assessment Report have been assessed at a species level in Appendix C (Wulguru Technical Services, 2023). Only two species of bird listed under the NC or EPBC Acts are considered to have the potential for losses of individuals as a consequence or turbine interaction. The glossy ibis (EPBC: Marine, Migratory) is considered to have the potential for rare loss of individuals, while the rainbow bee-eater (EPBC: Marine) is considered to have the potential for repeated loss of individuals as identified in previous tables.

Species recorded within the RSA have been assessed at a species level; data from the onsite BBUS was used to inform the assessment. Birds recorded within the RSA are assessed separately in Table 5 below.

2.3.5.3. RSA species

Analysis of the collision consequences for bird species within the RSA did not identify any species as having the potential for significant loss of individuals via turbine interaction. However, based on these assessments, four species were considered to have the potential for repeated loss of individuals. These are as follows:

- Black-faced woodswallow (*Artamus cinereus*)
- Little woodswallow (*Artamus minor*)
- Masked woodswallow (*Artamus personatus*)
- Rainbow bee-eater (*Merops ornatus*)

All other species recorded within the RSA are considered to have the potential for rare or occasional loss of individuals via turbine interaction.

Table 4. Collision Risk for Species Recorded Within Rotor Swept Area

Species	Description and behaviour	Total Records	Records within RSA	% within RSA	Collision Risk Susceptibility	Collision Consequence
Raptors						
Black kite (*Milvus migrans*)	A dark-coloured kite with a distinct fish-tailed appearance from below. The black kite is common across much of the country, often appearing in high abundance in response to favourable foraging conditions, such as bushfires, locust, and mouse plagues (Pizzey & Knight, 2012). The black kite is abundant around the mine and camp area, a typical trait of this species. It is likely this species will occur along the Knapdales in higher abundance when conditions are suitable. Recorded soaring within the RSA.	2	2	100	High	Occasional loss of individuals
Black-shouldered kite (*Elanus axillaris*)	A small, predominantly white kite with black shoulders. The black-shouldered kite is present across most of mainland Australia and may be irruptive in areas in response to prey availability (Pizzey & Knight, 2012). Observed foraging within the RSA	2	1	50	High	Occasional loss of individuals
Brown falcon (*Falco berigora*)	The brown falcon is a large species of falcon with distinct dark double teardrop markings descending from either side of the eye. This species is fairly common across most of Australia, often irruptive in response to high prey abundance (Pizzey & Knight, 2012). This species is known to fly within the RSA.	5	3	60	High	Occasional loss of individuals
Nankeen kestrel (*Falco cenchroides*)	A small falcon, light brown to rufous from above with distinct black wing tips. The nankeen kestrel is often seen hovering above grasslands searching for prey to dive on (Pizzey & Knight, 2012). It has been observed foraging within the RSA	3	1	33.3	High	Occasional loss of individuals
Wedge-tailed eagle (*Aquila audax*)	Australia's largest bird of prey with an unmistakeable diamond-shaped tail from below. The wedge-tailed eagle is typically varying shades of brown, with older individuals darker than the light brown immatures. Often scavenges on carrion but also a very proficient predator, capable of taking large prey items including macropods (Pizzey & Knight, 2012). Typically seen flying within the RSA, often soaring on thermal air currents of the Knapdale Range.	6	5	83.3	High	Occasional loss of individuals
Whistling kite (*Haliastur sphenurus*)	A medium-sized raptor typically sandy-brown in colouration. The whistling kite has a rounded tail from below, with a distinct pale band on each underwing. A regular species across most of Australia, the whistling kite feeds on carrion as well as captured prey (Pizzey & Knight, 2012). Typically flies within the RSA, observed soaring on thermal currents over the Knapdales.	4	4	100	High	Occasional loss of individuals
Aerial Insectivores						
Black-faced woodswallow (*Artamus cinereus*)	A common and widespread species, the black-faced woodswallow is regularly seen swooping from powerlines and other vantage points (Pizzey & Knight, 2012). It is abundant around the main mine area, as well as on the Knapdale Range. This species forages at or below RSA height.	35	29	82.9	High	Repeated loss of individuals

Species	Description and behaviour	Total Records	Records within RSA	% within RSA	Collision Risk Susceptibility	Collision Consequence
Little woodswallow (*Artamus minor*)	The smallest species of woodswallow. It is chocolate-brown in colour within a blueish bill (Pizzey & Knight, 2012). It is the most abundant aerial insectivore within the Project area for most of much of the year, though may be outnumbered by the masked woodswallow on seasonal migration. Forages at or below RSA height.	133	63	47.4	Moderate	Repeated loss of individuals
Masked woodswallow (*Artamus personatus*)	A distinct woodswallow with a large black mask extending from above the eye to the top of the breast. Considered a part-migratory species, the masked woodswallow typically arrives in northern Australia from its breeding habitat in the south in Autumn (Pizzey & Knight, 2012). These dispersive events often see the species travelling in expansive flocks which may be at a high risk of collision with turbines. Travels and forages at RSA height.	200	200	100	Moderate	Repeated loss of individuals
Rainbow bee-eater (*Merops ornatus*)	An unmistakable, vibrantly coloured bird with a finely curved bill. The rainbow bee-eater is a proficient predator of bees, wasps, flies, and similar insects which it catches on the wing (Pizzey & Knight, 2012). Large groups may forage at RSA height in periods of high insect activity.	11	9	81.8	High	Repeated loss of individuals
Fairy martin (*Petrochelidon ariel*)	A small martin with a distinct ginger cap. The fairy martin undertakes a regular migration to the north from its breeding habitat in southeastern Australia, typically arriving in the north from March to April before leaving in September to October (Pizzey & Knight, 2012). Recorded foraging at RSA height.	31	12	38.7	Moderate	Occasional loss of individuals
Other Birds						
Australasian Darter (*Anhinga novaehollandiae*)	A unique cormorant-like bird with a distinct long, pointed bill and long neck. The Australasian darter is an proficient semi-aquatic predator of fish and invertebrates (Pizzey & Knight, 2012). This species is probably a regular inhabitant of watercourses in the vicinity of the Project area. Flies at RSA height but likely limited to rare passes from dispersing individuals.	2	2	100	Moderate	Rare loss of individuals
Varied Lorikeet (*Psitteuteles versicolor*)	A small, predominantly green lorikeet with a pinkish cap and upper breast. The varied lorikeet is nomadic in response to the flowering patterns of *Eucalyptus* and *Melaleuca* species (Pizzey & Knight, 2012). It is very abundant across the project area but rarely enters the RSA. Most individuals or flocks fly quickly at around or just above canopy height.	52	1	1.9	Low	Occasional loss of individuals
White-faced Heron (*Egretta novaehollandiae*)	A medium-sized, mostly grey heron with a white face and yellow legs. It is likely a regular inhabitant of watercourses within the greater Project area. Flies at RSA height but likely limited to rare passes from dispersing individuals.	1	1	100	Moderate	Rare loss of individuals
White-necked Heron (*Ardea pacifica*)	A moderately large heron with a predominantly white head and neck and a slatey grey body. This species is probably a regular inhabitant of watercourses in the vicinity of the Project area. Flies at RSA height but likely limited to rare passes from dispersing individuals.	2	2	100	Moderate	Rare loss of individuals

Only two species of bird listed under the NC or EPBC Acts are considered to have the potential for losses of individuals as a consequence or turbine interaction. The glossy ibis (EPBC: Marine, Migratory; NCA: SL) is considered to have the potential for rare loss of individuals, while the rainbow bee-eater (EPBC: Marine) is considered to have the potential for repeated loss of individuals as identified in previous tables.

2.4. Bat Survey

2.4.1. Bat Survey Methodology

Bats are monitored at each BBUS site using Anabat Chorus passive high-frequency sound recorders to capture microbats calls. One Anabat Chorus bat detector was installed at each of the 12 survey sites for two nights. These passive detectors were set to record in full spectrum .wav files from one hour before sunset to one hour after sunrise. Bat call analysis to identify microbat species present was undertaken by Greg Ford of Balance Environmental for EcoSmart Ecology's two initial rounds of surveying. Bat call analysis undertaken in 2024 was undertaken by Professor Simon Robson for WTS. Additionally, the BBUS methodology can be used to record bat species should they be identified during surveys.

2.4.2. Bat Survey Results

The following bat species have been recorded during BBUS surveys of the Project Area, either by EcoSmart Ecology or WTS (Table 6). As bat presence is measured entirely by call monitoring, relative abundance of bats species is not able to be accurately estimated. Many factors influence the detectability of bat calls, including flight height, distance from recorder, weather and other variables. Additionally, repeated recordings of singular or small numbers of individuals flying close to the bat detector can significantly skew abundance data. As such, for this report we consider bat call records as a confirmation of presence only and not a determinant of relative bat abundance.

2.4.3. Bat Collision Risk Assessment

Collision Risk Susceptibility of bat species previously identified on site through call detection was determined through the review of available literature, with particular reference to flight heights. The collision risks for bats are explained in Table 7, and an evaluation of bat flight heights and their relative collision risks is outlined in Table 8. As with the bird collision risk table, these are derived from a report from Base Consulting (2022).

Table 5: Collision Risk Susceptibility for Bats Recorded on Site During BBUS Surveys

Risk Characteristic	Criteria	Collision Risk
Flight height Expected frequency a species enters the RSA.	Never – Species not expected to fly at RSA height	Low
	Occasional – Species may fly at RSA height during some scenarios	Moderate
	Frequent – Species regularly flies at RSA heigh	High

Table 6: Collision Risk for Bat Species Identified During BBUS Surveys

Species	RSA utilisation	General Description	Flight speed and Manoeuvrability (slow, medium, highly agile)	General flight height	Collision Risk Susceptibility	Collision Consequence
Finlayson's Cave Bat (*Vespadelus finlaysoni*)	Not expected	This species forms colonies that occupy caves or cavities within rocky terrain and will take residence in abandoned mining operations. This species forages for prey near water (Menkhorst & Knight, 2011).	Rapid flight with high mobility suited to foraging over water	<15m	Low	No loss of individuals
Gould's Wattled Bat (*Chalinolobus gouldii*)	Foraging	*C. gouldii* is insectivorous; in much of its range, moths are the most common food item. Other known prey includes cockroaches, flies, stoneflies, orthopterans, hemipterans, hymenopterans and other lepidopterans, including caterpillars. Grass seeds and twig fragments are occasionally ingested as well (Chruszcz & Barclay, 2002). In wooded areas, they are mostly arboreal, though they have also been found in the stumps and hollow limbs of trees or in bird nests.	Rapid flight with limited manoeuvrability	May fly to RSA height	Moderate	Occasional loss of individuals
Hoary Wattled Bat (*Chalinolobus nigrogriseus*)	Not expected	These bats prefer to roost in the hollows of eucalypt trees, and occasionally rock crevices. They like to fly fast below the canopy layer and therefore live in areas where the undergrowth is naturally sparse. They can commonly be found in a range of habitats, including Forests, woodlands, vine thickets, coastal scrub and open grasslands, across the coastal hinterland regions of Queensland (Churchill, Australian bats, 2008) (Hall, 2009).	Rapid flight with high mobility suited to foraging below the canopy	<15m	Low	No loss of individuals
Inland Broad-nosed Bat (*Scotorepens balstoni*)	Not expected	Foraging is achieved using echolocation whilst in continuous flight, keeping within 15 metres of the ground, with rapid diversions to pursue prey. Foraging mainly occurs between trees, not going above the tree canopy, as well as at	Rapid flight with high mobility suited to foraging below the canopy	<25m	Low	No loss of individuals

Species	RSA utilisation	General Description	Flight speed and Manoeuvrability (slow, medium, highly agile)	General flight height	Collision Risk Susceptibility	Collision Consequence
		the edges of forests venturing into open areas. Foraging locations in the drier distribution areas appear to depend on nearness to water points and roosting sites (Churchill, Australian bats, 2008).				
Inland Forest Bat (*Vespadelus baverstocki*)	Not expected	The flight of the species is fluttery and rapid, sharply turning as it forages over water.	Rapid flight with high mobility suited to foraging over water	<15m	Low	No loss of individuals
Little Broad-nosed Bat (*Scotorepens greyii*)	Foraging	The Little broad-nosed bat is an insectivore which feed and drink while in flight. They forage for prey close to treetops, over water, open grassland and other open habitat. They are characteristically fast fliers which make abrupt darts and turns to catch prey (Churchill, 2009) (Van Dyck & Strahan, 2008) (Menkhorst & Knight, 2011).	Rapid flight with high mobility suited to foraging over water and canopy	May fly to RSA height	Moderate	Occasional loss of individuals
Northern Freetail Bat (*Chaerophon jobensis*)	Foraging	They will fly and forage in groups of two or more individuals. Its foraging style utilizes fast, direct flight suited for open areas or above canopies. It is insectivorous, consuming beetles, bugs, moths, lacewings, grasshoppers, cockroaches, flies and leafhoppers (Kutt, Milne, & Richards, 2008).	Rapid flight with limited manoeuvrability	May fly to RSA height	Moderate	Occasional loss of individuals
Northern Free-tailed Bat (*Ozimops lumsdenae*)	Not expected	*O. lumsdenae* is associated with permanent water, agricultural dams, and watercourses in semi-arid regions, where it resides and forages in eucalypt woodland (Reardon & Armstrong, 2020). Roosts in tree hollows.	Rapid flight with high mobility suited to foraging below the canopy	<15m	Low	No loss of individuals
White-striped Freetail Bat (*Austronomus australis*)	Foraging	This free-tailed bat is a specialized high altitude, fast flying interceptor insectivore. Their diet consists principally of moths, beetles and bugs. This species can be	Rapid flight with high manoeuvrability	Flies at RSA height	High	Occasional loss of individuals

Species	RSA utilisation	General Description	Flight speed and Manoeuvrability (slow, medium, highly agile)	General flight height	Collision Risk Susceptibility	Collision Consequence
		found in most habitats from closed forest to open flood plain, and occurs in urban areas, in regions across temperate and subtropical Australia.				
Yellow-bellied Sheathtail Bat (*Saccolaimus flaviventris*)	Not expected	Yellow-bellied sheath-tailed bats are canopy feeders, meaning that they are capable of fast flight, but inefficient at rapid manoeuvring. They generally feed at heights of 20–25 m, unless feeding in open spaces or at forest edges, where they forage lower (Churchill, Australian bats, 2008) (Rhodes, Hall, & Parish, 1997).	Rapid flight with low manoeuvrability	<25m	Low	Rare loss of individuals
Bristle-faced Free-tailed Bat (*Setirostris eleyri*)		Bristle-faced Free-tailed Bats are locally uncommon across inland Australia, and only known to inhabit riparian zones and floodplains. During the day these bats roost in tree hollows of mature eucalypts, but are noted as squeezing themselves into other tiny crevices. The observations are along drainage lines and open channels, flying with slow fluttering movements below the canopy at a low altitude of 3 to 4 metres (Pennay, 2006).	Rapid flight with high mobility suited to foraging below the canopy	<15m	Low	No loss of individuals
Common Sheathtail Bat (*Taphozous georgeanis*)		Common Sheathtail Bats roost in caves, old mines and cracks in rocks. They often rest on rocks during the night's feeding. They hunt alone, flying slowly in a straight line while following a grid pattern over the feeding ground. They feed over bushes and water catching and eating insects while flying (Australian Museum, 2020).	Slow flight with low manoeuvrability	May fly to RSA height	Moderate	Rare loss of individuals

3. Potential impacts

The potential impacts of the windfarm to birds and bats lie within the construction and operation phases, and have been listed below:

- Loss or degradation of habitat through clearing of turbine pads and tracks.
- Wind turbine structures, primarily rotor blades and associated RSA, causing;
    - Collisions between flying fauna and wind turbine rotor blades or other structures, or barotrauma as a result of flight close to rotor blades, resulting in injury or fatality. The likelihood of a collision is dependent on a range of factors, including:
        - Design characteristics, such as:
            - the type of wind turbine; and
            - the layout of the wind farm;
        - site characteristics, including:
            - the ecosystems on the wind farm site;
            - proximity to bird concentrations;
            - the numbers of birds moving across the wind farm site;
            - the behaviours of birds and bats (e.g. soaring at RSA height); and
            - weather conditions (Brett Lane & Associates Pty Ltd, 2005).
    - Displacement and barrier effects resulting in greater energetic cost to fauna flying through the area;
- Noise pollution, pressure, and vibrations from the operation of the wind turbines;
    - Light confusing/disorientating aerial fauna increasing risk of collision (risk has been nullified by design adjustments – lighting will not be present on the turbines); or
    - Disturbing surrounding habitat making it less preferable for native species or conditioning avoidance and affecting normal distribution patterns.

4. Monitoring and Management

4.1. Ongoing BBUS

BBUS will continue throughout the construction and operation phase with the same methodology, with the potential to increase survey timing from biannually to quarterly as the construction and operation phases begin.

Ongoing BBUS during operation, compared to pre-construction surveys, should also monitor avoidance behaviours defined below:

- Avoidance – involves birds remaining on a wind farm site but flying around, over or under operating wind turbines and it is a commonly observed behaviour at wind farms.
- Diversion – involves birds remaining within the area around a wind farm but avoiding the wind farm site entirely.
- Displacement – involves birds being displaced through disturbance from the area around the wind farm.

4.2. Carrion monitoring

Carrion monitoring involves surveying of the areas immediately under or around the turbines for carcasses of birds and bats.

In the first instance, surveys should cover an area out to a distance equivalent to the height of the wind turbine for dead birds, remains and feather spots. This distance can be altered if carcass locations indicate this.

For each turbine in the windfarm, a 220m radius area will be searched surrounding the turbine once per month, on a random day, until searchers are satisfied they have found what they can/what is present. Information on each carcass found should be recorded as follows:

- date;
- species;
- signs of injury and likelihood of death due to collision;
- signs of scavenging;
- distance and bearing from turbine tower base;
- ground conditions (e.g. height and density of vegetation, presence of stock, etc.);and
- aerosphere conditions (e.g. visibility conditions such as fog, wind, rain, current and previous 24hr weather conditions).

Carrion monitoring should occur for the first 48 months of the windfarms operation phase. If a significant level of bird or bat mortality to a regional species or species population is measured, then the monitoring should continue (Brett Lane & Associates Pty Ltd, 2005).

The number of carcasses found during surveys is an underestimated measure of the true mortality rate, as it is affected by two major biases: the overlooking of carcasses present in the field; and carcass disappearance before being counted due to removal by scavengers or other means (Barrientos, et al., 2018; Wood, 2017).

A scavenging trial should be undertaken at least twice during the first 48 months of operation during different times of the year. The aim of this trial is to determine the typical rate of removal of carcasses by scavengers, and therefore estimate the likelihood a carcass is detected during carrion monitoring and provide more accurate estimates of bird and bat fatality rate from the wind farm.

Outside of the scavenging trial, carcasses should be removed when located to prevent unnecessary attraction of scavengers to the area potentially resulting in higher bird mortality.

Eight carcasses collected during carrion monitoring, or incidentally from the roads, should be frozen and kept for use in the scavenging trial, with an even ratio of small and large birds if available. One carcass should be placed within the carrion monitoring radius at each turbine, along with an appropriately placed camera trap to capture scavenging birds and monitor the condition of the carcass. Carcasses should be checked weekly until there is no flesh left for scavenging. It is important to note the condition (wholeness) of the carcass upon initial collection, the size (small or large bird), and the

time taken for partial (~50%) and complete (~100%) removal or decomposition of the carcass, as well as the species observed scavenging. The removal of carcasses during carrion monitoring will reduce the chance of scavenger swamping, a bias observed in some scavenging trials caused by an abundance of available carcasses reducing the likelihood of scavenging of the monitored ones.

A searcher efficiency trial should be run in the same season as the scavenger trial, up to twice per year, to determine the proportion of bird and bat fatalities that the observer undertaking the searches actually finds. Four to eight additional carcasses collected during carrion monitoring, or incidentally from the roads, should be frozen and kept for use in the searcher trial, with an even ratio of small and large birds if available. Chicken or mice sourced from pet food suppliers may be used as surrogates for bird and bat carcasses if required. Carcasses should be placed within a 50m radius surrounding a random wind turbine by a member of staff not involved in the searcher efficiency trial, ensuring that carcasses are placed in a stratified random manner that reflects a natural carcass resting place, and that they reflect the habitat of the full carrion monitoring area including different vegetation types/densities, crevices, gullies, and flat areas. An approximate 50/50 split should be used of carcasses in cover and in the open, with an even ration of small and large birds in each if available. The searcher efficiency trial search should be performed to the same thoroughness as the carrion monitoring, that is until searchers are satisfied they have found what they can/what is present.

Correction factors for scavenging and observer efficiency should be developed from these trials and applied to the monitored number of dead birds in order to derive an estimate of collision rate (Brett Lane & Associates Pty Ltd, 2005).

If carcasses are identified repeatedly for a period of 3 months a strategy will be developed to manage the risk of collision and monitoring design will be updated to confirm the level of impact.
It is assumed that a fauna collision with the turbine will be fatal. However, injured wildlife will be referred to local wildlife carers:
Western Qld Wildlife Rehabilitation Centres: Cloncurry – 0419 422 900

4.3. Management

Table 7: General Management Strategies

Threat	Impact	Controls/Management				
		Avoid	Minimise	Mitigate	Monitor	Timing
Introduction and/or spread of weed species due to vehicle and machinery movements across the landscape.	Modification of native habitats.	Where possible, activities must be planned to avoid movement of vehicles or machinery between properties, corridors, or areas with weed infestations. All equipment that enters site must be washed down on each occasion (including vehicles, earthmovers, generators, etc.)	General vehicle and machinery hygiene procedures implemented to minimise spreading of seeds.	Weed management and control methods will be implemented based on infestation size, location, and species of which it is comprised.	Monitoring performed as per DRM Land and Biodiversity Management Plan and management as per DRM Weed Control Program.	During construction and operation
Introduction of pest species or increase of their populations in the project area.	Competing with, predating on, or otherwise harming native species.	Not applicable.	Not applicable.	Implement a pest management plan (PMP) for pest species found in the project area.	Monitoring and management performed as per DRM Land and Biodiversity Management Plan.	During construction and operation
	Facilitating the infection of native species with diseases/parasites					
	Indirectly modifying the habitat of native species.					
	Indirect harm to native fauna through degradation of their habitat.	All waste generated must be stored, handled, and transported in sealed containers.	Not applicable.	Green waste produced may be used on site for rehabilitation, sediment, or erosion control.		
Noise, dust, light pollution, and vibrations (particularly	Confusion of birds by light causing increased risk of interactions.	Works will not occur at night.	Hours and amount of artificial light will be minimised wherever practical.	Not applicable.	Light meters can be used to monitor light pollution and ensure it stays at or below acceptable levels during works.	During construction and operation

during night-time works).	Disturbing surrounding habitat making it less preferable for native species or conditioning avoidance and affecting normal distribution patterns	Works will not occur at night. Misting or wetting can be used to manage airborne dust particles.	Hours and amount of artificial light and noisy machine operation will be minimised wherever practical to reduce impact on surrounding habitat. Watering down and implementation of sensible driving speeds on the access roads will minimise dust generation and reduce impact on surrounding habitat.		Light meters can be used to monitor light pollution and ensure it stays at or below acceptable levels during works. Air quality, Noise and Vibration monitoring and management performed as per DRM Air Quality, Noise and Vibration Management Plan.	
Construction or clearing activities.	Injury/fatality of fauna.	Pre-clearance surveys to be undertaken by qualified fauna spotter/catchers to avoid unintentional tampering of animal breeding places. Clearing will be performed sequentially to direct fauna towards adjacent habitat and away from work sites.	All people driving on site to stay on roads to lower risk of hitting an animal, and follow vehicle speed limits to further lower risk. Speed limit along turbine access roads will be 20km/h or less.	Fauna spotter/catchers operating under an approved rehabilitation permit to check areas prior to work commencing, and to be present during clearing. Fauna will preferably be allowed to move on their own accord, but if this does not occur and access is required immediately then fauna spotter/catchers operating under an approved rehabilitation permit will relocate them. Injured wildlife can be brought to local wildlife carers: **Western Qld Wildlife Rehabilitation Centres: Cloncurry – 0419 422 900**	Maintaining records of any fauna interactions on site as per existing WAF Permits to inform management adjustments.	During design and construction

	Destruction of native habitat	Where possible, avoid the clearing of areas of habitat	Not applicable.	Rehabilitate cleared areas that are no longer required after construction has finished.	Monitor and maintain rehabilitated sites to ensure they are progressing as required (control of weeds, etc.).	
Wind turbine structures, primarily rotor blades and associated RSA.	Collisions between flying fauna and wind turbine rotors or other structures, or barotrauma as a result of flight close to rotors, resulting in injury or fatality.	Not applicable.	Maintain slashed grass transitioning into low shrub cover surrounding turbine pad to minimise bird and bat foraging and to facilitate carcass counts/removal. Project design including turbine selection and siting to minimise on ground disturbance footprint and total RSA, and increase RSA low boundary to reduce impact on aerial fauna.	Follow impact triggers and associated adaptive management strategies.	Follow impact triggers and associated adaptive management strategies.	During design and construction

5. Impact triggers and Adaptive Management

The impact triggers below are in accordance with the interim standards for risk assessment for wind farms and birds (Brett Lane & Associates Pty Ltd, 2005).

An impact trigger for threatened species occurs where a carcass (or recognisable part) of a threatened bird or bat species (listed under the NCA or EPBC Act) is found under or in close proximity to a turbine during any carcass search or incidentally during commissioning or operation.

For non-threatened birds and bat species, an impact trigger is where two or more of the same species, in two successive searches at the same turbine is recorded (i.e. a total of four or more carcasses of the same species in two successive searches at the same turbine) (Brett Lane & Associates Pty Ltd, 2005).

Under Condition D34 of the EA Permit (EPML00731213), this information will be made available to the administering authority upon request, and within forty eight (48) hours of the discovery of any fauna mortalities. Details of mortalities will include but not be limited to:

- animal species of the discovery of any fauna mortality;
- number of animals;
- location; and
- likely cause of death.

If the event is considered a potentially regular occurrence (based on assessment of survey data), or likely to lead to an impact to the population (at the appropriate scale i.e. Local, Regional, State, National); species specific monitoring may be required to determine potential causes and mitigation measures.

Table 8: Impacts and Mitigation Measures

Potential cause of impact	Monitoring to determine cause of impact	Mitigation Measure in response to impact trigger	Likelihood of impact after implementation of mitigation
Foraging source identified that attracts 'at risk' species to impact areas (e.g. flowering eucalypts, carrion associated with road kills, or spawning of insects).	Conduct additional targeted BBUS to assist in determining activity during these events. Conduct additional carrion monitoring in response to these events to determine if events are linked to impacts.	Trial acoustic or visual deterrents at turbine/s responsible for impact trigger.	Low
			Low
Bushfire, low pressure systems and storm fronts creating favourable conditions for aerial foragers.			Low
Low visibility due to wind/rain/fog.			Low

Potential options for acoustic deterrents include:

- The NRG ultrasonic acoustic Bat Deterrent System – which showed a 50% reduction in bat fatalities between turbines with 5 modules and turbines with none over a two year study in Texas (NRG Systems, 2020); and
- The Scarecrow 180™ - a well-researched bio-acoustic bird dispersal system. When coupled with a Scarecrow 360™ 'slave' unit it creates a system that provides 360º of dispersal.

6. References

Ashmole, N. P. (2022, August 29). *pelecaniform*. Retrieved from Encyclopedia Britannica: https://www.britannica.com/animal/pelecaniform

Atlas of Living Australia. (n.d.). Retrieved from http://www.ala.org.au

Austin, O. L., Clench, M. H., & Gill, F. (2024, April 11). *passeriform*. Retrieved from Encyclopedia Britannica: https://www.britannica.com/animal/passeriform

Australian Museum. (2020, 12 03). *Common Sheathtail Bat*. Retrieved from Australian Museum: https://australian.museum/learn/animals/bats/common-sheathtail-bat/

Barrientos, R., Martins, R. C., Ascensão, F., D'Amico, M., Moreira, F., & Borda-de-Água, L. (2018). A review of searcher efficiency and carcass persistence in infrastructure-driven mortality assessment studies. *Biological Conservation 222*, 146-153.

BASE Consulting. (2022). *Mount James Wind Farm Bird and Bat Management Plan.* Porcupine: BASE Consulting.

Birdlife Australia. (2022). *Rainbow Bee-eater*. Retrieved from Birdlife Australia: https://birdlife.org.au/bird-profile/rainbow-bee-eater

Birdlife Australia. (2024). Retrieved from Birdlife Australia: Birdlife.org.au/bird-profile

BirdLife International. (2023). *Species factsheet: Hydroprogne caspia. IUCN Red List for birds*. Retrieved February 24, 2023

Bollich, E. (n.d.). *Struthioniformes*. Retrieved from Animal Diversity Web: https://animaldiversity.org/accounts/Struthioniformes/

Bouglouan, N. (n.d.). *otididae*. Retrieved from Oiseaux Birds: https://www.oiseaux-birds.com/page-family-otididae.html

Brett Lane & Associates Pty Ltd. (2005). *Wind Farms and Birds: Interim Standards For Risk Assessment.* Carlton North: Australian Wind Energy Association.

Chruszcz, B., & Barclay, M. (2002). *Mammalian Species Chalinolobus gouldii - Archived 2007-07-13 at the Wayback Machine.* The American Society of Mammalogists.

Churchill, S. (2008). *Australian bats.* Crows Nest: Allen & Unwin.

Churchill, S. (2009). *Australian bats, 2nd ed.* Crows Nest: Allen & Unwin.

Clunie, P. (1994). *Flora & Fauna Guarantee Action Statment No 60 - White-bellied Sea-eagle.* Retrieved from DSE Vic: http://www.dse.vic.gov.au/web%2Froot%2Fdomino%2Fcm_da%2Fnrenpa.nsf/frameset/NRE+Plants+and+Animals?OpenDocument

del Hoyo, J., Elliot, A., & Sargatal, J. (1992). *Handbook of the Birds of the World: Ostrich to Ducks.* Barcelona: Lynx Edicions.

del Hoyo, J., Elliott, A., & Sargatal, J. (1994). *Handbook of the Birds of the World. Volume 2: New World Vultures to Guineafowl.* Barcelona: Lynx Edicions.

Department of Environment and Science. (2022). *Terrestrial ecology—EIS information guideline, ESR/2020/5309.* Brisbane: Queensland Government.

Ferguson-Lees, J., & Christie, D. (2001). *Raptors of the World.* London: Christopher Helm.

Fogarty, M., & Hetrick, W. (1973). Summer Foods of Cattle Egrets in North Central Florida. *The Auk*, 90(2):268-280.

Friedmann, H. (2024, January 24). *cuculiform*. Retrieved from Encyclopedia Britannica: https://www.britannica.com/animal/cuculiform

Gill, F., & Brown, L. H. (2016, August 26). *falconiform*. Retrieved from Encyclopedia Britannica: https://www.britannica.com/animal/falconiform

Gill, F., & Woolfenden, G. E. (2024, April 10). *psittaciform*. Retrieved from Encyclopedia Britannica: https://www.britannica.com/animal/psittaciform

Gowland, P. (1988). *RAOU Microfiche.* Moonee Pond: RAOU.

Hall, L. (2009). *Bats, A Wild Australia Guide*. Steve Parish Publishing.

Haverschmidt, F. (2023, July 9). *galliform*. Retrieved from Encyclopedia Britannica: https://www.britannica.com/animal/galliform

Higgins, P., & Davies, S. (1996). *Handbook of Australian, New Zealand and Antarctic Birds. Volume Three - Snipe to Pigeons.* Melbourne: Oxford University Press.

Kutt, A. S., Milne, D. J., & Richards, G. C. (2008). Northern Freetail-bat Chaerephon jobensis. In S. Van Dyck, & R. Strahan, *The Mammals of Australia* (pp. 485-486). Reed New Holland.

Lane, B. (1987). *Shorebirds in Australia.* Sydney: Reed.

Maddock, M. (1990). Cattle Egrets: South to Tasmania and New Zealand for the winter. *Notornis*, 37(1):1-2.

Marchant, S., & Higgins, P. (1990). *Handbook of Australian, New Zealand and Antarctic Birds. Volume One - Ratites to Ducks.* Melbourne: Oxford University Press.

Marchant, S., & Higgins, P. (1993). *Handbook of Australian, New Zealand and Antarctic Birds. Volume 2 - Raptors to Lapwings.* Melbourne: Oxford University Press.

Marshall, J. T., & Gill, F. (2024, April 12). *owl*. Retrieved from Encyclopedia Britannica: https://www.britannica.com/animal/owl

May, R., Nygård, T., Falkdalen, U., Åström, J., Hamre, Ø., & Stokke, B. (2020). Paint it black: Efficacy of increased wind turbine rotor blade visibility to reduce avian fatalities. *Ecology and Evolution*.

McClure, C., Rolek, B., Dunn, L., McCabe, J., Martinson, L., & Katzner, T. (2021). Eagle fatalities are reduced by automated curtailment of wind turbines. *Journal of Applied Ecology*.

Menkhorst, P., & Knight, F. (2011). *A Field Guide to the Mammals of Australia.* Melbourne: Oxford University Press.

Murton, R. K. (2023, November 17). *columbiform*. Retrieved from Encyclopedia Britannica: https://www.britannica.com/animal/columbiform

Ocean Animals. (2023). *Suliformes*. Retrieved from Ocean Animals: https://oceananimals.org/seabirds/suliformes/#section-19211d0-2

Pennay, M. (2006). *Ecological Study of the Endangered Bristle-nosed Bat (Mormopterus species 6) and Survey of Microchiropteran Bats in Gundabooka National Park.* Upper Darling Region: NSW National Parks & Wildlife Service.

Pizzey, G., & Knight, F. (2012). *The Field Guide to the Birds of Australia.* Sydney: Harper Collins.

Pringle, J. (1987). The Shorebirds of Australia. In J. Pringle, *National Photographic Index of Australian Wildlife.* Sydney: Angus and Robertson.

Rand, A. L. (2023, September 14). *coraciiform*. Retrieved from Encyclopedia Britannica: https://www.britannica.com/animal/coraciiform

Reader's Digest. (1997). *Complete Book of Australian Birds (second edition).* Sydney: Reader's Digest Australia Pty Ltd.

Reardon, T., & Armstrong, K. (2020). Mormopterus lumsdenae. *IUCN Red List of Threatened Species*.

Rhodes, M., Hall, L., & Parish, S. (1997). Observations on Yellow-bellied sheath-tailed bats Saccoliamus flaviventris (Peters, 1867)(Chiroptera: Emballonuridae). *Australian Zoologist*, 30:351-357.

Rose, A. (2001). Supplementary records of the food of some terrestrial non-passerines in New South Wales. *Australian Bird Watcher*, 19:60-68.

Schwartz, P. A. (2008, July 9). *Caprimulgiform*. Retrieved from Britannica: https://www.britannica.com/animal/caprimulgiform

Seedikkoya, K., Azeez, P., & Shukkur, E. (2007). Cattle egret as a biocontrol agent. *Zoo's Print Journal*, 22(10):2864-2866.

Siegfried, W. (1971). The food of the Cattle Egret. *Journal of Applied Ecology*, 8(2):447-468.

Simpson, K., & Day, N. (1999). *Field guide to the birds of Australia, 6th Edition.* Penguin Books.

Storer, R. W. (2023, November 14). *grebe*. Retrieved from Encyclopedia Britannica: https://www.britannica.com/animal/grebe

Telfair II, R. (2006). Cattle Egret (Bubulcus ibis). *The Birds of North America Online*.

TSSC. (2015, October 31). *Conservation Advice Malurus coronatus coronatus purple-crowned fairy-wren (western).* Retrieved from Threatened Species Scientific Committee (TSSC): http://www.environment.gov.au/biodiversity/threatened/species/pubs/64442-conservation-advice-31102015.pdf

Van Dyck, S., & Strahan, R. (2008). *The Mammals of Australia.* New Holland Publishers.

Vestjens, W. (1977). *Technical Memorandum Division of Wildlife Research.* CSIRO.

Ward, S., & Woinarski, J. (2012, December). *PURPLE-CROWNED FAIRY-WREN (Western subspecies) Malurus coronatus coronatus.* Retrieved from Threatened Species of the Northern Territory: chrome-extension://efaidnbmnnnibpcajpcglclefindmkaj/https://nt.gov.au/__data/assets/pdf_file/0003/206364/purple-crowned-fairy-wren.pdf

Wood, M. (2017). *Macarthur Wind Farm Bat and Avifauna Mortality Monitoring.*

Wulguru Technical Services. (2023). *MMG - Dugald River Windfarm Ecological Assessment Report.*

Appendix A – incidental species records

Common Name (*Scientific Name*)	Order	Status*	
		NCA	EPBC
Collared Sparrowhawk (*Accipiter cirrocephalus*)	Accipitriformes	LC	NL
Spotted Harrier (*Circus assimilis*)	Accipitriformes	LC	NL
Black Swan (*Cygnus atratus*)	Anseriformes	LC	NL
Australian Owlet-nightjar (*Aegotheles cristatus*)	Caprimulgiformes	LC	NL
Spotted Nightjar (*Eurostopodus argus*)	Caprimulgiformes	LC	NL
Tawny Frogmouth (*Podargus strigoides*)	Caprimulgiformes	LC	NL
Black-fronted Dotterel (*Elseyornis melanops*)	Charadriiformes	LC	NL
Pied Stilt (*Himantopus leucocephalus*)	Charadriiformes	LC	NL
Little Button-quail (*Turnix velox*)	Charadriiformes	LC	NL
Peaceful Dove (*Geopelia placida*)	Columbiformes	LC	NL
Spinifex Pigeon (*Geophaps plumifera*)	Columbiformes	LC	NL
Crested Pigeon (*Ocyphaps lophotes*)	Columbiformes	LC	NL
Common Bronzewing (*Phaps chalcoptera*)	Columbiformes	LC	NL
Red-backed Kingfisher (*Todiramphus pyrrhopygius*)	Coraciiformes	LC	NL
Pallid Cuckoo (*Heteroscenes pallidus*)	Cuculiformes	LC	NL
Pheasant Coucal (*Centropus phasianinus*)	Cuculiformes	LC	NL
Horsefield's Bronze Cuckoo (*Chalcites basalis*)	Cuculiformes	LC	NL
Common Koel (*Eudynamys orientalis*)	Cuculiformes	LC	NL
Australian Hobby (*Falco longipennis*)	Falconiformes	LC	NL
Black Falcon (*Falco subniger*)	Falconiformes	LC	NL
Brown Quail (*Synoicus ypsilophorus*)	Galliformes	LC	NL
Australian Bustard (*Ardeotis australis*)	Otidiformes	LC	NL
Spiny-cheeked Honeyeater (*Acanthagenys rufogularis*)	Passeriformes	LC	NL
Yellow-rumped Thornbill (*Acanthiza chrysorrhoa*)	Passeriformes	LC	NL
Kalkadoon Grasswren (*Amytornis ballarae*)	Passeriformes	LC	NL
Dusky Woodswallow (*Artamus cyanopterus*)	Passeriformes	LC	NL
White-browed Woodswallow (*Artamus superciliosus*)	Passeriformes	LC	NL
Pied Honeyeater (*Certhionyx variegatus*)	Passeriformes	LC	NL
Spotted Bowerbird (*Chlamydera maculata*)	Passeriformes	LC	NL
Great bowerbird (*Chlamydera nuchalis*)	Passeriformes	LC	NL
Banded Honeyeater (*Cissomela pectoralis*)	Passeriformes	LC	NL
Black-tailed Treecreeper (*Climacteris melanurus*)	Passeriformes	LC	NL
Grey Shrike-thrush (*Colluricincla harmonica*)	Passeriformes	LC	NL
Little Shrike-thrush (*Colluricincla megarhyncha*)	Passeriformes	LC	NL
White-bellied Cuckoo-shrike (*Coracina papuensis*)	Passeriformes	LC	NL
Grey Butcherbird (*Cracticus torquatus*)	Passeriformes	LC	NL
Varied Sittella (*Daphoenositta chrysoptera*)	Passeriformes	LC	NL
Crimson Chat (*Epthianura tricolor*)	Passeriformes	LC	NL
Singing Honeyeater (*Gavicalis virescens*)	Passeriformes	LC	NL
Western Gerygone (*Gerygone fusca*)	Passeriformes	LC	NL

Magpie Lark (*Grallina cyanoleuca*)	Passeriformes	LC	NL
Australian Magpie (*Gymnorhina tibicen*)	Passeriformes	LC	NL
Pictorella Mannikin (*Heteromunia pectoralis*)	Passeriformes	LC	NL
White-winged Triller (*Lalage tricolor*)	Passeriformes	LC	NL
White-plumed Honeyeater (*Lichenostomus penicillatus*)	Passeriformes	LC	NL
Brown Honeyeater (*Lichmera indistincta*)	Passeriformes	LC	NL
Purple-backed Fairy-wren (*Malurus assimilis*)	Passeriformes	LC	NL
Red-backed Fairy-wren (*Malurus melanocephalus*)	Passeriformes	LC	NL
Yellow-throated Miner (*Manorina flavigula*)	Passeriformes	LC	NL
Rufous Songlark (*Megalurus mathewsi*)	Passeriformes	LC	NL
Northern Inland Hooded Robin (*Melanodryas cucullata picata*)	Passeriformes	LC	NL
Brown-headed Honeyeater (*Melithreptus brevirostris*)	Passeriformes	LC	NL
Black-chinned Honeyeater (*Melithreptus gularis*)	Passeriformes	LC	NL
Jacky Winter (*Microeca fascinans*)	Passeriformes	LC	NL
Paperbark Flycatcher (*Myiagra nana*)	Passeriformes	LC	NL
Crested Bellbird (*Oreoica gutturalis*)	Passeriformes	LC	NL
Olive-backed Oriole (*Oriolus sagittatus*)	Passeriformes	LC	NL
Rufous Whistler (*Pachycephala rufiventris*)	Passeriformes	LC	NL
Red-browed Pardalote (*Pardalotus rubricatus*)	Passeriformes	LC	NL
Striated Pardalote (*Pardalotus striatus*)	Passeriformes	LC	NL
Red-capped Robin (*Petroica goodenovii*)	Passeriformes	LC	NL
Long-tailed Finch (*Poephila acuticauda*)	Passeriformes	LC	NL
Grey-crowned Babbler (*Pomatostomus temporalis*)	Passeriformes	LC	NL
Spinifexbird (*Poodytes carteri*)	Passeriformes	LC	NL
Yellow-tinted Honeyeater (*Ptilotula flavescens*)	Passeriformes	LC	NL
Grey Fantail (*Rhipidura fuliginosa*)	Passeriformes	LC	NL
Weebill (*Smicrornis brevirostris*)	Passeriformes	LC	NL
Double-barred Finch (*Taeniopygia bichenovii*)	Passeriformes	LC	NL
Glossy Ibis (*Plegadis falcinellus*)	Pelicaniformes	SL	M
Australasian Grebe (*Tachybaptus novaehollandiae*)	Podicepediformes	LC	NL
Red-winged Parrot (*Aprosmictus erythropterus*)	Psittaciformes	LC	NL
Cloncurry Ringneck (*Barnardius zonarius macgilvrayi*)	Psittaciformes	LC	NL
Sulphur-crested Cockatoo (*Cacatua galerita*)	Psittaciformes	LC	NL
Southern Boobook (*Ninox boobook*)	Strigiformes	LC	NL
Eastern Barn Owl (*Tyto alba*)	Strigiformes	LC	NL
Emu (*Dromaius novaehollandiae*)	Struthioniformes	LC	NL

* NCA = *Nature Conservation Act 1992*; EPBC = *Environment Protection and Biodiversity Conservation Act 1999*; CR = Critically Endangered; EN = Endangered; VU = Vulnerable; NT = Near Threatened; SLC = Special Least Concern; LC = Least Concern; M = Migratory; Ma = Marine

Appendix B - General Collision Risk Assessment For Bird Orders/Families

Order	RSA Utilisation	General description	Flight speed and Manoeuvrability (slow, medium, highly agile)	General Flight height	Size (small/ medium/ large)	Total Records within Project area	Collision Risk Susceptibility	Collision Consequence
Accipitriformes	Foraging and dispersing	Accipitriformes is an order of birds that includes most of the diurnal birds of prey, including hawks, eagles, vultures, and kites, but not falcons (Atlas of Living Australia, n.d.).	Fast flight with medium manoeuvrability	Within RSA	Medium to large	16	High	Occasional loss of individuals
Anseriformes	Dispersal	Anseriformes is an order of birds also known as waterfowl that comprises about 180 living species of birds in three families. Most modern species in the order are highly adapted for an aquatic existence at the water surface. (Atlas of Living Australia, n.d.)	Slow with low manoeuvrability	Typically below RSA height, other than migration.	Large		Low	No loss of individuals
Caprimulgiformes	Dispersal	Caprimulgiformes are soft-plumaged birds, the major groups of which are called nightjars, nighthawks, potoos, frogmouths, and owlet-frogmouths. Most are twilight- or night-flying birds (Schwartz, 2008).	Medium speed with medium manoeuvrability	Typically below RSA height, other than dispersal.	Medium		Low	No loss of individuals
Charadriiformes	Dispersal	Charadriiformes is a diverse order of small to medium-large birds. Most charadriiform birds live near water and eat invertebrates or other small animals; however, some are pelagic (seabirds), others frequent deserts, and a few are found in dense forest. Members of this group can also collectively be referred to as shorebirds (Atlas of Living Australia, n.d.).	Slow to medium speed with low manoeuvrability	Foraging activities occur under RSA height, but dispersal flight height is within the RSA	Small to medium		Low	No loss of individuals

Order	RSA Utilisation	General description	Flight speed and Manoeuvrability (slow, medium, highly agile)	General Flight height	Size (small/ medium/ large)	Total Records within Project area	Collision Risk Susceptibility	Collision Consequence
Columbiformes	Not likely	Columbiformes is an order of birds containing the pigeons and doves in one family, and the extinct dodo and solitaire in another. The pigeon family (Columbidae) contains about 316 species (Murton, 2023).	Medium speed with medium manoeuvrability	Typically below RSA height	Small to medium	43	Low	Rare loss of individuals
Coraciiformes	Dispersal and foraging for some species	Coraciiformes is an order of usually colourful birds including kingfishers and bee-eaters. The members of this order are linked by their “slamming” behaviour in which they thrash their prey into surfaces (Rand, 2023).	Medium speed with high manoeuvrability	Dispersal flight height is within the RSA. Foraging may occur in the RSA for some species	Small to medium	11	Moderate to high	Rare to repeated loss of individuals
Cuculiformes	Dispersal	Cuculiformes is an order of birds containing the cuckoos and the hoatzin. Most cuckoos are solitary, often furtive birds that are inconspicuous even when relatively common, and they do not form flocks (Friedmann, 2024).	Medium speed with medium manoeuvrability	May fly within height of RSA	Small to medium		Low	No loss of individuals
Falconiformes	Foraging and dispersal	Falconiformes is an order of birds containing falcons; diurnal raptors but not included in the order Accipitriformes with the others. Although rarely abundant, falcons are widespread and live in diverse habitats (Gill & Brown, falconiform, 2016).	Fast flight with high manoeuvrability	Within RSA	Medium	8	High	Occasional loss of individuals
Galliformes	Not likely	Galliformes is an order of fowl-like birds containing 290 species including turkeys, chickens, quail, pheasant, and peacock (Haverschmidt, 2023).	Fast flight but rarely sustained for long distances. Low manoeuvrability	Typically below RSA height	Small to large		Low	No loss of individuals

Order	RSA Utilisation	General description	Flight speed and Manoeuvrability (slow, medium, highly agile)	General Flight height	Size (small/ medium/ large)	Total Records within Project area	Collision Risk Susceptibility	Collision Consequence
Otidiformes	Not likely	Otidiformes is an order of large birds containing bustards, floricans, and korhaans. They are highly terrestrial, often seen walking slowly or staying motionless among the vegetation. They don't fly very often but can sustain strong flight when they do (Bouglouan, n.d.).	Fast flight with low manoeuvrability	Typically below RSA height	Large		Moderate	Rare loss of individuals
Passeriformes *Artamidae*	Foraging and dispersal	The *Artamidae* family of the Order Passeriformes includes the woodswallows, butcherbirds and the Australian magpie. Most are predatory, feeding on a vast array of prey items, from insects to reptiles and other birds.	Variable. Some species fast and agile.	Some species frequently within RSA	Small to medium	292	Moderate to High	Occasional to repeated loss of individuals
Passeriformes *Hirundinidae*	Foraging and dispersal	The *Hirundinidae* family of the Order Passeriformes includes swallows and martins. These passerine birds are specifically adapted for aerial feeding on insects.	Fast flight with high manoeuvrability.	Within the RSA	Small	31	Moderate	Repeated loss of individuals
Passeriformes *Other families*	Foraging and dispersal	Passeriformes is the largest order of birds and the dominant avian group comprised of approximately 5700 species. Passeriformes are true perching birds characterised by their four toes, three directed forward and one backward. The majority are insectivorous, some being aerial feeders and others gleaning insects from surfaces (Austin, Clench, & Gill, 2024).	Variable. Some species fast and agile.	May fly within height of RSA	Small to medium	174	Low to Moderate	Occasional loss of individuals

Order	RSA Utilisation	General description	Flight speed and Manoeuvrability (slow, medium, highly agile)	General Flight height	Size (small/ medium/ large)	Total Records within Project area	Collision Risk Susceptibility	Collision Consequence
Pelecaniformes	Dispersal	Pelecaniformes is an order of large aquatic birds with webbing or partial webbing between all four toes, including pelicans, egrets, ibises, and spoonbills. The various groups of Pelecaniformes are specialized for different feeding methods, however they all feed at bodies of water (Ashmole, 2022).	Medium speed with low manoeuvrability	May fly within height of RSA	Large	5	Moderate	Rare loss of individuals
Podicipediformes	Dispersal	Podicipediformes is an order comprised of a single family of foot-propelled diving birds called Grebes. Grebes feed and breed on still or slow-moving bodies of water (Storer, 2023).	Medium speed with low manoeuvrability	May fly within height of RSA	Medium		Moderate	Rare loss of individuals
Psittaciformes	Dispersal	Psittaciformes is an order of more than 360 species of generally bright coloured, noisy birds. Typically, parrots are gregarious and noisy, often forming small groups, sometimes huge flocks, flying rapidly high overhead and screeching. Parrots feed almost entirely on plant materials. The smaller species tend to utilize grass seeds, berries, fruits, and the juices of blossoms; the larger forms obtain fruits and nuts from trees and bulbs, tubers, and roots from the ground (Gill & Woolfenden, 2024).	Medium speed with medium manoeuvrability	May fly within height of RSA	Medium	98	Moderate	Rare loss of individuals

Order	RSA Utilisation	General description	Flight speed and Manoeuvrability (slow, medium, highly agile)	General Flight height	Size (small/ medium/ large)	Total Records within Project area	Collision Risk Susceptibility	Collision Consequence
Strigiformes	Foraging and dispersing	Strigiformes is an order of primarily nocturnal raptors known as owls. Owls often attain higher population densities than hawks, the distribution and density of most species seem to be limited by the availability of suitable nesting sites, rather than by the number of potential prey animals. Owls that hunt over grassland hunt by sustained flight, dropping into the grass to catch rodents. Many woodland owls secure prey by dropping from perches at the edges of forest openings. The nocturnal routine of most owls involves peaks of activity at dusk and dawn (Marshall & Gill, 2024).	Fast flight with high manoeuvrability	May fly within height of RSA	Medium to large		Moderate	Rare loss of individuals
Struthioniformes	Not likely	Struthioniformes is an order of large flightless birds of which there are approximately 15 species. In Australia this refers to Emus and Cassowaries. They are omnivorous, and often good runners due to their long muscular legs (Bollich, n.d.).	Flightless	Flightless	Large		Low	No loss of individuals
Suliformes	Dispersal	Suliformes is a relatively new order of birds that includes cormorants, anhingas, frigatebirds, and boobies. These birds are adapted for life in the water and are generally large, with long wings and webbed feet. Suliformes are social animals and can often be found in large groups (Ocean Animals, 2023).	Medium speed with medium manoeuvrability	May fly within height of RSA	Large	2	Moderate	Rare loss of individuals

Appendix C - Collision Risk for NC and EPBC Act Listed Species

Common name (*Scientific name*)	Status*		Likelihood of occurrence	RSA Utilisation	Flight Habits	General Flight height	Size (small/ medium/ large)	Behaviour, habitat and feeding	Records on site	Collision Risk Susceptibility	Collision Consequence
	NCA	EPBC									
Cattle Egret (*Bubulcus ibis*)	LC	Ma	Possible	Dispersing	Capable of flying large distances. Is not considered highly mobile in the air	Would fly within the RSA.	Medium	The cattle egret has undergone one of the most rapid and wide-reaching natural expansions of any bird species (Telfair II, 2006). Cattle egret populations can be both sedentary and migratory (Maddock, 1990). If migrating, migration takes place from the south during spring. The cattle egret feeds on a wide range of prey, particularly insects, especially grasshoppers, crickets, flies (adults and maggots), and moths, (Seedikkoya, Azeez, & Shukkur, 2007)	Nil	Moderate	No loss
Sharp-tailed Sandpiper (*Calidris acuminata*)	SL	M, Ma, V	Possible	Dispersing	Capable of flying great distance during migration.	Likely to fly within RSA height during migration	Medium	The Sharp-tailed sandpiper prefers the grassy edges of shallow inland freshwater wetlands. It is also found around sewage farms, flooded fields, mudflats, mangroves, rocky shores and beaches. Its breeding habitat in Siberia is the peat hummock and lichen tundra of the high Arctic The Sharp-tailed sandpiper feeds on aquatic insects and their larvae, as well as worms, molluscs, crustaceans and sometimes, seeds. It is often found in large flocks, often with other waders, foraging in shallow waters (Pringle, 1987) (Simpson & Day, 1999).	Nil	Low	No loss

Common name (*Scientific name*)	Status*		Likelihood of occurrence	RSA Utilisation	Flight Habits	General Flight height	Size (small/ medium/ large)	Behaviour, habitat and feeding	Records on site	Collision Risk Susceptibility	Collision Consequence
	NCA	EPBC									
Black-eared Cuckoo (*Chalcites osculans*)	LC	Ma	Possible	Dispersing	Mobile agile flyer	May fly within height of RSA, but not normally at this height	Small	The Black-eared cuckoo is a parasitic breeder, that is, it lays its eggs in the nests of other birds. By preference, the Black-eared cuckoo chooses the domed or enclosed nests of species such as the Speckled Warbler, or the Redthroat (Birdlife Australia, 2024) It is migratory, moving into the sub-coastal areas of south-east and south-west Australia for the summer. The Black-eared Cuckoo perches on a shrub or tree, and drops from its perch to forage for insects on the ground. Would generally forage within canopy height (Birdlife Australia, 2024).	Nil	Low	No loss of individuals
Latham's Snipe (*Gallinago hardwickii*)	SL	M, Ma, V	Possible	Dispersing	Capable of flying great distance during migration. Moderate mobility	May fly to RSA during migration	Medium	Latham's Snipe is a migratory wader, travelling to Australia during the warmer months, typically arriving in Australia in September. Birds may fly directly between Japan and Australia, stopping at a few staging areas. They leave their breeding areas from August to November, arriving in Australia mainly in September. They leave the south-east by the end of February, moving northwards along the coast. Most have left Queensland by mid-April (Pringle, 1987) (Higgins & Davies, 1996). Latham's snipes are omnivorous, eating seeds and plant material, worms, spiders and insects, some molluscs, isopods and centipedes (Higgins & Davies, 1996) (Lane, 1987).	Nil	Low	No loss of individuals

Common name (*Scientific name*)	Status*		Likelihood of occurrence	RSA Utilisation	Flight Habits	General Flight height	Size (small/ medium/ large)	Behaviour, habitat and feeding	Records on site	Collision Risk Susceptibility	Collision Consequence
	NCA	EPBC									
White-bellied Sea-Eagle (*Haliaeetus leucogaster*)	LC	Ma	Possible	Dispersing	Capable of flying great distance. Moderate mobility	Likely to fly within RSA height	Large	Inhabits a variety of habitats including coasts, islands, estuaries, inlets, large rivers, inland lakes, reservoirs. Widespread along all Australian coasts, travels inland along large rivers or to large water sources. (Pizzey & Knight, 2012). The White-bellied Sea-Eagle feeds opportunistically on a variety of fish, birds, reptiles, mammals and crustaceans, and on carrion and offal (Rose, 2001). The White-bellied Sea-Eagle hunts its prey from a perch, or whilst in flight (by circling slowly, or by sailing along 10–20 m above the shore). When a prey item is located, the sea-eagle usually launches into a dive or shallow glide to snatch its prey, usually in one foot, from the ground or water surface (Clunie, 1994) (del Hoyo, Elliott, & Sargatal, Handbook of the Birds of the World. Volume 2: New World Vultures to Guineafowl, 1994) (Ferguson-Lees & Christie, 2001) (Marchant & Higgins, 1993).	Nil	High	No loss of individuals
Caspian tern (*Hydroprogne caspia*)	SL	M, Ma	Possible	Dispersing	Capable of flying great distance during migration. Moderate mobility	May fly to RSA during migration	Medium	A large, part-migratory to migratory species of tern with a cosmopolitan distribution. In Australia, this species is primarily coastal, though travels inland to visit large bodies of water (Pizzey & Knight, 2012). The Caspian Tern's diet consists predominantly of fish (5–25 cm in length) as well as the eggs and young of other birds, carrion, aquatic invertebrates (e.g. crayfish), flying insects and earthworms (Birdlife International 2010a). They	Nil	Low	No loss of individuals

Common name (*Scientific name*)	Status*		Likelihood of occurrence	RSA Utilisation	Flight Habits	General Flight height	Size (small/ medium/ large)	Behaviour, habitat and feeding	Records on site	Collision Risk Susceptibility	Collision Consequence
	NCA	EPBC									
								forage diurnally, mostly early to mid-morning, patrolling in slow lazy flight, 3–15 m above the water. The species may forage up to 60 km from their nesting site (BirdLife International, 2023) (Higgins & Davies, 1996).			
Purple-crowned Fairy-wren (*Malurus coronatus*)	V		Possible	Foraging	Highly agile	Unlikely to fly within the RSA	Small	The species occurs from the Kimberly region to the gulf of Carpentaria drainage of western Queensland and north-eastern Northern Territory (TSSC, 2015). The species is restricted to a narrow band around well-vegetated river channels. They prefer thick riparian vegetation, typically of cane grass and/or pandanus, but also dense patchy shrubs up to 3 m (Ward & Woinarski, 2012). Purple-crowned fairy-wrens are territorial and sedentary, feeding in loose groups in the undergrowth or on the ground. The species is mainly insectivorous, consuming a range of small invertebrates such as beetles, ants, bugs, wasps, grasshoppers, moths, larvae, spiders, and worms and small quantities of seeds. They forage for their prey amongst foliage and in the leaf litter on the ground that may have accumulated as debris during floods.	Nil	Low	No loss of individuals

Common name (*Scientific name*)	Status*		Likelihood of occurrence	RSA Utilisation	Flight Habits	General Flight height	Size (small/ medium/ large)	Behaviour, habitat and feeding	Records on site	Collision Risk Susceptibility	Collision Consequence
	NCA	EPBC									
Rainbow Bee-eater (*Merops ornatus*)	LC	M	Known	Dispersing / Foraging	Highly mobile and agile in flight. Able to forage for insects on the wing. On migration, the Rainbow bee-eater may also fly over the top of non-preferred habitats such as rainforest or treeless plains	Would fly within the RSA.	Small	The Rainbow Bee-eater is most often found in open forests, woodlands and shrublands, and cleared areas, usually near water. It will be found on farmland with remnant vegetation and in orchards and vineyards. It will use disturbed sites such as quarries, cuttings and mines to build its nesting tunnels (Birdlife Australia, 2022). The species is mainly insectivorous. Birds consume a range of small invertebrates captured in flight, including wasps, bees, dragonflies and similar.	11 (BBUS)	High	Repeated loss of individuals
Glossy ibis (*Plegadis falcinellus*)	SL	Ma, M	Known	Dispersing	Capable of flying large distances. Is not considered highly mobile in the air	Would fly within the RSA.	Medium	Prefers well-vegetated wetlands, floodplains, irrigated pastures, sewage ponds, mangroves, mudflats though may occur in dry grasslands further inland, particularly during good rainfall years. The migratory and nomadic species breeds in southern Australia between October to December and in north Australia between February to April (Pizzey & Knight, 2012). Glossy Ibis feed mainly on aquatic invertebrates/insects such as freshwater snails, mussels, crabs and crayfish. The species will also, however, eat fish, frogs and tadpoles, dryland invertebrates (such as beetles and grasshoppers), lizards, small snakes and nestling birds (del Hoyo, Elliot, & Sargatal, 1992) (Gowland, 1988) (Marchant & Higgins, 1990) (Vestjens, 1977).	One (prelim. surveys)	Moderate	Rare loss of individuals

Common name (*Scientific name*)	Status*		Likelihood of occurrence	RSA Utilisation	Flight Habits	General Flight height	Size (small/ medium/ large)	Behaviour, habitat and feeding	Records on site	Collision Risk Susceptibility	Collision Consequence
	NCA	EPBC									
Australian Painted Snipe (*Rostratula australis*)	E	E, Ma	Possible	Dispersing	Capable of flying great distances. Moderate mobility	No reference to flight height.	Medium	The Australian painted snipe occurs in shallow freshwater (occasionally brackish) waters, both ephemeral and permanent, such as lakes, swamps, claypans, inundated or waterlogged grassland, dams, rice crops, sewage farms and bore drains, generally with a good cover of grasses, rushes and reeds, low scrub, *Muehlenbeckia* spp. (lignum), open timber or samphire (Reader's Digest, 1997) (Marchant & Higgins, 1993). This species feeds on insects, freshwater snails and worms from dusk to early morning, mostly in shallow water.	Nil	Low	No loss of individuals
Common Greenshank (*Tringa nebularia*)	SL	Ma, M, E	Possible	Dispersing	Capable of flying great distances. Highly agile.	Would fly within the RSA.	Medium	Inhabits mudflats, estuaries, saltmarshes, lake and pond margins, wetlands. Generally found in coastal environments, but present inland where habitat is suitable. Widespread summer migrant, with some overwintering. (Pizzey & Knight, 2012). The Common Greenshank is carnivorous. In Australia is has been recorded eating molluscs, crustaceans, insects, and occasionally fish and frogs. Elsewhere, it has also been recorded eating annelids, lizards, and rodents. The species feeds during both day and nighttime. It is active and agile, finding prey by sight or, occasionally, by touch (Higgins & Davies, 1996).	Nil	Low	No loss of individuals

APPENDIX M: Bird and Bat Utilisation Survey (WTS, 2024b)



Bird and Bat Utilisation Study

DUGALD RIVER WINDFARM

MMG DUGALD RIVER PTY LTD

May 2024

WULGURU TECHNICAL SERVICES

Contact Details	
Company	Wulguru Technical Services Pty Ltd
Project Manager	Glyn Thomas
Email	glyn@wulgurutechservices.com.au
Mail	PO Box 2553 IDALIA QLD 4810
ABN	79 644 301 655

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1. Introduction

1.1. Project Description

The Dugald River Mine (DRM) is predominantly a zinc mining operating under Environmental Authority EPML00731213 (the EA) held by MMG Dugald River Pty Ltd (MMG). MMG are seeking approval to establish a wind farm (the Project) and ancillary infrastructure to support the DRM's goal of achieving net zero emissions by 2050.

Nine locations across the Knapdale Range were selected for geotechnical investigations with the intended purpose of installation of wind turbines. Construction of turbine pads, access tracks, powerlines, and laydown areas requires 75 ha of land clearing within the lease footprint. There will be eight turbines, with the ninth potential turbine pad being used as a laydown area. The Rotor-swept Area (RSA, i.e. referring to the height range within which the blades of operating wind turbines move (Brett Lane & Associates Pty Ltd, 2005)) was considered at the largest dimensions possible to allow for design adjustments. The Goldwind GW 165-5.2/5.6/6.0MW (or equivalent) with a 130m hub height and 165m rotor blade diameter, giving an RSA between 47.5 m - 212.5 m height above ground level, with blade rotation area of 21,382m^2. This assessment has been based on these criteria in consideration of the Precautionary Principle and in accordance with accepted methodology and conditioning style adopted through State Code 23.

The project will consist of an early works and clearing phase, a construction phase, an operation phase, and a decommissioning phase following mine closure.

1.2. Site Description

DRM is located approximately 70km northwest of Cloncurry in western Queensland and situated adjacent to the Knapdale Range. Other infrastructure such as the mine camp are located on the range itself along with the valley fill tailings dam which is situated in the northern one-third of the range. The mine falls within the Cloncurry Shire Council region and maintains a policy of sourcing locally where possible.

While the main mine infrastructure lies adjacent to the Knapdale Range, the footprint for the proposed windfarm is situated in the higher elevation areas of the Knapdale Range in *Eucalyptus leucophloia* dominant habitat.

The Knapdale Range lies within the Mount Isa Inlier subregion of the Northwest Highlands bioregion which is characterised largely by the tilted metamorphic hills and ranges evident on the Knapdale. Weather in the region tends towards mild to cool winters and hot summers often with heavy tropical and intense rain events.

DRM sits at approximately 200m Australian Height Datum (AHD) on relatively flat, grassy plains. To the west the Knapdale Range reaches maximum elevation of approximately 300 m AHD. The proposed wind turbine pads are located at between 270-290 m elevation.

DRM lies between the Leichhardt Basin and the Flinders Basin. Ephemeral drainage features in the project area range between stream orders one and two. Two major rivers flow either side of the DRM, but do not enter the project area: Cabbage Tree Creek in the northwest, a 5th order stream flowing south and draining into the Leichardt basin, and Dugald River in the southeast, another 5th order streaming flowing south and draining into the Flinders Basin.

Streams and drainage lines are ephemeral. Numerous rocky water holes are known to retain water for varying lengths of time into the dry season, and some may be deep and large enough to persist through the dry season in wetter years.

Vegetation of the Project area consists of low open woodland and open Spinifex dominant grasslands, with moderate to sparse Acacia dominant shrub layers throughout. Soil types range from rocky, skeletal soil types to shallow -moderate sandy loam towards the eastern base of the range.

The rocky habitat of Knapdale Range supports populations of Purple-necked Rock-wallaby (PNRW) (*Petrogale purpuriecolis*) which is considered a vulnerable species under the Nature Conservation Act 1992 (NCA). Local populations are currently monitored under the MMG DRM Purple-necked Rock-wallaby Monitoring Program and reported annually to the Department of Environment, Science and Innovation (DESI) in accordance with the EA.

1.3. Scope

Wulguru Technical Services Pty Ltd (WTS) was engaged by MMG Dugald River Pty Ltd (MMG), to prepare a Bird and Bat Utilisation Study (BBUS) to provide baseline data on bird and bat use of the Project area. The methodology follows a Before-After-Control-Impact (BACI) design, in accordance with Appendix 1 of the Planning guidance State Code 23: Wind Farm Development (Department of State Development, Infrastructure, Local Government and Planning, 2023).

The specific objectives of the BBUS are to:

- Review existing bird and bat data for the Project area;
- Describe the diversity of birds and bats found in the Project area;
- Identify the known or likely occurrence of conservation significant species;
- Identify bird species that are susceptible to collision impacts based on observed or recorded flight behaviours; and
- Identify bat species that are susceptible to barotrauma based on passive acoustic detection.

Where there is potential for wind turbine collisions, migratory paths and local use may inform the final turbine footprint and layout to minimise the likelihood of those collisions, tested via Collision Risk Models (CRMs).

Other considerations include:

- habitat destruction and other impacts resulting from clearing of native vegetation for the construction of roads and turbine hardstands; and

- indirect effects (such as potential avoidance behaviour at a site), where wind farms change the use of habitats by birds and bats on or near a wind farm.

The BBUS informs a Bird and Bat Management Plan (BBMP) to mitigate impacts and demonstrate PO1 of Planning guidance State Code 23: Wind Farm Development which outlines the requirement for the identification of risks to flora, fauna, and associated ecological processes, and how these risks may be mitigated or managed through the design, siting, and operation of the wind farm (Department of State Development, Infrastructure, Local Government and Planning, 2023).

1.4. Legislation

Environmental Protection Act 1994 (Queensland)

The *Environmental Protection Act 1994* (EP Act) is Queensland's primary piece of environmental legislation. The objective of the EP Act is to 'protect Queensland's environment while allowing for development that improves the total quality of life, both now and in the future, in a way that maintains the ecological processes on which life depends'. The EP Act ensures adherence to the protection and conservation of protected matters listed in Queensland's other key pieces of legislation such as the *Nature Conservatio*n Act *1992,* the *Water Act 2000,* and the *Vegetation Management* Act *1999.*

Environment Protection and Biodiversity Conservation Act 1999 (Commonwealth)

The *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) is the Commonwealth Government's key piece of environmental legislation. It provides a legal framework to protect and manage nationally and internationally important flora, fauna, ecological communities, and heritage places — defined in the EPBC Act as Matters of National Environmental Significance (MNES).

MNES under the EPBC Act are:

- World Heritage Properties;
- National Heritage Places;
- Wetlands of international importance (listed under the Ramsar Convention);
- Nationally threatened species and ecological communities;
- Migratory species;
- Commonwealth marine areas;
- The Great Barrier Reef Marine Park;
- Nuclear actions (including uranium mining); and
- A water resource, in relation to coal seam gas and large coal mining developments.

Actions that have, will have or are likely to have a significant impact on MNES are called "controlled actions" and require approval under the EPBC Act.

Nature Conservation Act 1992

The *Nature Conservation Act 1992* (NCA), the Nature Conservation (Animals) Regulation 2020 and the Nature Conservation (Plants) Regulation 2020 provide a legislative framework for the protection and conservation of Queensland's native plants and animals.

Under the framework, species of conservation significance are assessed and categorised with respect to population, distribution and potential threats and impacts.

The objectives of the NCA are achieved through an integrated and comprehensive conservation strategy that protects and conserves threatened and special interest species and their habitat, and protected areas.

State Code 23: Wind farm development

The DRM wind farm project is to be assessed under the EP Act however as no criteria for assessment within the legislation relates to the construction of a wind farm the Department of Environment, Science and Innovationhave indicated that an assessment of the Project using performance outcomes of state development code State Code 23: Wind farm development will be sufficient for the application.

The purpose of State Code 23 is to ensure that the impacts arising from the construction, operation, and decommissioning of wind farms do not result in unacceptable adverse impacts on individuals, communities, and the natural environment. Under State code 23, the relevant Performance Outcomes (PO) were considered as part of the impact assessment to ensure adherence to standards of assessment. The following relevant PO were considered as part of this assessment.

- PO1 Development is designed and sited to ensure that threatened species and associated habitats and areas of high environmental value are protected from adverse impacts;
- PO2 Development is constructed to ensure that threatened species and associated habitats, and areas of high environmental value are protected from adverse impacts;
- PO3 Development operations ensure that threatened species and birds and bats are protected from adverse impacts;
- PO4 Development operations ensure that areas cleared for the construction of a wind farm are replanted to the maximum extent possible following construction without impeding operations and maintenance of the wind farm;
- PO5 ensures that the wind farm, including ancillary infrastructure, is designed and sited to minimise crossings of and interference with natural drainage lines and watercourses;

Level of assessment and ecological methodology

Assessment benchmarks for a proposed wind farm are set in the State Development Assessment Provisions (SDAP) under the Planning Regulation 2017 Schedule 10, Part 21, Division 2, Table 1. A wind farm may be code or impact assessable, with the State Assessment and Referral Agency (SARA) is the assessment manager.

State Code 23: Wind Farm Development (State Code 23) is part of SDAP, it applies to a material change of use for a new or expanding wind farm. The code's object is to protect individuals, communities and the environment against impacts from the construction, operation and decommissioning of a wind farm development.

Section 3.3 of the Planning guidance State code 23: Wind farm development February 2022 lays out how the code can be demonstrated. More detail is provided in Appendix 1 - Ecological assessment

methodology, including the desktop and field study specifications for a Bird and Bat Utilisation Survey (BBUS).

2. Methodology

Methodology for this BBUS is based on previous work from the Dugald River Project by EcoSmart Ecology, as well as other existing scientific literature such as the Wind Farms and Birds: Interim Standards For Risk Assessment (Brett Lane & Associates Pty Ltd, 2005). This survey first involved a comprehensive desktop assessment and review of available data, including survey data from previous ecological studies. Following this, a specific survey methodology was formulated to ensure comprehensive assessment of the Project area.

2.1. Desktop Assessment

A desktop assessment of available literature and prior studies was conducted to provide a contextual background on the bird and bat species known to occur or having the potential to occur within the site. Comprehensive desktop assessments were undertaken in WTS's Ecological Assessment Report (EAR) report, which provided a basis for this Bird and Bat Utilisation Survey Report (Wulguru Technical Services, 2023). A review of the extensive ecological survey history of the Dugald River Project Area was completed with particular reference to likelihood of occurrence for key bird/bat species, Migratory species overflight routes and general species profiles.

2.2. Bird Utilisation Surveys

2.2.1. Before and After Control Impact (BACI) Survey Design

Surveys utilise a Before and After Control Impact (BACI) survey design as is recommended in Appendix 1 of the planning guidance produced by the Department of State Development, Infrastructure, Local Government and Planning (2023).

A BACI design includes reference sites placed at a sufficient distance (>500m), from the proposed turbine locations to obtain data outside the zone of influence of the turbines. Data is collected at pre-determined points, with consideration of local weather, site use seasonality and the likelihood of any migratory stopovers or overflight of the locality.

Data is captured to allow for a collision risk assessment to estimate the potential likelihood and consequence of turbine collisions.

2.2.2. BBUS Methodology

Bird utilisation surveys were conducted at 12 locations across the Knapdale Range. The 12 sites were surveyed three times, each at a different time of the day. Surveys were split into sunrise, midday and sunset periods. Most diurnal birds are generally more vocal and active earlier in the day (Keast, 1984) (Bibby, Burgess, & Hill, 1982) (Slater, 1994) (Drapeau, Leduc, & McNeil, 1999), with calling often starting before sunrise. Some birds, however, prefer to call in the evening and may continue after sunset. The larger soaring birds are typically easier to detect later in the day when thermals form.

Similarly, the likelihood of detecting nocturnal birds usually differs over the course of the night and is typically greater just after dusk and before dawn (Kavanagh & Peake, 1993) (Debus, 1995). Due to the obvious restrictions imposed by surveying in the dark, it is not viable to accurately record nocturnal species with the BBUS methodology at night. Bibby et al. 2001 determine search for active individuals the most appropriate survey method for nocturnal species at dawn and dusk (Bibby, Jones, & Marsden, 2000), and therefore there is potential to detect nocturnal species during these periods. As such the sunrise survey period occurred in the two hours immediately following sunrise (~6:50am – 8:50am), midday surveys were conducted an hour either side of midday (11am – 1pm), and sunset surveys were conducted in the two hours prior to sunset (~4:25pm – 6:25pm).

Each observational survey lasted 20 minutes, with each site receiving a total of 60 minutes of survey effort. Surveys followed a "fixed-point count" methodology where an observer is stationed at a fixed survey point and records all incidents of birds present.

BBUS and Incidental Observations

Observations of birds (and theoretically diurnally flying bats) during the survey periods are broken into "BBUS" and incidental observations. BBUS observations are those which include individuals observed to be flying above the predominant canopy. These observations do not include individuals that briefly fly out of the canopy layer at a low height. All other observations, including positively identified calls, are considered to be incidental observations only. For each BBUS observation, the following data is recorded:

- Species
- Number of individuals
- Estimated distance from observer
- Estimated height above observer
- Bearing to record
- Direction of flight
- Behaviour
- Any additional notes on the observation

2.2.3. Prior studies

Initial BBUS surveys by EcoSmart Ecology took place in May and September of 2023. These surveys selected four of the eight initially proposed turbine locations as permanent "impact" sites. Comparable "control" locations were also established in adjacent habitat at least 500m from proposed turbine locations.

2.2.4.Survey Locations

The survey design is comprised of 12 locations were surveyed sites, four impact sites and eight control sites. These 12 survey sites included eight established sites from the original BBUS surveys completed by EcoSmart Ecology as well as four new control sites to increase survey coverage of the Knapdale

Range. Impact and control sites are to be monitored twice yearly, once post-wet season and once pre-wet season during construction and operational phases of the project. These survey locations are outlined in Table 1 below.

Table 1: BBUS survey site locations

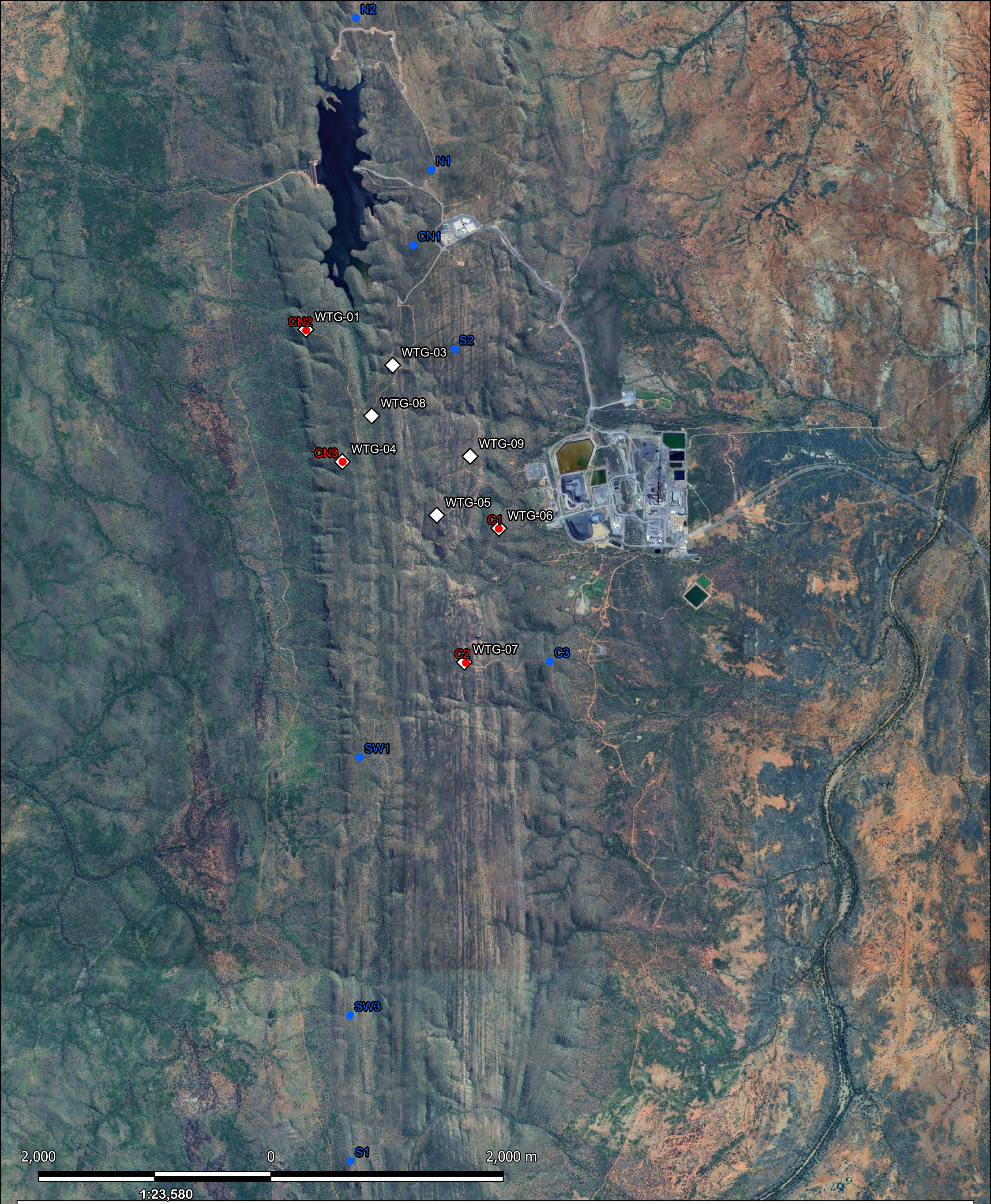
Site (status)	Description	Regional Ecosystem	Representative photograph (North)
C1 (Impact)	Low woodland of *Eucalyptus leucophloia* with *Corymbia capricornia, Grevillea striata* and *Acacia monticola*. A significant subcanopy of *Acacia monticola* is present with a mixed shrub layer predominantly of *Acacia sp*, *Grevillea striata, Carissa lanceolata* and *Santalum lanceolatum*. The ground layer is largely *Triodia pungens*.	1.11.2a	
C2 (Impact)	Low open woodland of *Eucalyptus leucophloia* and *Corymbia capricornia*. A significant subcanopy of *Acacia monticola* is present with some *Acacia humifusa*. The ground layer is largely *Triodia pungens*.	1.11.2a	

C3 (Control)	Low open woodland of *Eucalyptus leucophloia* and *Corymbia capricornia* with rare *Eucalyptus leucophylla*. The shrub layer is largely made up of *Tephrosia sp*, *Acacia humifusa* and *Acacia monticola*. The ground layer is largely *Triodia pungens*.	1.11.2a	
CN1 (Control)	Low shrubby woodland of *Acacia monticola* with some *Eucalyptus leucophloia*. A sparse shrub layer of *Santalum lanceolatum, Acacia humifusa* and *Eremophila latrobei* is present. The ground layer is largely *Triodia pungens*.	1.11.2a	
CN2 (Impact)	Low open woodland primarily of *Eucalyptus leucophloia*. A significant subcanopy of *Acacia monticola* is present with some *Acacia humifusa*. The ground layer is largely *Triodia pungens* with some *Grevillea dryandri*.	1.11.2a	

CN3 (Impact)	Low open woodland primarily of *Eucalyptus leucophloia*. A significant subcanopy of *Acacia monticola* is present with some *Acacia holosericea* and *Santalum lanceolatum*. The ground layer is largely *Triodia pungens* with some *Grevillea dryandri*.	1.11.2a	
N1 (Control)	Low open woodland of *Eucalyptus leucophloia* with some *Corymbia capricornia*. A subcanopy of *Acacia monticola* and *Acacia holosericea* is present with a shrub layer of juvenile canopy and subcanopy species as well as *Eremophila latrobei and Santalum lanceolatum*. The ground layer is largely *Triodia pungens*.	1.11.2a	
N2 (Control)	Low open woodland of *Corymbia capricornia* and *Eucalyptus leucophloia*. A subcanopy of *Acacia monticola* is present with a shrub layer of *Acacia humifusa*. The ground layer is dominated by *Triodia pungens* and *Grevillea dryandri*.	1.11.2a	

S1 (Control)	Low open woodland of *Eucalyptus leucophloia*. A shrub layer primarily consisting of *Acacia humifusa* is present. The ground layer is *Triodia pungens*.	1.11.2a	
S2 (Control)	Low open woodland of *Corymbia capricornia* and *Eucalyptus leucophloia*. A significant subcanopy of *Acacia monticola* is present with a shrub layer including *Acacia humifusa, Acacia monticola* and *Grevillea striata*. The ground layer is dominated by *Triodia pungens* and *Grevillea dryandri*.	1.11.2a	
SW1 (Control)	Low open woodland of *Eucalyptus leucophloia* with a significant subcanopy of *Acacia monticola* also present. The ground layer is dominated by *Triodia pungens*.	1.11.2a	

SW3 (Control)	Low open woodland of *Eucalyptus leucophloia* and *Acacia monticola*. A shrub layer of *Acacia monticola, Acacia humifusa* and *Santalum lanceolatum* is present. The ground layer is dominated by *Triodia pungens*.	1.11.2a	



Client: MMG Dugald River Mine Pty Ltd
Project number: 2024.04001
CRS: EPSG 7844
Date: 13/05/2024

Print as A3

Figure 1. Wind turbine locations and BBUS sites

Legend

BBUS sites
- Control
- Impact

Turbine locations

Disclaimer:
Whilst every effort and care has been taken to ensure the accuracy of this report, Wulguru Technical Services Pty Ltd makes no representations or warranties about its accuracy, reliability, completeness or suitability for any particular purpose and disclaims all responsibility and all liability (including without limitation, liability in negligence) for all expenses, losses, damages (including indirect or inconsequential damage) and costs which you might incur as a result of the product being inaccurate or incomplete in any way and for any reason.
Digital data for this report is available on the Queensland Government Spatial Portal at https://qldspatial.information.qld.gov.au.

WULGURU TECHNICAL SERVICES

2.3. Bat Utilisation Surveys

2.3.1. Acoustic Detection

One Anabat Chorus bat detector was installed at each of the 12 survey sites for two nights. These passive detectors were set to record in full spectrum .wav files from one hour before sunset to one hour after sunrise. Bat detectors were installed at approximately two metres high on canopy trees and placed near flyways or likely areas of bat activity.

3. Results

3.1. Desktop Results

3.1.1. Regional Context and Climate

The Project is situated centrally on the Knapdale Range which falls within the Northwest Highlands bioregion, and is surrounded North, East, and West by the Gulf Plains bioregion.

The Project area lies on the boundary of the Leichhardt Basin and the Flinders Basin. Drainage from the Knapdale range flows to stream order five watercourse Cabbage Tree Creek of the Leichhardt River sub-basin to the north and west and to stream order five watercourse Dugald River of the Cloncurry River sub-basin to the east and south. Watercourses in the Project area itself are unnamed stream order one and two and are typically non-perennial though rocky waterholes that may persist through the dry season are known to occur in the upper catchments of these smaller drainage features.

A summary of data from weather station 0291411 at the Cloncurry Airport indicate that temperatures in the region tend towards mild to cool dry winters with lowest mean minimums temperatures around 10°C in July. December is the month with the highest mean maximum temperature of 38.8°C. Summers are typically hot and wet with heavy tropical rain events common in this period. Mean annual rainfall for the region is 500 mm. The three months prior to the April 2024 BBUS surveys received approximately 60% more than the average rainfall for this period.

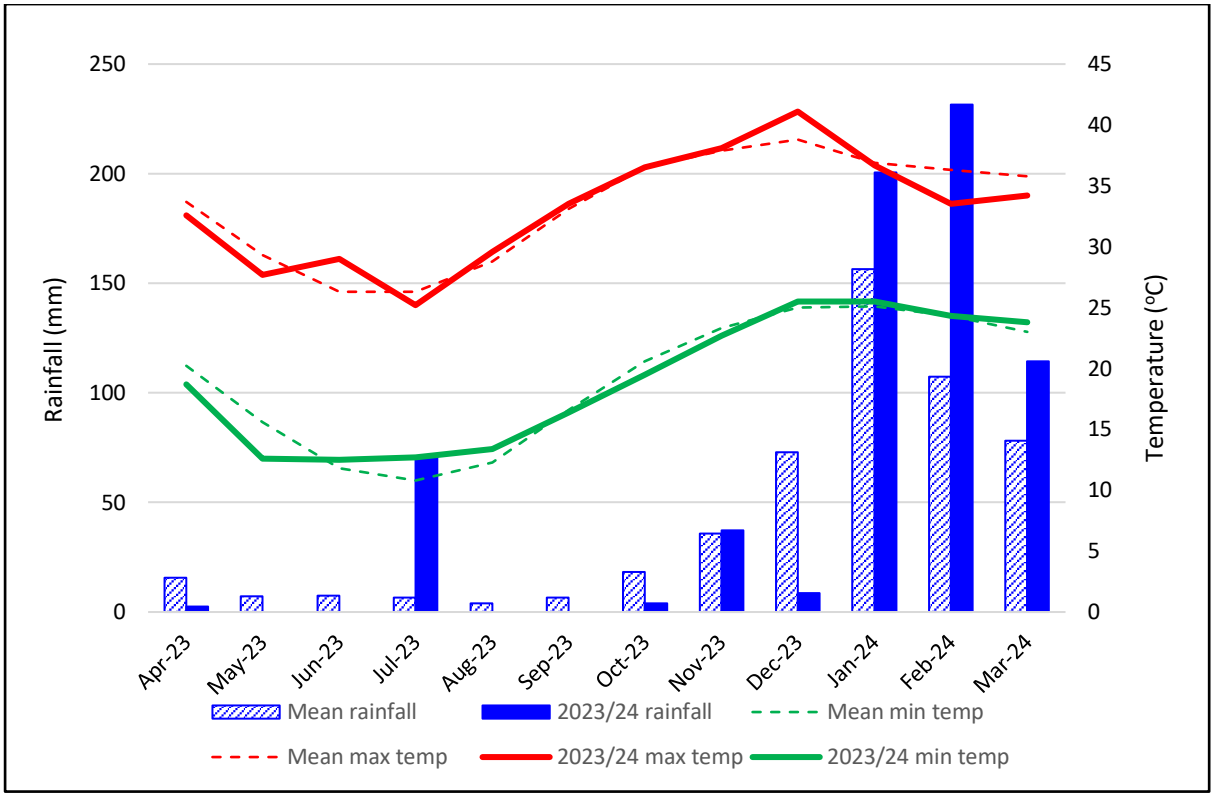


Figure 2: Climate statistics in at Cloncurry Airport weather station (029141) 2023-2024

3.1.2. Geology and Soils

The geology of the Knapdale Range is characterized by the fine-grained pink and white Knapdale Quartzites. It is bordered to the west by Lady Clayre Formation siltstones and dolostone and Coocerina Formation mudstone and bound by Mount Roseby Schist intermingled with poorly consolidated sediment and to the east.

The DRM infrastructure is located at on grassy plains approximately 200 m (AHD) elevation. The rolling hills of the Knapdale Range reach maximum elevations of approximately 300 m AHD, declining in all directions into grassy plains. The wind farm is proposed to be located on the Knapdale Range at elevations between 270-290 m AHD.

3.1.3. Land Zones

The Knapdale Range and immediate surrounding area is mapped as Land zone 11: Mesozoic/Proterozoic metamorphosed sediments and interbedded volcanics. At a local scale this is intersected by Land zone 3: alluvial soils associated with the smaller drainage line features associated with the range. Land zone 7: Cainozoic duricrusts is also mapped to occur within the Project area, though has not been specifically observed during ground-truthing surveys.

3.1.4. Regional Ecosystems

Regional Ecosystems (REs) mapped for the broader Dugald River Project Area are largely heterogeneous (mixed) polygons, with the vast majority of the Knapdale Range itself contained within

a single mapped polygon of RE 1.11.2a/1.11.2x1(1.7.7a). All survey site locations for the BBUS field study are contained within this polygon aside from C1, which is within a polygon mapped as 1.11.2a/1.11.2e. Ground-truthing of survey site REs during field surveys identified very similar vegetation at each of the 12 sites. Broadly, each site was characterised by a low canopy dominated by *Eucalyptus leucophloia* and/or *Corymbia capricornia,* with a significant subcanopy or tall shrub layer of predominantly *Acacia monticola* and a ground layer of *Triodia pungens*. This vegetation conforms to RE 1.11.2a. Given the parameters for the selection of proposed wind turbine sites, including the height and position on the Knapdale Range, it is unsurprising that vegetation at each of the survey sites is similar.

Table 2: Regional Ecosystems within the Project area

Regional Ecosystems	Long Description	VM Status*	BD Status#	Special Values
1.11.2a	*Eucalyptus leucophloia* low open woodland often with *Corymbia terminalis, Corymbia capricornia, Terminalia aridicola* and *Eucalyptus leucophylla* with shrub layer of *Acacia spp.* and ground layer of *Triodia spp.* Occurs on steep hills and strike ridges.	LC	NC	1.11.2: Potential habitat for NCA listed species: *Eucalyptus nudicaulis*, *Ipomoea antonschmidii*, *Solanum carduiforme*, *Trachymene glandulosa*.
1.11.2e now 1.11.3a	Low open woodland of *Corymbia terminalis* and/or *Eucalyptus leucophylla* with *Acacia* spp. dominated shrub layer and ground layer of *Triodia* spp. and/or tussock grasses. Includes areas of *Acacia* spp. shrubland and *Triodia* spp. grassland. Occurs on metabasalts and dolerites; some felsic metavolcanics; skeletal soils, some shallow loams. Not a Wetland. (BVG1M: 19b).	LC	NC	1.11.3: Potential habitat for NCA listed species: *Eucalyptus nudicaulis*.
1.11.2x1 now 1.7.7a	Low open woodland of *Corymbia capricornia*, commonly with *Eucalyptus leucophloia*. *Eucalyptus miniata*, *Eucalyptus herbertiana* and *Corymbia ferruginea* are commonly present in the north. Mixed shrub layer usually including *Grevillea wickhamii*. Ground layer of *Triodia* spp. and *Schizachyrium fragile*. Occurs on silcrete. Not a Wetland. (BVG1M: 19a).	LC	NC	1.7.7: Potential habitat for NCA listed species: *Ipomoea antonschmidii*.

3.2. Field Surveys

3.2.1. Survey Timing and Conditions

Surveys by WTS were completed from the 16th – 21st of April 2024. This period experienced variable conditions, with the onset of seasonal cooler weather occurring in earlier in the month. Higher than average winds were also experienced during this period.

3.2.2. Bat Field Survey Results

Approximately 68,000 files were recorded across 24 detector nights at 12 sites. These files were then analysed by Professor Simon Robson, an expert with over 30 years of experience in the microbat study field. Professor Robson provided a report on this data which is attached (Appendix A).

Analysis of data collected identified 10 species of microbat as present at the windfarm BBUS survey sites. None of these species are listed as Endangered, Vulnerable or Near Threatened at either the State or Federal level. Three additional bat species were recorded during previous bat surveys by EcoSmart Ecology. The following bat species have been recorded from the Project area (species previously recorded by EcoSmart Ecology are also included here).

- Northern free-tailed bat (*Chaerephon jobensis*)
- Gould's wattled bat (*Chalinolobus gouldii*)
- Hoary wattled bat (*Chalinolobus nigrogriseus*)
- Lesser long-eared bat (*Nyctophilus geoffroyi*)
- Lumsden's free-tailed bat (*Ozimops lumsdenae*)
- Yellow-bellied sheathtail bat (*Saccolaimus flaviventris*)
- Inland broad-nosed bat (*Scotorepens balstoni*)
- Bristle-faced free-tailed bat (*Setirostris eleyri*)
- Common sheathtail bait (*Taphozous georgianus*)
- Inland cave bat (*Vespadelus finlaysoni*)
- Litte broad-nosed bat (*Scotorepens greyii*) (EcoSmart)
- Inland forest bat (*Vespadelus baverstocki*) (EcoSmart)
- White-striped free-tailed bat (*Austronomus australis*) (EcoSmart)

As bat presence is measured entirely by call monitoring, relative abundance of bats species is not able to be accurately estimated. Many factors influence the detectability of bat calls, including flight height, distance from recorder, weather and other variables. Additionally, repeated recordings of singular or small numbers of individuals flying close to the bat detector can significantly skew abundance data. As such, for this report we consider bat call records as a confirmation of presence only and not a determinant of relative bat abundance. Table 2 below shows abundance data from this survey alongside data from the previous BBUS surveys completed by EcoSmart Ecology in 2023. Site specific bat presence data for April 2024 surveys is available in Appendix B.

Table 3: BBUS Bat Species Records

Confidence	*Scientific Name* Common Name	Status*		Presence of calls		
		NCA	EP BC	May-23 (EcoSmart)	Sep-23 (EcoSmart)	Apr-24 (WTS)
Positive Identification	*Chalinolobus gouldii* Gould's Wattled Bat	LC		YES	YES	YES
	Taphozous sp.			YES	YES	
	Taphozous georgeanis Common Sheathtail Bat	LC				YES
	Chaerephon jobensis Northern Freetail Bat	LC		YES	YES	YES
	Saccolaimus flaviventris Yellow-bellied Sheathtail Bat	LC		YES	YES	YES
	Scotorepens greyii Little Broad-nosed Bat	LC		YES	YES	
	Setirostris eleyri Bristle-faced Free-tailed Bat	LC				YES
	Vespadelus baverstocki Inland Forest Bat	LC		YES	YES	
	Chalinolobus nigrogriseus Hoary Wattled Bat	LC		YES	YES	YES
	Vespadelus finlaysoni Finlayson's Cave Bat	LC		YES	YES	YES
	Ozimops lumsdenae Northern Free-tailed Bat	LC		YES	YES	YES
	Scotorepens balstoni Inland Broad-nosed Bat	LC		YES	YES	YES
	Ozimops sp.			YES	YES	
	Austronomus australis White-striped Freetail Bat	LC		YES	YES	YES
	Nyctophilus geoffroyi Lesser Long-eared Bat					YES
	Nyctophilus sp.			YES	YES	
Uncertain Identification	*C. gouldii* or *Ozimops* sp.			YES	YES	
	C. nigrogriseus or *S. greyii*			YES	YES	
	S. greyii or *V. baverstocki*			YES	YES	
	C. gouldii or *S. balstoni*			YES	YES	
	O. lumsdenae or *Taphozous* sp.			YES	YES	
	S. balstoni or *Ozimops* sp.			YES	YES	

Five species of microbat, Gould's wattled bat, the little broad-nosed bat, the northern free-tailed bat, the common sheath-tailed bat and the white-striped free-tailed bat are considered to have the potential to enter the RSA while foraging. Of these, the white-striped free-tailed bat is considered the highest collision risk and have been regular casualties in prior studies, largely due to its high-flying foraging behaviour (Bennett, 2022). The remainder of the bat species detected during surveys generally fly well below the RSA height. A full table of flight heights and collision risks is available in WTS's BBMP (Wulguru Technical Services, 2024).

3.2.3. Bird Field Survey Results

During the April 2024 BBUS campaign, 36 individual surveys across the 12 sites recorded a total of 176 instances of birds. Of these, 49 records met the BBUS criteria, with the rest considered supplementary incidental records. BBUS records consisted of 16 species of bird, with the little woodswallow the most frequently recorded of these, while the masked woodswallow was the most abundant (a single observation of a very large flock, ~200 individuals). The species recorded during BBUS surveys in April 2024 are listed below.

- Little woodswallow (*Artamus minor*)
- Varied lorikeet (*Psitteuteles versicolor*)
- Black-faced woodswallow (*Artamus cinereus*)
- Wedge-tailed eagle (*Aquila audax*)
- Black-faced cuckoo-shrike (*Coracina novaehollandiae*)
- Nankeen kestrel (*Falco cenchroides*)
- Rainbow bee-eater (*Merops ornatus*)
- Little friarbird (*Philemon citreogularis*)
- Australasian darter (*Anhinga novaehollandiae*)
- Black kite (*Milvus migrans*)
- Brown falcon (*Falco berigora*)
- Masked woodswallow (*Artamus personatus*)
- Pied butcherbird (*Cracticus nigrogularis*)
- Whistling kite (*Haliastur sphenurus*)
- White-faced heron (*Egretta novaehollandiae*)
- Willie wagtail (*Rhipidura leucophrys*)

Activity across the 12 survey sites was broadly similar during the April survey period. Due to the general habitat similarity between all survey sites, the entirety of the Knapdale Range is considered likely to have very similar patterns of bird and bat activity. Table 3 below shows abundance data from this survey alongside data from the previous BBUS surveys completed by EcoSmart Ecology in 2023. Site specific bird presence data for April 2024 surveys is available in Appendix B.

Table 4: BBUS Bird Species Records

Within/Outside Rotor-swept Area (RSA)	Common Name (*Scientific Name*)	Status*		Count			
		NCA	EPBC	May-23 (EcoSmart)	Sep-23 (EcoSmart)	Apr-24 (WTS)	Total
Within RSA	Australasian Darter (*Anhinga novaehollandiae*)	LC				2	2
	Black Kite (*Milvus migrans*)	LC			1	1	2
	Black-faced Woodswallow (*Artamus cinereus*)	LC			18	11	29
	Black-shouldered Kite (*Elanus axillaris*)	LC		1			1
	Brown Falcon (*Falco berigora*)	LC		2	1		3
	Fairy Martin (*Petrochelidon ariel*)	LC			12		12
	Little Woodswallow (*Artamus minor*)	LC		5	28	30	63
	Masked Woodswallow (*Artamus personatus*)	LC				200	200
	Nankeen Kestrel (*Falco cenchroides*)	LC				1	1
	Rainbow Bee-eater (*Merops ornatus*)	LC	M			9	9
	Varied Lorikeet (*Psitteuteles versicolor*)	LC			1		1
	Wedge-tailed Eagle (*Aquila audax*)	LC		1		4	5
	Whistling Kite (*Haliastur sphenurus*)	LC		1		1	2
	White-faced Heron (*Egretta novaehollandiae*)	LC				1	1
	White-necked Heron (*Ardea pacifica*)	LC		2			2
Outside RSA	Australian Raven (*Corvus coronoides*)	LC		1	1		2
	Black-breasted Buzzard (*Hamirostra melanosternon*)	LC			2		2
	Black-faced Cuckoo-shrike (*Coracina novahollandiae*)	LC		1	11	8	20
	Black-faced Woodswallow (*Artamus cinereus*)	LC		1	1	4	6
	Black-shouldered Kite (*Elanus axillaris*)	LC			1		1
	Brown Falcon (*Falco berigora*)	LC		2			2
	Brown Goshawk (*Accipiter fasciatus*)	LC		2			2
	Budgerigar (*Melopsittacus undulatus*)	LC		22	15		37
	Cockatiel (*Nymphicus hollandicus*)	LC			7		7
	Diamond Dove (*Geopelia cuneata*)	LC			43		43
	Eastern Great Egret (*Ardea alba*)	LC		2			2
	Fairy Martin (*Petrochelidon ariel*)	LC		1	18		19
	Galah (*Eolophus roseicapilla*)	LC			2		2
	Grey-fronted Honeyeater (*Ptilotula plumula*)	LC		7	7		14
	Grey-headed Honeyeater (*Ptilotula keartlandi*)	LC		2	3		5
	Little Friarbird (*Philemon citreogularis*)	LC		7	3	3	13
	Little Woodswallow (*Artamus minor*)	LC		4	21	45	70
	Mistletoebird (*Dicaeum hirundinaceum*)	LC		1	8		9
	Nankeen Kestrel (*Falco cenchroides*)	LC				2	2
	Painted Finch (*Emblema pictum*)	LC		2			2
	Pied Butcherbird (*Cracticus nigrogularis*)	LC		1		1	2
	Rainbow Bee-eater (*Merops ornatus*)	LC	M		1	1	2
	Rufous-throated Honeyeater (*Conopophila rufogularis*)	LC			2		2
	Silver-crowned Friarbird (*Philemon argenticeps*)	LC		1			1
	Varied Lorikeet (*Psitteuteles versicolor*)	LC		6	18	27	51
	Wedge-tailed Eagle (*Aquila audax*)	LC				1	1
	Willie Wagtail (*Rhipidura leucophrys*)	LC			1	1	2
	Zebra Finch (*Taeniopygia guttata*)	LC		6	1		7

* NCA = *Nature Conservation Act 1992*; EPBC = *Environment Protection and Biodiversity Conservation Act 1999*; CR = Critically Endangered; EN = Endangered; VU = Vulnerable; NT = Near Threatened; SLC = Special Least Concern; LC = Least Concern; Mi = Migratory; M = Marine

The most abundant birds considered to be at higher risk can be broadly grouped into two categories – raptors and aerial insectivores. These groups both frequently fly and feed in the proposed RSA, leading to increased likelihood of interaction with turbines.

3.2.3.1. Raptors

Raptors are typically recorded as individuals or in pairs or small groups, frequently recorded thermaling in the updrafts created by wind contacting Knapdale range. Raptors include the following species recorded during BBUS surveys (species previously recorded by EcoSmart Ecology are also included here):

- Black kite (*Milvus migrans*)
- Brown falcon (*Falco berigora*)
- Nankeen kestrel (*Falco cenchroides*)
- Wedge-tailed eagle (*Aquila audax*)
- Whistling kite (*Haliastur sphenurus*)
- Black-shouldered kite (*Elanus axillaris*) (EcoSmart)
- Black-breasted buzzard (*Hamirostra melanosternon*) (EcoSmart)
- Brown goshawk (*Accipiter fasciatus*) (EcoSmart)

The following species have not been recorded in BBUS surveys though are known to inhabit the site, having been recorded during previous fauna surveys within the Project area.

- Australian hobby (*Falco longipennis*)
- Black falcon (*Falco subniger*)
- Collared sparrowhawk (*Accipiter cirrocephalus*)
- Spotted harrier (*Circus assimilis*)

3.2.3.2. Aerial insectivores

Aerial insectivores are insectivorous species predominantly foraging on airborne insects. For this report, all woodswallows species have been considered, along with the fairy martin and rainbow bee-eater as aerial insectivores. The following species were recorded on site during BBUS surveys (species previously recorded by EcoSmart Ecology are also included here):

- Black-faced woodswallow (*Artamus cinereus*)
- Little woodswallow (*Artamus minor*)
- Masked woodswallow (*Artamus personatus*)
- Rainbow bee-eater (*Merops ornatus*)
- Fairy martin (*Petrochelidon ariel*) (EcoSmart)

The following species have not been recorded in BBUS surveys though are known to inhabit the site.

- White-breasted woodswallow (*Artamus superciliosus*)
- White-browed woodswallow (*Artamus leucorynchus*)

3.2.4.Threatened and Migratory Species

No listed EVNT bird or bat species have been recorded during BBUS surveys. One listed migratory bird species, the glossy ibis, has historically been recorded from the Project area, though has not been recorded during BBUS surveys. The Project area may be overflown by several migratory bird species during annual events. These species include the sharp-tailed sandpiper (*Calidris acuminata*), Latham's Snipe (*Gallinago hardwickii*), the Caspian tern (*Hydroprogne caspia*) and the common greenshank (*Tringa nebularia*). In depth modelling of flight paths for these species is available in WTS's Ecological Assessment Report (Wulguru Technical Services, 2023). Presence of listed Migratory bird species within the windfarm area are likely largely restricted to very rare flyovers.

In addition to international migratory events, other species may migrate or be broadly nomadic within Australia, resulting in mass movements and therefore increased risk of interaction with turbines. The masked woodswallow travels northward from its breeding habitat in southern Australia in Autumn, often arriving in extensive flocks mixed with other woodswallow species (Pizzey & Knight, 2012). A large flock (~240 total birds) of masked woodswallows (~200), little woodswallows (~20) and black-faced woodswallows (~20) was recorded during the sunrise survey period at SW3. Given the timing, this observation is potentially part of the annual arrival of the masked woodswallow to the area. It should also be noted here that the masked woodswallow is not a listed Migratory species, but large-scale movements like these likely increase the risk of collisions with turbines.

3.2.5. Flight Heights

Observed flight heights of birds were recorded to assess the risk of collisions. All BBUS records are categorised into either within the RSA (rotor swept area of the turbine) or outside of the RSA. The rotor swept area was considered for the largest possible turbine, the Goldwind GW 165-5.2/5.6/6.0MW. This rotor has a blade diameter of 165 m and a hub height of 130 m. The rotor swept area is between the heights of 47.5 and 212.5m above ground level.

14 bird species have been recorded in the proposed RSA by WTS or EcoSmart Ecology. These are shown in Table 2 below.

Table 5: Bird Species Recorded Within the Rotor Swept Area

Species	Total Recordsi	Records within RSA	% within RSA
Black kite (*Milvus migrans*)	2	2	100
Black-shouldered kite (*Elanus axillaris*)	2	1	50
Brown falcon (*Falco berigora*)	5	3	60
Nankeen kestrel (*Falco cenchroides*)	3	1	33.3
Wedge-tailed eagle (*Aquila audax*)	6	5	83.3
Whistling kite (*Haliastur sphenurus*)	4	4	100
Black-faced woodswallow (*Artamus cinereus*)	35	29	82.9
Little woodswallow (*Artamus minor*)	133	63	47.4

Species	Total Recordsi	Records within RSA	% within RSA
Masked woodswallow (*Artamus personatus*)	200	200	100
Rainbow bee-eater (*Merops ornatus*)	11	9	81.8
Fairy martin (*Petrochelidon ariel*)	31	12	38.7
Australasian Darter (*Anhinga novaehollandiae*)	2	2	100
Varied Lorikeet (*Psitteuteles versicolor*)	52	1	1.9
White-faced Heron (*Egretta novaehollandiae*)	1	1	100
White-necked Heron (*Ardea pacifica*)	2	2	100

3.3. Collision Risk and Consequence

The risk of a bird or bat colliding with a wind turbine is affected by both the turbine design and the ecology of the species of concern. A simple risk assessment adapted from one used by BASE consulting (BASE Consulting, 2022), was used to identify the susceptibility of species to turbine interaction for both bats and birds. Assessments for bird collision risks are shown in Table 2 and Table 3 and for bats in Table 4.

Table 6: Bird Collision Risk Assessment Table

Risk Characteristics	Criteria	Score
Flight height Expected frequency a species enters the RSA.	Never – Species not expected to enter RSA	0 – Negligible
	Occasional – Species is typically present outside of RSA but may enter infrequently.	5 – Low
	Regular – Species may regularly enter RSA, but majority of records are outside RSA.	10 – Medium
	Predominant – Species within RSA most of the time while in flight.	15 – High
Movements and biology Annual presence of a species within the Project Area.	Rare – Present once or twice per year	0 – Negligible
	Intermittent – Present <1 month of the year	2 – Low
	Seasonal/migration – Present for 1-5 months of the year	5 – Medium
	Resident – Present throughout most of the year (>5 months)	10 – High
Manoeuvrability Size and relative manoeuvrability of the bird species	Small size, highly manoeuvrable	0 – Negligible
	Small size, constrained manoeuvrability or medium size, highly manoeuvrable	2 – Low
	Medium size, constrained manoeuvrability or large size, highly manoeuvrable	4 – Medium
	Large size, constrained manoeuvrability	6 – High

Scores for each of the criteria in the above table were combined to produce an overall value for the Collision Risk Susceptibility in Table 4. Species expected to never fly in the RSA are all considered to have a low Collision Risk Susceptibility regardless of other criteria.

Table 7: Bird Collision Risk Susceptibility Ratings

Collision Risk Scoring	Overall Collision Risk Susceptibility
Risk score 0-10	Low
Risk score 11-20	Moderate
Risk score 21+	High

Table 8: Bat Collision Risk Assessment Table

Risk Characteristic	Criteria	Collision Risk
Flight height Expected frequency a species enters the RSA.	Never – Species not expected to fly at RSA height	Low
	Occasional – Species may fly at RSA height during some scenarios	Moderate
	Frequent – Species regularly flies at RSA heigh	High

From these calculated collision risk assessments, collision consequences are able to be estimated. It is important to note that these values are potential only, and actual consequences must be observed and measured via ongoing monitoring post-construction.

Table 9: Collision Conseqeunce

Collision Consequence	Collision Consequence Criteria
No loss of individuals	• Not previously identified on site or, • Low abundance with low collision risk susceptibility
Rare loss of individuals	• Low abundance with moderate collision risk susceptibility or, • Moderate abundance with low collision risk susceptibility
Occasional loss of individuals	• Low abundance with high collision risk susceptibility or, • Moderate abundance with moderate collision risk susceptibility or, • High abundance with low collision risk susceptibility
Repeated loss of individuals	• Moderate abundance with high collision risk susceptibility or, • High abundance with moderate collision risk susceptibility
Significant loss of individuals	• High abundance with high collision risk susceptibility

Assessments identified no species as having the potential for significant loss of individuals, though four species as having the potential for repeated loss of individuals were identified. These species deemed most as risk to turbine collisions are:

- Black-faced woodswallow (*Artamus cinereus*)
- Little woodswallow (*Artamus minor*)
- Masked woodswallow (*Artamus personatus*)
- Rainbow bee-eater (*Merops ornatus*)

Detailed assessments for all species recorded within the RSA, all possible or known EPBC/NCA listed species, all bat species, and all bird Orders present within the site are available in WTS's Bird and Bat Management Plan (BBMP) (Wulguru Technical Services, 2024).

4. Conclusions

Bird and Bat Utilisation Surveys have to date been completed in three separate campaigns. Most recently by WTS in April 2024 and previously by EcoSmart Ecology in May and September 2023. These surveys have two broad bird groups as being at the greatest risk of mortality through interaction with wind turbines. Due to their regular presence along the ridge lines of the Knapdale Range, and behavioural patterns within the rotor swept area of the proposed wind turbines, raptors and aerial insectivores are considered to be the most likely to be involved in turbine strikes. In particular, it is considered that the three locally abundant woodswallow species (black-faced, little and masked) and the rainbow bee-eater have the potential for repeated loss of individuals via collision with turbines. All other species present or considered possible inhabitants of the site have lower collision risk consequences.

Bat species known to forage well above the canopy are considered to be at the highest risk to collision with turbines. This includes the white-striped free-tailed bat (*Austronomus australis*), Gould's wattled bat (*Chalinolobus gouldii*), the little broad-nosed bat (*Scotorepens greyii*), the northern free-tailed bat (*Chaerephon jobensis*) and the common sheath-tailed bat (*Taphozous georgianus*). While the white-striped free-tailed bat flies well within the RSA and is cited as being susceptible to wind turbine collision, it was one of the least abundant bats on site and as such, has a potential collision consequence of occasional loss of individuals.

Aside from the rainbow bee-eater, which is listed as a Marine species, no EPBC or NC Act listed species are considered to have the potential for anything greater than rare losses of individuals. This includes listed Migratory species, where presence within the Project Area is most likely limited to rare or extremely rare fly overs (Wulguru Technical Services, 2023).

5. Recommendations

WTS has produced a Bird and Bat Management Plan report which provides in depth recommendations for further surveys, monitoring and mitigation of impacts (Wulguru Technical Services, 2024). In short, the following are recommendations for future work:

1. Ongoing BBUS monitoring – BBUS surveys should continue to be conducted biannually prior to the establishment of the wind turbines. These surveys should occur in April/May and

September/October. Increasing monitoring from biannually to quarterly after the establishment of turbines is also recommended. BBUS surveys completed after the installation of turbines should also focus on the avoidance/diversion/displacement behaviour of birds/bats.

2. Carrion monitoring – Surveys for the carcasses of birds and bats should be conducted at each turbine on a monthly basis following the commissioning of the windfarm for the first 48 months of the windfarms operation phase. If a significant level of bird mortality to a regional species or species population is measured, then the monitoring should continue.

3. Scavenging trial – A trial should be undertaken at least twice during the first 48 months of operation during different times of the year. The aim of this trial is to determine the typical rate of removal of carcasses by scavengers, and therefore estimate the likelihood a carcass is detected during carrion monitoring. Outside of the scavenging trial, carcasses should be removed when located to prevent unnecessary attraction of scavengers to the area.

4. Searcher efficiency trial – A trial to determine an observer's efficiency at locating carcasses in the carrion monitoring area should be completed. This may be done prior to the establishment of turbines or during the operational period.

6. References

BASE Consulting. (2022). *Mount James Wind Farm Bird and Bat Management Plan.* Porcupine: BASE Consulting.

Bennett, E. F. (2022). Curtailment as a successful method for reducing bat mortality at a southern Australian wind farm. *Austral Ecology*, 1329-1339.

Bibby, C., Burgess, N., & Hill, D. (1982). Bird Census Techniques. *Academic Press*.

Bibby, C., Jones, M., & Marsden, S. (2000). *Expedition Field Techniques - Bird Surveys.* Cambridge: BirdLife International.

Brett Lane & Associates Pty Ltd. (2005). *Wind Farms and Birds: Interim Standards For Risk Assessment.* Carlton North: Australian Wind Energy Association.

Debus, S. (1995). Surveys of large forest owls in northern New South Wales: methodology, calling behaviour and owl responses. *Corella, Vol. 19*, 38-50.

Department of State Development, Infrastructure, Local Government and Planning. (2023). *Planning Guidance - State code 23: Wind farm development.*

Drapeau, P., Leduc, A., & McNeil, R. (1999). Refining the use of point counts at the scale of individual points in studies of bird-habitat relationships. *Journal of Avian Biology, Vol. 30*, 367-382.

Kavanagh, R., & Peake, P. (1993). *Survey procedures for nocturnal forest birds: an evaluation of the variability in census results due to temporal factors, weather and technique.* Melbourne: Australasian Raptor Association.

Keast, A. (1984). *Assessment of community composition and species richness in contrasting habitats', in Methods of Censusing Birds in Australia.* Melbourne; Perth: Royal Australian Ornithologists Union; Department of Conservation and Environment.

Pizzey, G., & Knight, F. (2012). *The Field Guide to the Birds of Australia.* Sydney: Harper Collins.

Slater, P. (1994). Factors affecting the efficiency of the area search method of censusing birds in open forests and woodlands. *Emu, vol. 94*, 9-16.

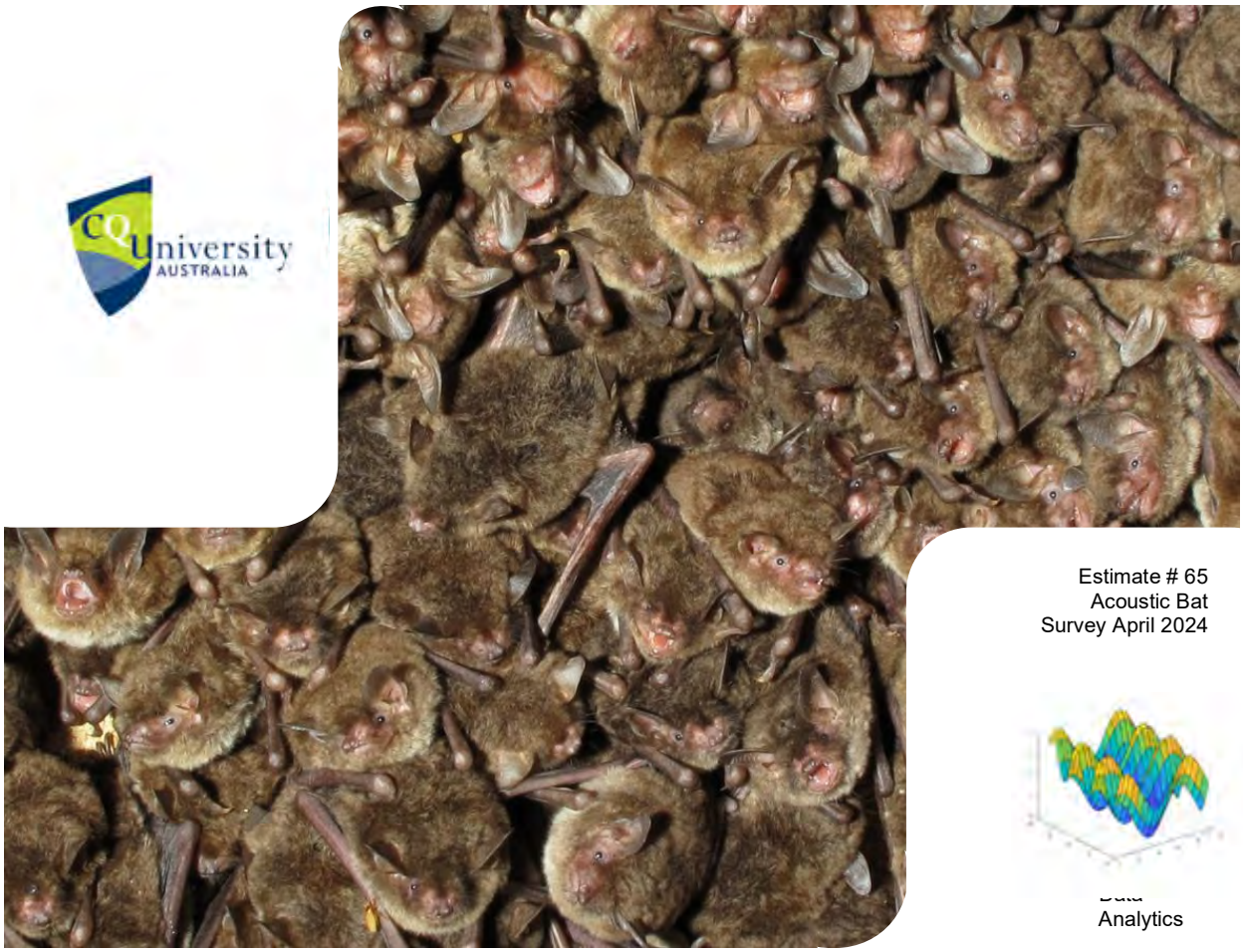
Wulguru Technical Services. (2023). *MMG - Dugald River Windfarm Ecological Assessment Report.*

Wulguru Technical Services. (2024). *MMG - Dugald River Windfarm Bird and Bat Management Plan .*

7. Appendix A: Bat Detection Report

DUGALD RIVER

ACOUSTIC MICROBAT SURVEY REPORT
16 – 21 APRIL 2024



Estimate # 65
Acoustic Bat
Survey April 2024

Analytics

SERVICE PROVIDER	CLIENT
Prof. Simon Robson **Data Analytics** 60 Armstrong St Hermit Park QLD 4812 Ph: + 61 04111 60805 ABN: 67 629 055 786 Simon.Robson99@gmail.com	Dylan Case **Wulguru Tech Services** 559 Flinders St Townsville City QLD 4810 MOB: 0487 449 962 dylan@wulgurutechservices.com.au

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Version	Purpose of document	Authored by	Reviewed by	Approved by	Review date
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Chaerephon jobensis **7**

Chalinolobus gouldii **7**

Chalinolobus nigrogriseus **7**

Ozimops lumsdenae **7**

Nyctophilus geoffroyi **7**

Saccolaimus flaviventris **7**

Scotorepens balstoni **7**

Setirostris eleyri **7**

Taphozous georgianus **8**

Vespadelus finlaysoni **8**

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Executive Summary

Ultrasound surveys of the twelve sites identified ten bat species 1: *Chaerephon jobensis, 2: Chalinolobus gouldii, 3: Chalinolobus nigrogriseus, 4: Nyctophilus geoffroyi, 5: Ozimops lumsdenae, 6: Saccolaimus flaviventris, 7: Scotorepens balstoni, 8: Setirostris eleyri, 9: Taphozous georgianus* and *10: Vespadleus finlaysoni.*

No detected species were listed within the EPBC Act List of Threatened Fauna.
All species were listed as being of Least Concern within the Qld Government Threatened Species Listing.

Scope of Study

To implement ultrasound bat surveys to report on the species of microchiropteran bats present at Dugald River QLD during April 2024, and to provide an analysis of nightly activity patterns for any species of particular conservation interest found.

Material & Methods

Data collection

Ultrasound (.wav) files were recorded for two nights at each of twelve sites at the Dugald river site using Titley Chorus® bat detectors (Table 1).

Identification of bat calls

Call analysis was conducted by Prof. Simon Robson who has over 30 years' experience in the ecology, behaviour and identification of bats (Australia, Central, South and North America, Papua New Guinea, South East Asia) and over 20 years experience in the detection and analysis of bat calls from northern Queensland specifically. The majority of reference calls used in this analysis were obtained during a month-long survey of the bats of Cape York by Robson and colleagues (Reardon *et al*. 2010), which now forms the basis of many conservation decisions concerning the bats of this region.

Sound files (.wav) containing bat calls were detected and analysed with Filters and a Decision Tree program written in Anabat Insight (Titley Electronic ®) in concert with a sound analysis program written in R®.

Filters and Decision Trees were tailored to those microbat species bats that are likely to be found in North Queensland, based on personal records, published records (Churchill 2008, van Dyck *et al*. 2013), on-line records (Atlas of Living Australia) and discussion with other Australian bat researchers.

Relevant call metrics used in the Filters and Decision Trees were similar to those used in other published keys e.g. (Milne 2002, Pennay *et al*. 2004, Reinhold *et al*. 2001), calibrated against a personal reference library of over 1700 calls of bats from the North Queensland Region, collected over the last 20 years as part of Robson's ongoing research into the ecology and behaviour of bats of the region e.g. Hourigan (2001), Hourigan *et al*. (2006), Inkster (2008, 2011), Parsons (2005, 2011), Parsons *et al*. (2006, 2007, 2010, 2011), Reardon *et al*. (2010) and Stiso (2013).

Recent changes in bat taxonomy follow Jackson & Groves (2015), van Dyck *et al.* (2013) and ongoing discussions with the Australian bat research community.

The species pool of bats likely to be present within a 50 km radius of the survey sites was determined using the BatMap function of the Australasian Bat Society https://www.ausbats.org.au/batmap.html. Specific searches were also conducted for Semon's leaf-nosed bat (*Hipposideros semoni*).

The Environmental Protection & Biodiversity Conservation Act and the Nature Conservation Act conservation status of individual species was determined using the EPBC Protected Matters WWW Search Tool https://www.environment.gov.au/cgi-bin/sprat/public/publicthreatenedlist.pl and the NCA WWW Search tool https://apps.des.qld.gov.au/species-search/details/?id=992.

Results and Discussion

A total of 68,365 sound files were collected and examined from the twelve sites of which 5,769 could be identified as bat calls (Table 1). Representative bat calls are provided in Appendix 1.

Ultrasound surveys of the twelve sites identified ten bat species listed as being of Least Concern within the Qld Government Threatened Species Listing, and none were listed within the EPBC Act List of Threatened Fauna. These species are 1: *Chaerephon jobensis, 2: Chalinolobus gouldii, 3: Chalinolobus nigrogriseus, 4: Nyctophilus geoffroyi, 5: Ozimops lumsdenae, 6: Saccolaimus flaviventris, 7: Scotorepens balstoni, 8: Setirostris eleyri, 9: Taphozous georgianus and 10: Vespadleus finlaysoni.*

Table 1. Potential Dugald microbat species pool, their conservation listing and the actual microbat species detected through acoustic ultrasound surveys.

Species possibly present	Common name	EPBC	NCA	C1 16-17 Apr 2024	SW1 18-19 Apr 2024	C2 16-17 Apr 2024	SW3 18-19 Apr 2024	C3 16-17 Apr 2024	S1 19-20 Apr 2024	CN2 17-18 Apr 2024	N1 19-20 Apr 2024	CN1 17-18 Apr 2024	S2 19-20 Apr 2024	CN3 17-18 Apr 2024	N2 19-20 Apr 2024
Austronomus australis	White-striped Freetail Bat	NL	LC												
Chaerephon jobensis	Northern Freetail Bat	NL	LC	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
Chalinolobus gouldii	Gould's Wattled Bat	NL	LC	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
Chalinolobus nigrogriseus	Hoary Wattled Bat	NL	LC	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
Hipposideros ater	Dusky Leaf-nosed Bat	NL	LC												
Nyctophilus geoffroyi	Lessor Long-eared Bat	NL	LC												
Ozimops lumsdenae	Lumsden's Freetail Bat	NL	LC	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
Saccolaimus flaviventris	Yellow-bellied Sheathtail Bat	NL	LC	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
Scotorepens balstoni	Inland Broad-nosed Bat	NL	LC	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
Setirostris eleyri	Bristle-faced Free-tailed bat	NL	LC	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
Taphozous georgeanis	Common Sheathtail Bat	NL	LC	YES			YES			YES	YES	YES	YES	YES	YES
Taphozous troughtoni	Troughton's Sheathtail Bat	NL	LC												
Vespadelus finlaysoni	Inland Cave Bat	NL	LC	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES	YES
Total # bat call files				**629**	**284**	**599**	**242**	**893**	**324**	**1033**	**341**	**363**	**200**	**647**	**214**
Total # sound files				**4309**	**7861**	**5178**	**880**	**6415**	**385**	**7087**	**3622**	**6212**	**6890**	**13124**	**6402**

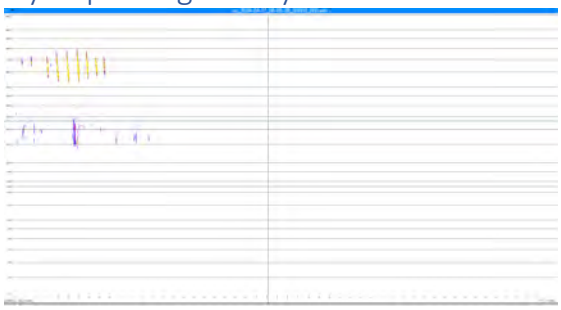
EPBC (NL = Not Listed, V=Vulnerable), NCA (LC = Least Concern, V = Vulnerable, E = Endangered

Representative Microbat Calls

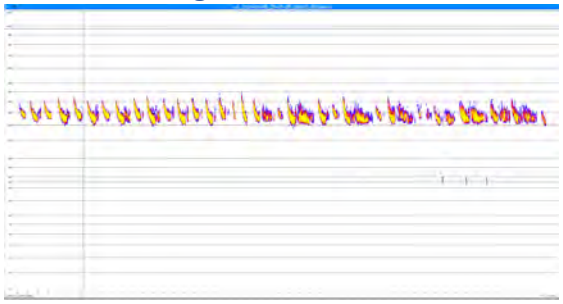
Chaerephon jobensis



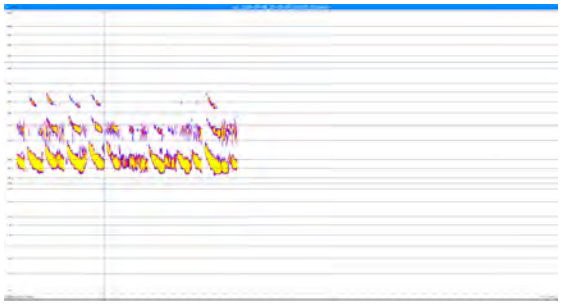
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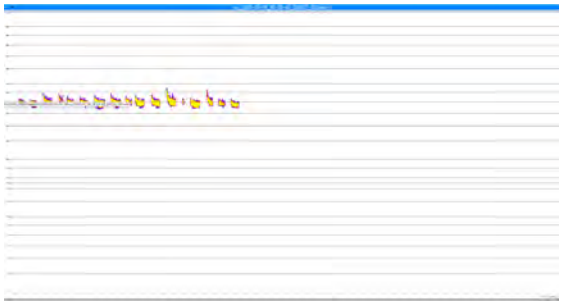
Chalinolobus gouldii



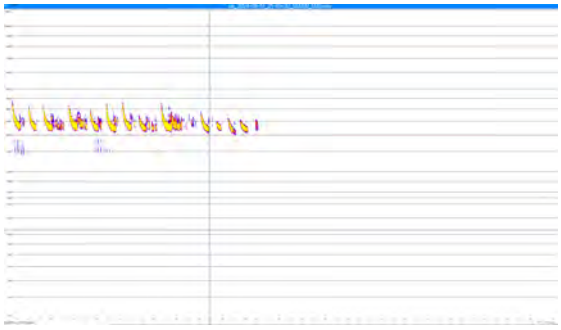
Saccolaimus flaviventris



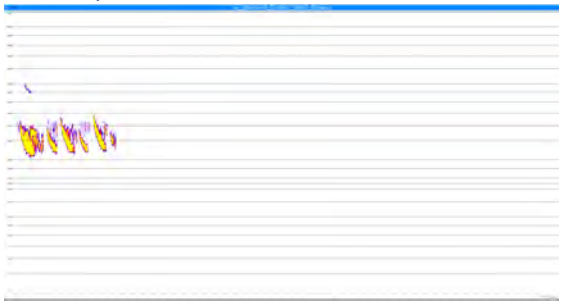
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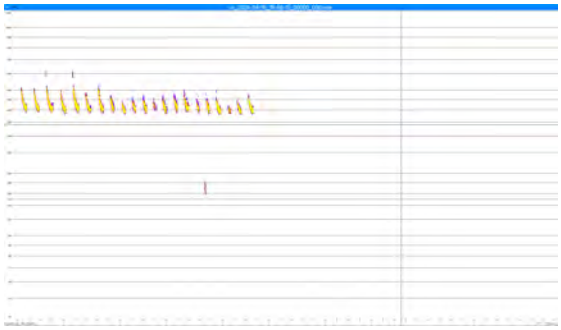
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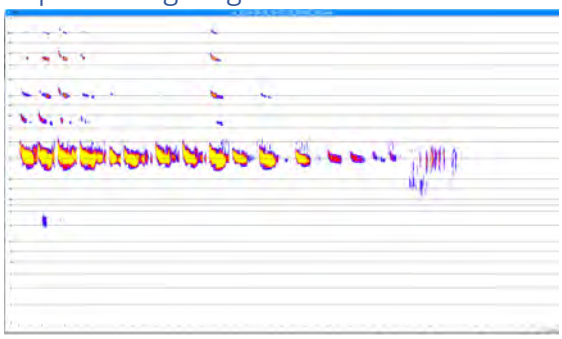
Ozimops lumsdenae



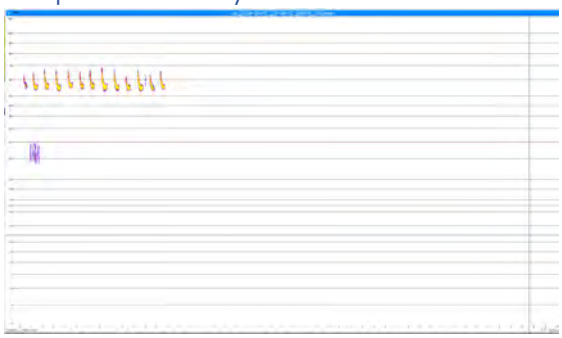
Setirostris eleyri



Taphozous georgianus



Vespadelus finlaysoni



References

Atlas of Living Australia. https://www.ala.org.au/

Castle S. 2015. Mangrove bat communities in space and time. Honours thesis, James Cook University.

Churchill S. 2008. Australian Bats. Jacana Books, Allen & Unwin; Sydney. 2nd Ed.

EPBC Protected Matters Search Tool http://www.environment.gov.au/webgis-framework/apps/pmst/pmst.jsf

Hourigan C. 2001. Microchiropteran community structure in the tropical urban environment of Townsville, north Queensland: implications for bat conservation. Honours thesis, James Cook University.

Hourigan C, Johnson C, Robson SKA. 2006. The structure of a micro-bat community in relation to gradients of environmental variation in a tropical urban area. Urban Ecosystems 9:67-82.

Inkster T. 2008. Habitat use and fire ecology of insectivorous bats (Suborder: Microchiroptera) in Eucalypt woodlands of Northern Australia. Honours thesis, James Cook University.

Inkster T. 2017. Biogeography of bats in the Australian Wet Tropics: current distribution and response to future climate change PhD thesis, James Cook University.

Jackson S. and Groves C. (2015). Taxonomy of Australian Mammals. CSIRO Publishing, Melbourne.

Milne DJ. 2002. Key to the bat calls of the Top End of the Northern Territory. Technical Report No. 71; Parks and Wildlife Commission of the Northern Territory, Darwin.

NCA WWW Search tool https://apps.des.qld.gov.au/species-search/details/?id=992.

Parsons J. 2005. Spatial and temporal patterns of resource use by spectacled flying foxes (*Pteropus conspicillatus*). Honours thesis, James Cook University.

Parsons J. 2011. Studying mobile species in spatially complex ecosystems: flying-fox strikes as a case study. PhD thesis, James Cook University.

Parsons JG, Cairns A, Johnson CN, Robson SKA, Shilton LA, Westcott DA. 2006. Dietary variation in spectacled flying foxes (*Pteropus conspicillatus*) of the Australian Wet Tropics. Aust J Zool 54:417-428.

Parsons J, Cairns A, Johnson C, Robson SKA, Shilton L, Westcott D. 2007. Bryophyte dispersal by flying foxes: a novel discovery. Oecologia 152: 112-114.

Parsons JG, Blair D, Luly J, Robson SKA. 2009. Bat strikes in the Australian aviation industry. J Wildlife Management 73: 526-529.

Parsons JG, VanDerWal J, Robson SKA, Shilton LA. 2010. The implications of sympatry in the Spectacled and Grey-headed flying fox, *Pteropus conspicillatus* and P*. poliocephalus*. Acta Chiropt 12(2): 301-309.

Parsons JG, Robson SKA, Shilton LA. 2011. Roost fidelity in spectacled flying foxes (Pteropus conspicillatus): implications for conservation and management. Pp 66-71, In The Biology and Conservation of Australasian Bats. (Ed. B Law, P Eby, D Lunney & L Lumsden). Royal Zoological Society of NSW. 498 pp.

Pennay M. 2006. Ecological study of the endangered bristle-nosed bat (*Mormopterus* 'species 6') and survey of microchiropteran bats in Gundabooka National Park. Report for NSW National Parks and Wildlife Service, Upper Darling Region. Department of Environment and Conservation, Queanbeyan, New South Wales. Available at: http://batcall.csu.edu.au/abs/references/PennayGundabooka.pdf

Pennay M, Law B, Reinhold L. 2004. Bat calls of New South Wales: Region based guide to the echolocation calls of Microchiropteran bats. NSW Department of Environment and Conservation, Hurstville.

Reardon TR, Robson SKA, Parsons JG, Inkster T. 2010. Review of the threatened status of microchiropteran bat species on Cape York Peninsula. Caring for Our Country Report. Pp 1-83

Reinhold L, Law B, Ford G, Pennay M. 2001. Key to the bat calls of south-east Queensland and north-east New South Wales. Department of Natural Resources and Mines, Brisbane.

Stiso S. 2013: The influence of environmental factors and habitat type on microbat species distribution on the Cape York Peninsula. Applied Masters thesis, James Cook University.

van Dyck S, Gynther I, Baker A. (ed.) .2013. Field Companion to the Mammals of Australia. New Holland; Sydney.

8. Appendix B: Site Specific Bird and Bat Presence from WTS Wet Season BBUS

Common Name (*Scientific Name*)	Status*		Site											
	NCA	EPBC	C1	C2	C3	CN1	CN2	CN3	N1	N2	S1	S2	SW1	SW3
Birds														
Australasian Darter (*Anhinga novaehollandiae*)	LC									2				
Black Kite (*Milvus migrans*)	LC								1					
Black-faced Cuckoo-shrike (*Coracina novahollandiae*)	LC		1				3			4				
Black-faced Woodswallow (*Artamus cinereus*)	LC		3							1			1	10
Brown Falcon (*Falco berigora*)	LC			1										
Little Friarbird (*Philemon citreogularis*)	LC						1	2						
Little Woodswallow (*Artamus minor*)	LC		10	6	5		3	2	2		3		1	43
Masked Woodswallow (*Artamus personatus*)	LC													200
Nankeen Kestrel (*Falco cenchroides*)	LC					1			1			1		
Pied Butcherbird (*Cracticus nigrogularis*)	LC		1											
Rainbow Bee-eater (*Merops ornatus*)	LC	M									1	9		
Varied Lorikeet (*Psitteuteles versicolor*)	LC		19				5	2				1		
Wedge-tailed Eagle (*Aquila audax*)	LC		1					2				1	1	
Whistling Kite (*Haliastur sphenurus*)	LC										1			
White-faced Heron (*Egretta novaehollandiae*)	LC													1
Willie Wagtail (*Rhipidura leucophrys*)	LC			1										
Bats														
Bristle-faced Free-tailed Bat (*Setirostris eleyri*)	LC	X	X	X	X	X	X	X	X	X	X	X	X	X

Common Name (*Scientific Name*)	Status*		Site											
	NCA	EPBC	C1	C2	C3	CN1	CN2	CN3	N1	N2	S1	S2	SW1	SW3
Common Sheathtail Bat (*Taphozous georgeanis*)	LC		X			X	X	X	X	X		X		X
Gould's Wattled Bat (*Chalinolobus gouldii*)	LC		X	X	X	X	X	X	X	X	X	X	X	X
Hoary Wattled Bat (*Chalinolobus nigrogriseus*)	LC		X	X	X	X	X	X	X	X	X	X	X	X
Inland Broad-nosed Bat (*Scotorepens balstoni*)	LC		X	X	X	X	X	X	X	X	X	X	X	X
Inland Cave Bat (*Vespadelus finlaysoni*)	LC		X	X	X	X	X	X	X	X	X	X	X	X
Lumsden's Freetail Bat (*Ozimops lumsdenae*)	LC		X	X	X	X	X	X	X	X	X	X	X	X
Northern Freetail Bat (*Chaerephon jobensis*)	LC		X	X	X	X	X	X	X	X	X	X	X	X
Yellow-bellied Sheathtail Bat (*Saccolaimus flaviventris*)	LC		X	X	X	X	X	X	X	X	X	X	X	X

* NCA = *Nature Conservation Act 1992*; EPBC = *Environment Protection and Biodiversity Conservation Act 1999*; CR = Critically Endangered; EN = Endangered; VU = Vulnerable; NT = Near Threatened; SLC = Special Least Concern; LC = Least Concern

APPENDIX N: Dugald River Wind Farm Fauna Survey (EcoSmart Ecology, 2023)



DUGALD RIVER WIND FARM FAUNA SURVEY RESULTS

Dugald River Mine

PREPARED FOR MMG AUSTRALIA PTY LTD
November 2023

Dugald River Wind Farm Fauna Survey Results

Dugald River Mine

Prepared for MMG Australia Ltd

November 2023

ECOSMART ECOLOGY
48 Streeton Parade
Everton Park QLD 4053 Australia

Tel: +61 7 3162 1161

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Project Number:	MMG_2303
Project Manager:	Mark Sanders
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1.0 INTRODUCTION

1.1 Background

EcoSmart Ecology has been engaged by MMG Ltd to report on terrestrial fauna surveys conducted on the Knapdale Range between 2013 and 2023. The purpose of the report is to provide baseline information for a proposed wind farm on the Knapdale Range within the existing Dugald River Mine lease footprint (Figure 1.1). In addition to baseline reporting, EcoSmart Ecology have been engaged to conduct Bird and Bat Utilisation Surveys (BBUS) to assess the potential collision risk of bird and bat species with wind turbines. This report includes preliminary results from two BBUS monitoring periods.

Nine locations across the Knapdale Range have been selected for potential installation of wind turbines. Construction of turbine pads and access tracks requires 75.05 ha of additional land clearing within the lease footprint. Final turbine selection remains unconfirmed, so all analysis is based on the precautionary principle and assumes that the largest possible turbines will be installed. Presently these are Goldwind GW 165-5.2/5.6/6.0MW turbines, with a hub height above the ground of 130 m and a turbine blade diameter of 165m.

1.2 Survey Location

The Knapdale Range is located approximately 20 km to the north-west of Quamby in the Mount Isa Inlier bioregion in north-west Queensland. The range occupies approximately 295 km^2 and runs north-south for a distance of approximately 12 km, rising to a peak of 85 m above the surrounding plains at its highest point. At its widest point the range is approximately 2 km wide, though for most of its length it is closer to 1.5 km in width. The top of the range is characterised by a rocky undulating plateau. Along the range small gullies and waterlines drop from the plateau, forming broken rocky slopes with scattered large boulders or cliff-faces. Other steep rocky areas are also present, particularly along the western slopes. Steep slopes with large rock outcrops are less abundant in the southern third of the range, and along the very north-east tip, though small isolated rock outcrops can be present.

The Knapdale Range is a prominent range of hills formed by Knapdale Quartzite. The Dugald River deposit is located within the Mt Roseby Corridor (3-4 km wide north-to-south trending high strain domain) and is comprised of the Mt Roseby Schist Formation (1686±7 Ma) that includes the local Hangingwall Calc-silicates, Dugald River Slate (DRS) and the Footwall Limestone. It is situated within the Mt Albert Group between the older Knapdale Quartzite (1728±5 Ma) and the younger Coocerina Formation that outcrop to the west of the Knapdale Range (R. Cooper pers. comm.).

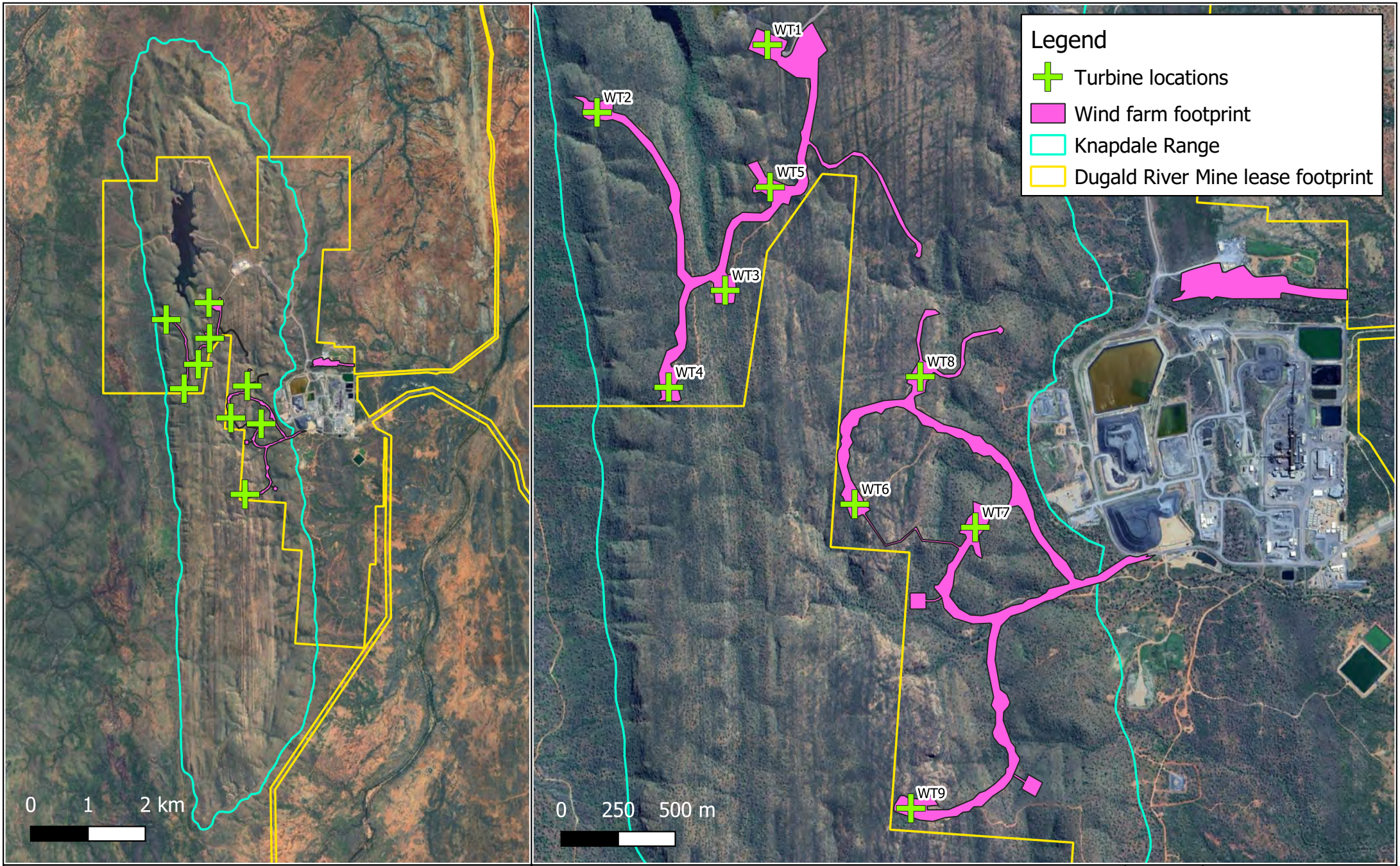


Figure 1
The Knapdale Range, existing Dugald River Mine lease footprint, and additional proposed wind farm footprint and turbine locations

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1.3 Study Team and Qualifications

Consistent with Eyre et al. (2014), Table 1.1 outlines the study team, their qualifications, and respective tasks.

Table 1.1. Study team and qualifications

Personnel	Qualifications	Experience	Tasks
Mark Sanders	BSc (Hons)	20+ yrs	Field monitoring, report preparation, data analysis, project management (2014 – 2023)
Angus McNab	MSc	10+ years	Field monitoring, report preparation, data analysis (2014 – 2016, 2019)
Katrin Lowe	PhD	10+ years	Field monitoring, report preparation (2016 - 2017, 2023)
Jarrad Barnes	BSc	7+ years	Field monitoring, report preparation, data analysis (2018 – 2023)
Anders Zimny	BSc	10+ years	Field monitoring (2015)
Jesse Rowland	MSc	10+ years	Field monitoring (2017)
Nick Kilvert	BSc	10+ years	Field monitoring (2014)
Henry Jackson	N/A	10 years	Field monitoring (2021)

2.0 METHODS

2.1 Desktop Assessment

A desktop assessment has conducted in the form of a WildNet fauna search, Protected Matters fauna search and an Atlas of Living Australia fauna search using a 25 km buffer around a central point on the Knapdale Range. This information was used to identify locally known EVNT (Endangered, Vulnerable and Near Threated) species which formed the basis for the habitat suitability assessment. An assessment of the likelihood of each of these species inhabiting and/or utilising the Knapdale Range was determined from local records and perceived habitat amenity determined through the field survey.

2.2 Fauna Survey Methods

2.2.1 Overall Survey Effort

A variety of survey techniques have been used across the Knapdale Range to survey fauna species. Most effort has been directed toward monitoring the effect, if any, of mining activities on populations of Purple-necked Rock-wallaby (*Petrogale purpureicollis*) and Carpentarian Pseudantechinus (*Pseudantechinus mimulus,* which was listed as a Matter of National Environmental Significance until 2021). These monitoring surveys have relied heavily on white-flash remote cameras. Over the years other methods have been used haphazardly to supplement the work. These activities, along with extensive traverses exploring the range, has provided a robust understanding of vertebrate species (noting some exceptions as detailed in Section 2.4) and habitat features present.

A summary of overall survey effort by year and survey method is provided in Table 2.1. Further information on each methodology is provided in the following sections. A list of all previous and ongoing monitoring locations is provided in Appendix A. Survey timing and monitoring conducted during each survey is provided in Appendix B.

2.2.2 White-flash Remote Camera Surveys

2.2.2.1 Purple-necked Rock-wallaby Monitoring

Purple-necked Rock-wallaby ("PNRW") populations on the Knapdale Range have been monitored by EcoSmart Ecology since 2014. Populations are monitored using a single white-flash PIR camera ("camera trap"). Between 2014 and 2015 only eight PNRW populations were monitored. Nine further sites were established in 2016, and a final site in 2017. All 18 sites (Figure 2.1) have been monitored twice yearly since 2017, once post-wet season and once pre-wet season. Since 2014, attractants including specialised macropod pellets, peanut butter/oat bait balls and lucerne have been used to increase rock-wallaby activity at the cameras. Prior to 2014 only lucerne was used as an attractant. Total trap effort to date is 1,525 trap-nights (Table 2.1).

Table 2.1. Survey effort by year and survey method

Method	Unit	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	TOTAL
BBUS – Anabat	Anabat-nights											16	16 Anabat-nights
BBUS – Bird Survey	Person hours											16	16 person hours
Bird Survey Transect	Person hours							3	6	4.5	6	9	28.5 person hours
PNRW white-flash camera	Trap-nights		80	80	115	170	180	180	180	180	180	180	1525 trap-nights
PSEUD white-flash camera	Trap-nights			269	480	480	480	480	480	480			3149 trap-nights
Pest black-flash camera	Trap-nights	20	20	20	20	20	20	20	20	20	20	20	200 trap-nights
Elliott Trap	Trap-nights			2000									2000 trap-nights
Pitfall Trap	Trap-nights										15	15	30 trap-nights
Foot traverses	Person hours		168	408	240	240	240	240	240	240	168	240	2424 person hours

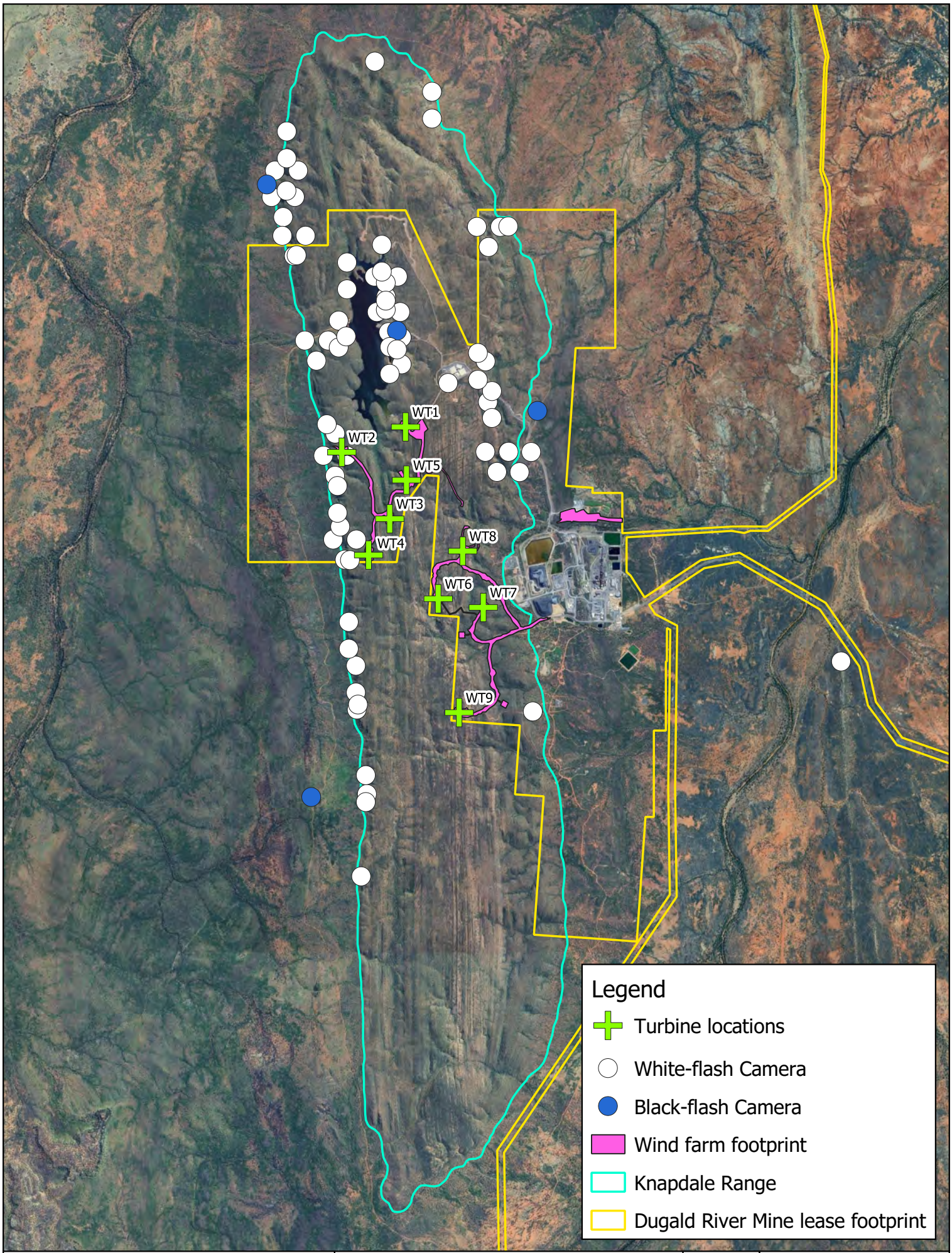


Figure 2.1
Remote field camera survey locations

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The number of recognisable individuals is recorded for each night, and for the survey duration, using indicators such as size, sex, reproductive status (i.e., pouch young), pelt/ear marks or damage. Juveniles at foot and pouch young (only if observed) are included in the count. Observers also record the total number of PNRW observed when setting and retrieving cameras. The highest number of PNRW observed by either method (camera or direct observation) is recorded as the population size for a given survey.

While the methodology targeted PNRW, the selected attractants (pellets, peanut butter/oat bait balls) will have been suitable to attract a wide variety of other vertebrate species and incidental records of all fauna species were noted.

2.2.2.2 Pseudantechinus targeted surveys

Following the unexpected appearance of Pseudantechinus during PNRW monitoring, a targeted survey for the species was conducted in 2015. The survey utilised both camera and Elliot trap methods with ten cameras located in close proximity to the Dugald River Mine, and a further 21 across the broader Knapdale Range.

Each camera was baited by smearing peanut butter over the rocks 2-3 m in front of the camera. Cameras were left in-situ and operational for a minimum of eight nights, though some were left for longer. Total white-flash camera effort in 2015 was 269 camera-trap-nights.

2.2.2.3 Ongoing Carpentarian Pseudantechinus Monitoring

Ongoing Carpentarian Pseudantechinus (*Pseudantechinus mimulus*) monitoring across the Knapdale Range was conducted using white-flash camera traps between 2016 and 2021. Two surveys were undertaken each year, once post-wet season and once pre-wet season. Each survey utilised 30 cameras located at independent locations in rocky habitats within the Knapdale Range (Figure 2.1). All cameras were operational for eight consecutive nights and baited by smearing peanut butter on the rocks. Cameras were checked and rebaited after the fourth or fifth night. Carpentarian Pseudantechinus was recorded as present or absent on each night. A supplementary list of other vertebrate species recorded on cameras was also recorded. Total camera trap effort across all monitoring years was 3,149 trap-nights.

2.2.3 Estimating Purple-necked Rock-wallaby abundance

An initial population estimate was calculated in 2014 by determining the mean number of rock-wallabies at 26 known sub-populations, and extrapolating this to an estimated 56 sub-populations based on interpretation of aerial imagery. Population sizes were not subsequently calculated in future surveys; however, a population estimate has been made in this report based on this same methodology using the most recent mean population size of the 18 permanently-monitored sub-populations across the Knapdale Range.

Trends in Purple-necked Rock-wallaby abundance between 2014 and 2022 at each sub-population have previously been determined by calculating the regression slope (i.e., number of recorded individuals over time) for each sub-population. Regression slopes >0 are were considered to be associated with an increase in sub-population size, and regression slopes <0 are with a decrease in sub-population size. While calculating a regression slope across the entire survey duration is useful in determining an overall change since monitoring began, it

does not provide information on the stability of a population; large, anomalous fluctuations in either a reduction or increase in PNRW numbers in a monitoring year may considerably impact the regression slope and lead to misinterpretation of the population dynamics at a colony.

Therefore, to determine if populations appear to be decreasing, increasing or stable over time, a regression slope was calculated for every monitoring period. The average of these slopes was then calculated with a 95% confidence interval. If the confidence interval includes 0, a population is considered likely to be stable, if the lower bound of the confidence interval is >0, the population is considered likely to be increasing, and if the upper bound of the confidence interval is <0, the population is considered likely to be decreasing.

2.2.4 Small Mammal (Elliot) Trapping

Elliot trapping to confirm the occurrence of Carpentarian Pseudantechinus was conducted in July 2015. Trapping was conducted at 20 locations, ten within close proximity to the Dugald River Mine and ten within the broader Knapdale Range (Figure 2.2).

At each site 25 Elliot traps were positioned approximately 5-10 m apart, in a straight line, U-shaped or circular fashion to maximise the rock area sampled. The traps, which were operational for four consecutive nights, were baited with peanut butter, oats and vanilla essence. All sites were visited daily to identify and release captured animals, as well as to rebait and maintain the traps. Total Elliott trap effort was 2000 trap-nights (Table 2.1).

2.2.5 Black-flash Camera Surveys

Black-flash surveys to observe pest predator species (cat, fox and dingo) have been conducted twice yearly since 2013, once post-wet season and once pre-wet season. The surveys utilise four black-flash ("covert") camera traps positioned at various locations around the Knapdale range (Figure 2.2). Chicken necks is used as an attractant. Cameras are operational for five nights per survey. Total pest camera survey effort to date is 200 trap-nights (Table 2.1).

2.2.6 Bird Surveys

Three permanent bird survey transects were established in October 2019. All three transects are located on the western edge of the Knapdale Range in three distinct vegetation types (Table 2.2). Transects are 500 m in length and have been surveyed twice per year since bird monitoring commenced. Two observers meander along the transect for a total duration of ~30 minutes. All bird species and the total number of individuals of each species heard or seen within 50 m of the transect are recorded. Species beyond 50 m are recorded but no counts are taken. Total bird survey effort to date is 28.5 person hours (Table 2.1).

Table 2.2. Vegetation descriptions of bird survey transects

Transect	Description
BRD01	Low, open eucalypt woodland with dense tussock grass and *Triodia pungens* ground layer
BRD02	Low, open eucalypt woodland with *Acacia* spp. shrub layer and *Triodia pungens* ground layer, adjacent ephemeral creek lined with *Lophostemon grandiflora*
BRD03	Low, open eucalypt woodland with *Acacia* spp. shrub layer, tussock grass and *Triodia pungens* ground layer and localised patches of *Acacia cambagei*; transitioning in north of transect to tall eucalypt woodland of *Corymbia aparrerinja* with *Acacia* spp. shrub layer and *Triodia pungens* ground layer

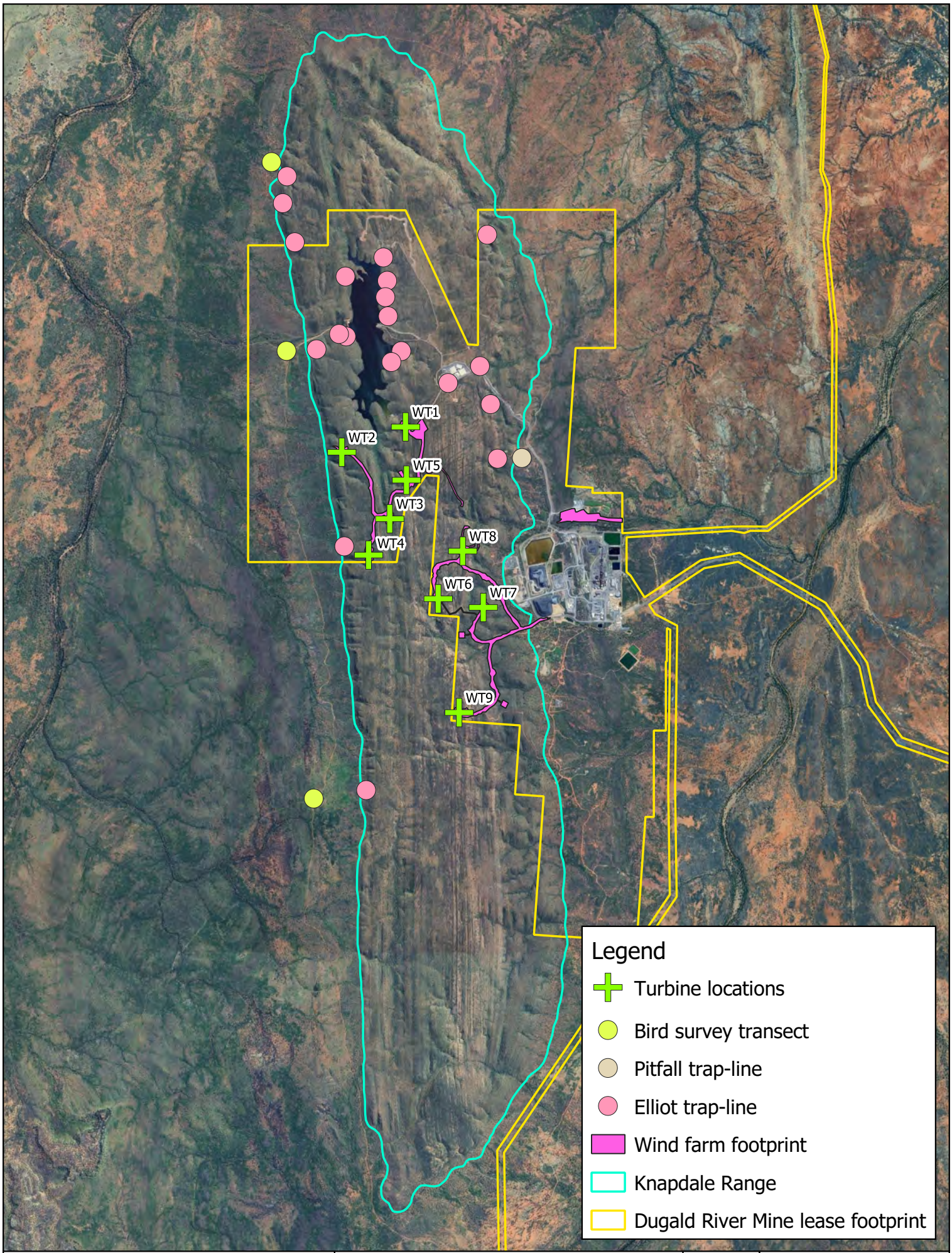


Figure 2.2
Elliot trap, pitfall trap, and bird survey locations

0 0.5 1 km

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2.2.7 Pitfall Traps

A single pitfall trap-line was established in 2022 (Figure 2.2) The trap-line consists of three 10L buckets spaced approximately 3 m apart. Pitfall traps are open for five nights and are checked within two hours of sunrise and two hours of sunset. Total pitfall trap effort to date is 30 trap-nights (Table 2.1).

2.2.8 Incidental Observations / Active Searches

Across all surveys, ecologists remain vigilant for all species seen or heard while traversing the Knapdale Range. Specific time spent traversing the range has not been recorded; however, a conservative estimate of six hours per person per day has been assumed to calculate overall effort (Table 2.1). Most incidental observations have been made while traversing between permanent monitoring locations; however, particular attention has also been paid to rocky gullies and waterholes which provide important water and foraging resources as well as daytime refugia for a wide range of species, especially birds and Purple-necked Rock-wallabies. Exact coordinates are recorded for EVNT and locally rare or significant fauna, but most incidental observations are supplied with a generic GPS coordinate.

2.2.9 Bird and Bat Utilisation Surveys (BBUS)

Nine potential turbine locations were considered for bird and bat utilisation surveys (BBUS). From these, four impact sites were selected for ongoing BBUS monitoring, in conjunction with four control sites (Figure 2.3). Each control site was set in a similar landscape position to turbine locations (i.e., a high point on the edge of the range), and a minimum of 500 m from any turbine location. Each impact and control site will be monitored twice yearly, once post-wet season and once pre-wet season. Two surveys have so far been conducted, one in May 2023, and one in September 2023. Surveys include bird monitoring and bat monitoring. Reporting guidelines largely follow those recommended by Lane and Associates (2005).

2.2.9.1 Bird Monitoring

Bird monitoring consists of three surveys conducted at each control and impact suite during the survey period, one within two hours after sunrise ("morning"), one within one hour 1 h either side of midday ("midday") and one within two hours before sunset ("afternoon"). No two surveys are conducted at any given location on the same day. Bird Utilisation Surveys (BUS) consist of 20 min of monitoring for all bird species flying above the canopy, with the following parameters recorded:

- Number of individuals
- Time first observed
- Distance from observer (in metres) when first observed
- Bearing (i.e., direction of bird/s relative to observer) when first observed
- Height relative to observer (in metres) when first observed
- Direction of flight when first observed

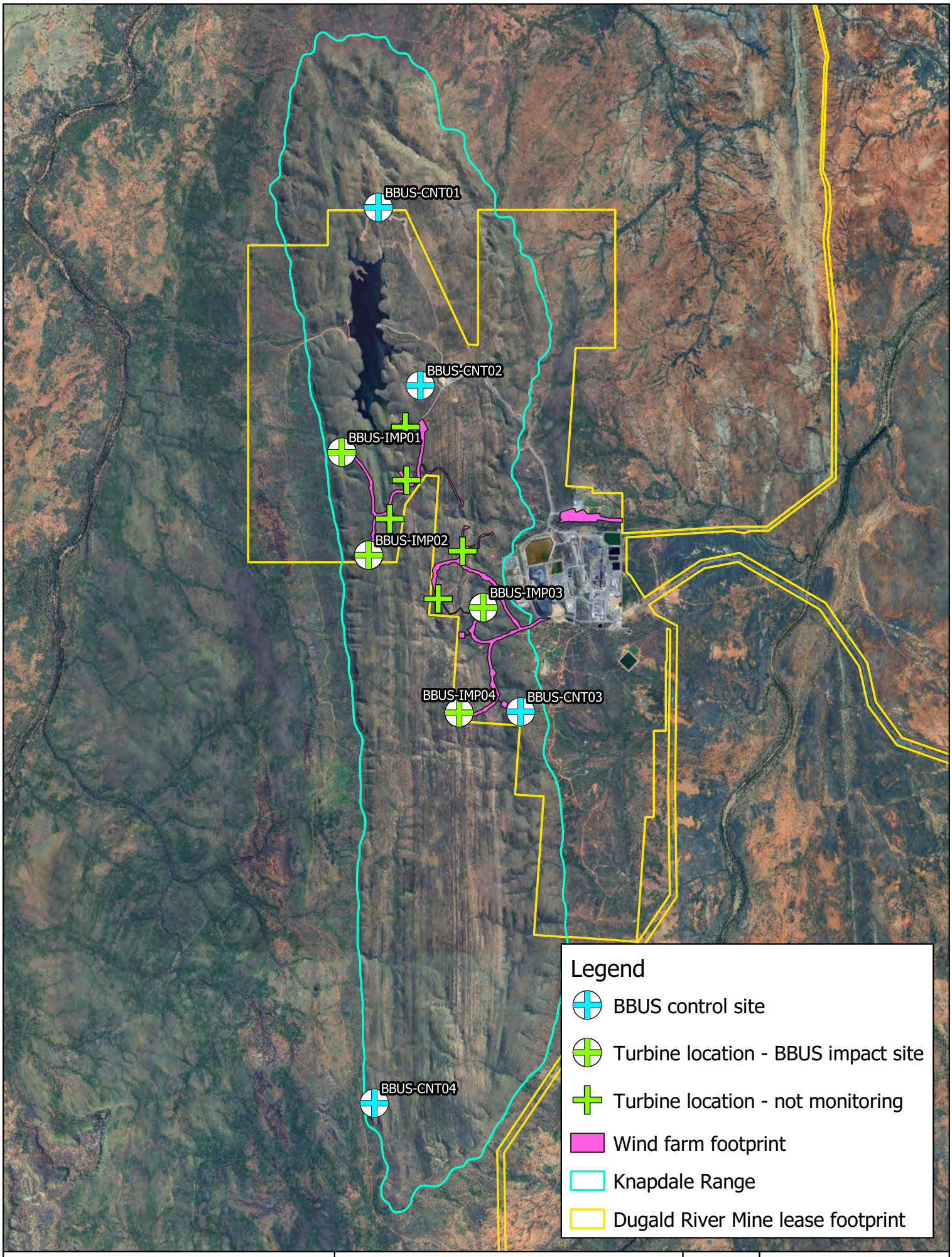


Figure 2.3
Bird and bat utilisation survey (BBUS) locations

0 0.5 1 km

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- Behaviour, categorised as one of:
  - Powered flight (i.e., flapping)
  - Gliding (i.e., directional unpowered glide)
  - Foraging (i.e., circular hunting pattern observed in raptors and woodswallows and/or hovering observed in some raptors e.g., Black-shouldered Kite)
  - Soaring/Thermaling (i.e., use of air currents to increase altitude)
- Minimum distance from observer (in metres) over the entire sub-survey
- Maximum height relative to observer (in metres) over the entire sub survey

A complete list of all other bird species observed below the canopy or heard calling within each survey is also recorded; however, only bird species flying above the canopy are considered in further analysis. Total BUS bird monitoring effort to date is 16 person-hours (Table 2.1).

2.2.9.2 Data Analysis

To determine which species are of greatest concern, species were sorted into two groups:

1. Species recorded within the rotor-swept area (RSA; i.e., the area of influence of the rotor specified as a range in metres above the ground). The RSA was considered for the largest possible turbine, the Goldwind GW 165-5.2/5.6/6.0MW. This rotor has a blade diameter of 165 m and a hub height of 130 m, for an RSA of 35 – 165 m above the ground.
2. Species recorded outside the RSA of the largest possible turbine

Species were then ranked based on the total number of individuals observed across all 48-surveys across May and September 2023.

To determine if most species likely to be present have been detected, a species accumulation curve (SACs) was produced using the *specaccum* function in the R package '*vegan'*. The SAC was produced using the "random" method, which randomly permutes the order of sub-survey blocks and, therefore, the order in which species are accumulated, and determines an average SAC (± standard deviation). Calculating an SAC using random permutations provides a more robust method of determining survey adequacy than a chronological "collector" method by minimising the effect of daily variation in occurrence (Thompson and Thompson 2007). The data informing the SAC were analysed to determine if the SAC showed signs of reaching an asymptote, or "levelling off". This was determined based on the suggested guidelines in Lane and Associates (2005) that a curve shows signs of levelling off if the final 10% of counts increase species richness by <10%.

2.2.9.3 Bat Monitoring

Bat monitoring utilises Anabat passive high-frequency sound recorders to capture the calls of microbats at each BBUS monitoring site. One Anabat unit is deployed at each site for a total of two consecutive nights per survey. A single recorder deployed at site BBUS-CNT02 failed to record during initial deployment in September 2023. This unit was redeployed for a single night at the end of the survey to accumulate one Anabat-night of data. Total BBUS Anabat effort to date is 16 Anabat-nights (Table 2.1).

2.3 FLORA SURVEYS

2.3.1 BBUS Site Assessment

Under the Regional Ecosystem (RE) framework the Knapdale Range is mapped as a heterogeneous polygon consisting of two RE types, 1.11.2a and 1.7.7a. Vegetation at each BBUS impact and control site was therefore categorised to verify which of these, or possibly alternative, REs are present at each monitoring location. The following were recorded at each site:

- Landform
- Dominant species within ground, shrub and tree strata
- Percent cover estimate of each stratum
- Height estimate (range) of shrub and tree strata

This is sufficient to exceed a Quaternary assessment; however, does not include all necessary data (basal area abundance, complete list of all woody species present) to attain a Tertiary assessment of the vegetation at each site (Neldner *et al.* 2019). Four photographs were taken at each site, one each facing north, east, south, and west to provide a visual representation of each site.

2.3.2 Weed Surveys

Weed surveys have not been systematically undertaken across the site; however, incidental notes and observations over 10 years have been collated. Observers are also vigilant for weeds at newly constructed turbine pads.

2.4 Survey Limitations

The following limitations have affected all surveys conducted by EcoSmart Ecology within the Knapdale Range and surrounding areas:

- No spotlighting effort has been undertaken, meaning nocturnal species are generally underrepresented unless they are rock-dwelling and thus have a higher likelihood of being recorded by camera traps or during sporadic opportunistic habitat searches;
- No searching has been conducted in wet conditions, so amphibians are likely underrepresented with only chance sightings recorded on camera or sporadic opportunistic habitat searches;
- Surveys have all been conducted either pre- or post-wet season (typically within Sept/Oct and Apr/May). Some species which may only occur after large rain events (e.g., some wading birds) may be underrepresented;
- Pitfall trapping has only recently commenced at a single location, so survey effort using this method is limited. While pitfall trapping may increase overall species inventory, many species likely to be detected by this method have been detected using other methods.

None of these limitations need to be overcome to detect EVNT species with the potential to occur across the Knapdale Range. Therefore, while addressing these limitations may increase overall species inventory, it will not increase the likelihood of detecting any EVNT species.

3.0 RESULTS AND DISCUSSION

3.1 Desktop Assessment

A desktop assessment identified 17 EVNT species known or with the potential to occur within 25 km of the Knapdale Range. A likelihood assessment was conducted to determine the potential for these species to occur on the Knapdale Range. One species was determined as present, the Purple-necked Rock-wallaby. Short-beaked Echidna, a species of special least concern under the Nature Conservation Act (NC Act) has also been recorded from the range.

Two other species are not expected to occur except as perhaps vagrant individuals; these species, The Painted Honeyeater and Grey Falcon, are considered to be 'Transient'.

All other species were categorised as "Will Not Occur" on the Knapdale Range. One species, the Mertens' Water Monitor, has been recorded in surveys at Longamundi Waterhole, but was categorised as "Will Not Occur" due to the lack of suitable habitat on the Knapdale Range. The complete assessment is provided in Appendix D.

3.2 Fauna

Fauna surveys since from 2014–2023 have recorded 153 vertebrate species across the Knapdale Range (Appendix C) including four native amphibians, 23 native reptiles, 104 native birds, and 18 native mammals. This includes several species notable under the NCA including a Vulnerable mammal (Purple-necked Rock-wallaby) and one Special Least Concern mammal (Short-beaked Echidna).

The NCA Endangered reptile, Mertens' Water Monitor (*Varanus mertensi*), has been recorded in the surrounding areas (i.e., the nearby Dugald River) but is not known from the Knapdale Range. To date this species has not been recorded within MMG's Dugald River mining lease and no suitable habitat for it occurs. No threatened species under the EPBC Act have been identified.

A single migratory species (Glossy Ibis) listed under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) has been recorded.

Two introduced mammals and one introduced amphibian have been regularly recorded.

3.2.1 Known Special Conservation Vertebrate Fauna

Following considerable survey and time spent traversing the Knapdale range, only two species of special conservation significance have been identified as present, the Purple-necked Rock-wallaby and Short-beaked Echidna. These species are discussed in further detail below.

3.2.1.1 Purple-necked Rock-wallaby

NCA: Vulnerable | EPBC: Not listed | Likelihood Assessment: Present

Occurrence and habitat

PNRW are known from multiple locations across the Knapdale Range in association with large rocky features. Purple-necked Rock-wallaby habitat is not uniform and instead occurs in discrete locations associated with complex rocky scree slopes, cliffs and gullies. This significantly influences PNRW distribution, with colonies occurring as discrete units of variable size across the landscape. Colony size is closely correlated with habitat quality; larger, more complex rocky features with more abundant sheltering opportunities support greater numbers than smaller, less complex features. Mixing between colonies within the Knapdale range is likely to be frequent. Larger more secure colonies probably act as 'source' populations, allowing dispersal to nearby habitats and facilitating recolonisation following local extinction of more marginal areas. Natural fluctuation of numbers within each colony is therefore expected.

Population size and trends

Initial estimates of the Purple-necked Rock-wallaby population on the Knapdale Range calculated in 2014 were for a total population size of 137 individuals (EcoSmart Ecology 2014). This was based on an average of 2.45 individuals per colony across 56 possible locations (both known populations, and populations hypothesised to be present based on aerial imagery interpretation). Purple-necked Rock-wallaby sub-population sizes have fluctuated over 10 years of monitoring (Table 3.1); however, average population size across the Knapdale Range was at its highest ever-recorded value (4.83±2.12 individuals per colony) in September 2022 (EcoSmart Ecology 2022). Based on these most recent estimates and on the 56 sub-populations assumed in 2014, the current total population size on the Knapdale Range may be as high as 270 individuals. As noted in 2014, this estimate should be used conservatively as 30 locations were only hypothesised to support populations, with no visual inspection of these locations conducted. Some locations have become or will soon be inundated by the filling of the tailings storage facility (TSF) dam, meaning the actual number of potential colonies is likely fewer than estimated in 2014. The average population size per colony across all monitoring periods (i.e., average population size from Apr 2014 to Sep 2022) is 3.3±1.07 individuals (Table 3.1).

Table 3.1. Purple-necked Rock-wallaby abundance recorded using trail cameras from 2014 to 2022

Site	2014		2015		2016		2017		2018		2019		2020		2021		2022		Mean	Slope
	Apr	Aug	May	Sep	May	Aug	May	Aug	May	Oct	Apr	Oct	Apr	Sep	Apr	Sep	May	Oct		
CNT01	1	2	1	2	3	1	3	4	0	2	1	2	1	3	2	3	3	3	1.9	0.0004
CNT02	4	3	5	5	4	3	3	2	2	4	3	3	3	5	2	4	3	5	3.5	0.0000
CNT03	2	3	5	6	3	3	3	3	2	1	2	1	3	4	2	2	2	3	2.9	-0.0004
CNT04	1	4	6	6	2	3	3	4	3	5	1	6	2	9	9	8	14	11	3.9	0.0024
IMP01	3	3	4	5	3	4	4	4	4	2	5	3	2	4	4	4	2	4	3.7	-0.0001
IMP02	1	3	#	4	4	3	2	3	#	4	2	4	4	3	2	3	3	4	3.1	0.0003
IMP03	2	3	1	3	3	3	4	4	2	4	3	2	3	3	#	4	4	6	2.9	0.0007
IMP04	0	0	0	0	0	0	0	1	2	0	1	2	2	0	0	0	1	2	0.6	0.0006
KR01					4	4	2	4	3	3	3	1	1	#	3	4	4	5	2.8	0.0004
KR05						3	3	1	3	0	2	3	0	4	1	4	4	4	2.1	0.0008
KR07						4	3	4	4	5	6	3	4	4	2	5	3	4	4.1	-0.0002
KR10						2	3	1	4	4	5	2	3	4	2	6	4	5	3.2	0.0008
KR13						4	4	4	3	4	3	4	2	4	0	5	4	7	3.6	0.0007
KR14						3	2	#	5	4	3	0	3	6	2	4	7	7	3.3	0.0019
KR16						2	2	2	1	3	0	1	1	2	0	3	4	2	1.6	0.0004
KR18							4	4	3	1	2	4	1	5	1	4	4	6	3.4	0.0011
KR19							3	5	5	5	0	0	2	2	2	4	2	5	2.7	-0.0006
KR20							3	#	2	4	4	5	3	5	3	4	2	4	3.8	-0.0001

equipment failure

Purple-necked Rock-wallaby sub-population sizes have varied between 2014 and 2022, and not all sub-populations have varied at the same rate. Regression slopes calculated in 2022 are shown in Figure 3.1. As of September 2022, most locations showed an overall increase in population. However, recent surveys have occurred following exceptional rainfall years due to La Niña and likely reflect increased forage resource availability supporting larger numbers of PNRW.

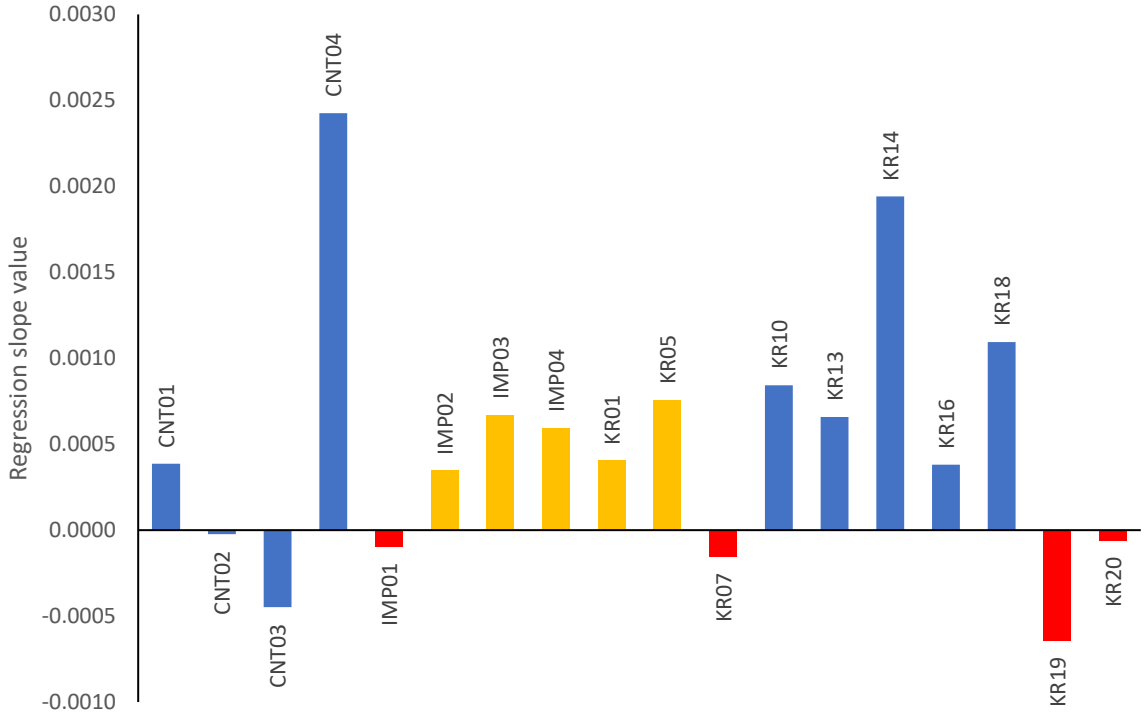


Figure 3.1. Regression slopes for PNRW colonies. Positive regression values suggest an increase in PNRW numbers, negative values suggest a decline – the greater the value the more abrupt the change. Sites coloured blue are located considerable distance from the effects of mining (> 1 km), sites coloured red are immediately adjacent the TSF, sites coloured yellow are near to other mining impacts (village, access roads, exploration etc).

Monitoring camera KR19 was the first to be inundated by rising water levels in the TSF dam and shows a strong decreasing population trend. This perhaps supports the understanding that PNRW are unable to tolerate direct loss of shelter habitat.

Since 2022, a new vehicle track made conducting watches at one known colony easier, and this location has had colony watches conducted on it across three monitoring periods. While not sufficient effort to determine population trends, this colony is known to contain at least 6–8 individual PNRW, well above the average population size as of September 2022. Given the size of this colony and its position in relation to the proposed wind farm footprint (~600 m south of WT7, see Figure 3.2) it may act as a source population from which individuals may return if disturbance occurs during construction.

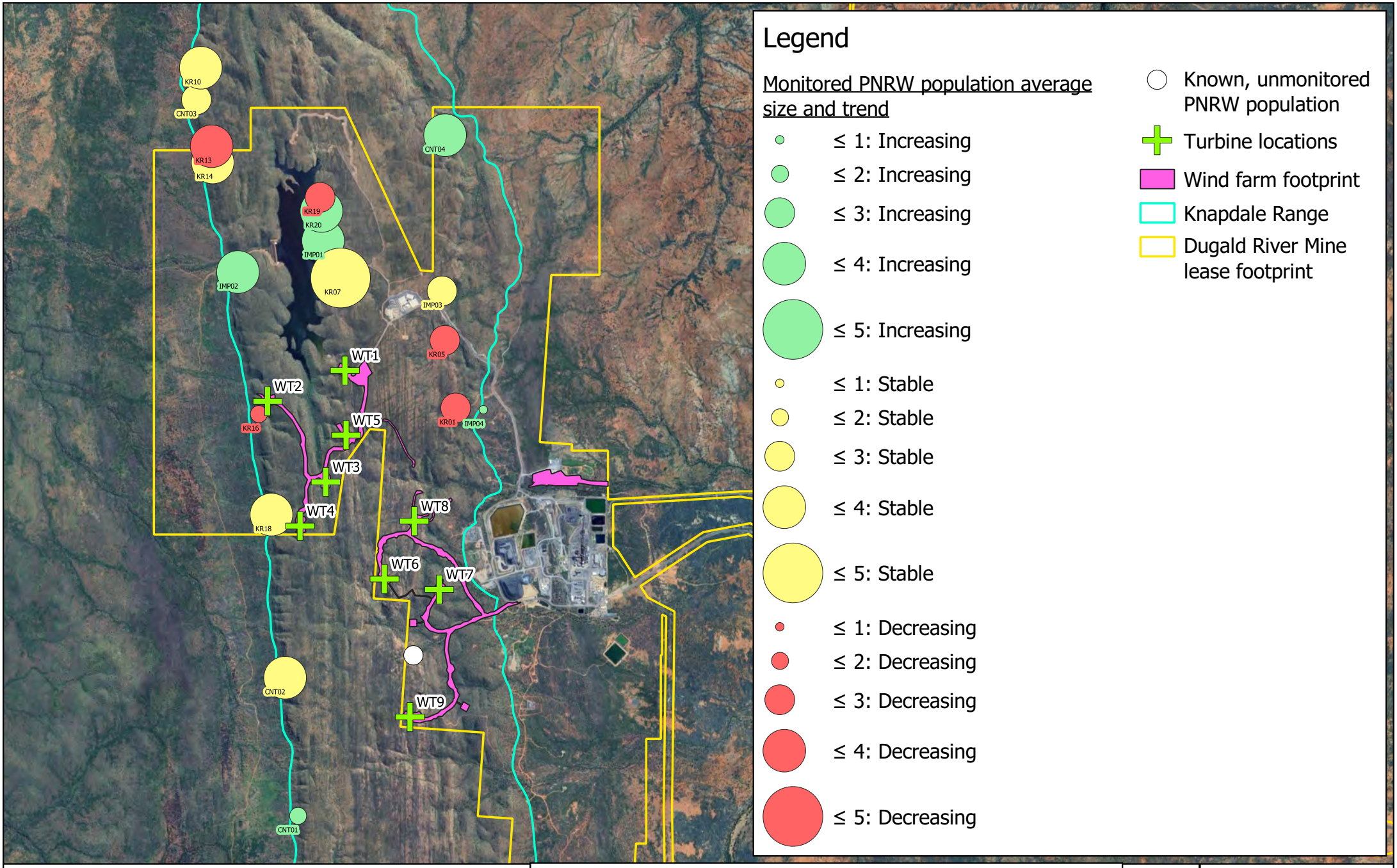


Figure 3.2
Monitored Purple-necked Rock-wallaby (PNRW) colony average population size and trend. A known, unmonitored population is also shown; however, no average population size estimate is available for this location. Further detail in Section 3.2.1.1.

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Impact considerations

Shelter habitat, rather than forage habitat, is the limiting resource for PNRW across the Knapdale Range. Construction activities across the Knapdale Range therefore need to consider the impacts of any proposed activities on PNRW shelter habitat, rather than on foraging habitat.

The currently proposed turbine locations are not located at any known PNRW colonies; however, some are nearby. Turbine pads WT2 and WT4 are ~150 m NE and ~300 m ESE of PNRW populations at monitoring sites KR16 and KR18. The colony at KR16 is below average in size (1.6 individuals) and is in decline. Reasons for decline at this location are not fully understood. Site KR18 is a larger colony with an above average population size across monitoring periods (3.4 individuals), a population trend currently indicated as stable. This site is also more rugged and has more shelter opportunities than KR16 and may therefore provide greater protection from predators and any perceived disturbance from construction.

Currently proposed tracks and 5 m buffer footprint do not traverse any known or visually suitable PNRW shelter habitat. Two PNRW vehicle deaths have occurred on the Dugald River Mine village road since its operation. Risks associated with vehicle strike on access roads to the turbines is considerably less, probably negligible, due to lower vehicle speed and less frequent use (especially during operation).

3.2.1.2 Short-beaked Echidna

NCA: Special Least Concern | EPBC: Not listed | Likelihood Assessment: Present

Short-beaked Echidna is infrequently recorded across the Knapdale Range, by both direct and indirect (e.g., scats) observation, and the entire range constitutes high amenity shelter and foraging habitat. The construction of turbine pads and associated infrastructure, especially roads has the potential to impact on Short-beaked Echidna shelter and foraging habitat via direct disturbance of this habitat. However, the spatial extent of impacts are minor constituting ~0.17% of the Knapdale Range. Impacts are not expected to prevent the species from utilising remaining habitat outside the construction footprint.

3.2.2 Other Special Conservation Fauna

Two species identified within the desktop assessment, the Grey Falcon and Painted Honeyeater, are highly mobile and able to traverse large expanses of unsuitable or sub-optimal habitats. These species have been recorded within the local area and have some chance to occur, at least theoretically. However habitats on the Knapdale Range are suboptimal at best and resident populations do not occur, nor could the possibly occur due to low or no habitat amenity. These species are considered 'transient' in nature and discussed below.

A third species, the Carpentarian Grasswren, is also discussed below for greater clarity but will not occur on the Knapdale Range.

3.2.2.1 Grey Falcon

NCA: Vulnerable | EPBC: Vulnerable | Likelihood Assessment: Transient

The Grey Falcon (*Falco hypoleucos*) has never been recorded on site and is considered unlikely to occur. Nearby records are sparse and infrequent, indicating transiency rather than residency in the broader region. The Grey Falcon is most commonly observed on vast, featureless plains with scattered trees, ecosystems which typically predominate further south and west of the Knapdale Range. Even during irruptive events of other birds favoured as prey by the Grey Falcon (e.g., Budgerigars), the species has never been observed. Future observations of the species across the Knapdale Range cannot be discounted, but the area is unlikely to support a resident pair or to have any other significant conservation value for the species.

3.2.2.2 Painted Honeyeater

NCA: Vulnerable | EPBC: Vulnerable | Likelihood Assessment: Unlikely

The Painted Honeyeater (*Grantiella picta*) has never been recorded on site in 10 years of survey and is considered unlikely to occur. This species is a mistletoe specialist, relying heavily on mistletoe plants for its entire life cycle. Painted Honeyeaters typically inhabit *Eucalyptus* and *Acacia* forests and woodlands where mistletoe, particularly Grey Mistletoe (*Amyema quandang*), is abundant. Despite the presence of suitable host trees for Grey Mistletoe, particularly Gidgee (*Acacia cambagei*), on the flat lands at the base of the Knapdale Range, this mistletoe has not been observed on site. While detailed mistletoe surveys have not been conducted, only one species has been observed on the Knapdale Range, Collared Mistletoe (*Lysiana spathulata*). This species has been observed parasitising several tree and shrub species, notably Arid Peach (*Terminalia aridicola*), False Sandalwood (*Santalum lanceolatum*) and Red Wattle (*Acacia monticola*) and appears to occur only sparsely across the Knapdale Range. Combined with the geographic location of the Knapdale Range towards the northwestern edge of the Painted Honeyeater's range, the presence and scarceness of a single, unfavoured mistletoe species indicates that Painted Honeyeaters are highly unlikely to occur on site, even as a vagrant.

3.2.2.3 Carpentarian Grasswren

NCA: Endangered | EPBC: Endangered | Likelihood Assessment: Will Not Occur

In ten years of survey, monitoring and observations, the Carpentarian Grasswren (*Amytornis dorotheae*) has never been recorded on the Knapdale Range. The related Kalkadoon Grasswren (*Amytornis ballarae*) is frequently recorded across the entire Knapdale Range during targeted surveys and monitoring as well as through incidental observations. The prevalence of records of Kalkadoon Grasswren across multiple years indicates that survey methods utilised over the past ten years are suitable for recording this genus of birds, and provides further support for the assertion that Carpentarian Grasswren will not occur on the range. Kalkadoon and Carpentarian Grasswren are known to occur in close proximity in certain locations north of Mount Isa. At these locations, the two species appear to separate by habitat type, with Kalkadoon Grasswren occurring at higher elevations on massive, rocky outcrops, hills and ranges (e.g. locations similar to the Knapdale Range), and Carpentarian Grasswren occurring at lower elevations on stony, skeletal soils among large, mature hummock grass (*Triodia* spp.).

Low to moderate amenity habitat for Carpentarian Grasswren occurs on the rolling plains to the east of the Knapdale Range (i.e., between the Knapdale Range and Dugald River). However, this area has been traversed by EcoSmart ecologists and no Carpentarian Grasswrens have been recorded. Importantly, these habitats are considerably different from the Knapdale Range where turbine impacts are expected. Habitat on the Knapdale Range is unsuitable.

3.2.3 Migratory Species

NCA: Special Least Concern | EPBC: Migratory | Likelihood Assessment: Will Not Occur

A single record of Glossy Ibis (*Falcinellus plegadis*) is known from the Knapdale Range from 2021. An individual bird was observed on beached tailings in the TSF dam among a small flock of Pied Stilts (*Himantopus leucocephalus*). This observation followed a significant rainfall event (>40mm) on the Range, and this may have contributed to the presence of this species at this location. It is unlikely that the TSF dam provided suitable foraging resources due to the composition of tailings sediments, and this location was more likely utilised as a staging area (i.e., rest site) than a long-term foraging location. Glossy Ibis has not been subsequently recorded on the Knapdale Range and is unlikely to occur in the future.

3.2.4 Pest Species

A total of four terrestrial vertebrate pests have been historically recorded on camera across the Knapdale Range: Feral Cat (*Felis catus*), Dingo/Dog (*Canis familiaris/C. dingo*), Feral Pig (*Sus scrofa*). A fourth, Cane Toad (*Rhinella marina*), has been incidentally observed during surveys.

3.2.5 Bird Utilisation

A total of 30 bird species have been recorded flying above the canopy across four impact and four control sites (Table 3.2). Aerial insectivores and raptors are the most commonly observed birds observed at bird utilisation monitoring locations. These groups form largely permanent populations on the Knapdale Range and are frequently observed thermaling (i.e., using warm updrafts to rise through the air column) and actively foraging within the potential RSA. To date ten species of bird have been identified as species of concern due to observations within the potential rotor-swept area (RSA). These include (in decreasing order of number of individuals recorded):

- Little Woodswallow (Artamus minor)
- Black-faced Woodswallow (Artamus cinereus)
- Fairy Martin (Petrochelidon ariel)
- Brown Falcon (Falco berigora)
- White-necked Heron (Ardea pacifica)
- Wedge-tailed Eagle (Aquila audax)
- Black-shouldered Kite (Elanus axillaris)
- Whistling Kite (Haliastur sphenurus)
- Black Kite (Milvus migrans)
- Varied Lorikeet (Psitteuteles versicolor)

Of these species, >10 individuals of all three aerial insectivores (Woodswallows and Fairy Martin) have been recorded during BUS monitoring, while most raptor observations are singletons with the exception of Brown Falcon (3 individuals recorded).

In addition to these species, other birds at risk (due to similar behaviour) which have been observed on the Knapdale Range but not during BUS surveys include:

- Masked Woodswallow (Artamus personatus)
- White-browed Woodswallow (Artamus superciliosus)
- White-breasted Woodswallow (Artamus leucorhynchus)
- Collared Sparrowhawk (Accipiter cirrocephalus)
- Brown Goshawk (Accipiter fasciatus)
- Spotted Harrier (Circus assimilis)
- Nankeen Kestrel (Falco cenchroides)
- Australian Hobby (Falco longipennis)
- Black Falcon (Falco subniger)
- Black-breasted Buzzard (Hamirostra melanosternon)

Of these species, Black Falcon has only been observed once during ten years and is unlikely to be a regular occurrence across the Knapdale Range. All other species have been observed in multiple years and have the potential to occur within the potential RSA at any time during daylight operation and should also therefore be considered species of concern.

A species accumulation curve for all 48 surveys is shown in Figure 3.3. The curve shows species accumulation approaching an asymptote with fewer than three new species added in the final ten surveys (i.e., the final 20% of counts increased the total count by less than 10%).

Table 3.2. Ranked list of bird species recorded across impact and control sites within and outside the rotor-swept area (RSA). Species are ranked by total count across two surveys.

Within/Outside Rotor-swept Area (RSA)	*Scientific Name* Common Name	Status*		Count		
		NCA	EPBC	May 2023	Sep 2023	Total
Within RSA	*Artamus minor* Little Woodswallow	LC		5	28	33
	Artamus cinereus Black-faced Woodswallow	LC			18	18
	Petrochelidon ariel Fairy Martin	LC			12	12
	Falco berigora Brown Falcon	LC		2	1	3
	Ardea pacifica White-necked Heron	LC		2		2
	Aquila audax Wedge-tailed Eagle	LC		1		1
	Elanus axillaris Black-shouldered Kite	LC		1		1
	Haliastur sphenurus Whistling Kite	LC		1		1
	Milvus migrans Black Kite	LC			1	1
	Psitteuteles versicolor Varied Lorikeet	LC			1	1

Within/Outside Rotor-swept Area (RSA)	*Scientific Name* Common Name	Status*		Count		
		NCA	EPBC	May 2023	Sep 2023	Total
Outside RSA	*Geopelia cuneata* Diamond Dove	LC			43	43
	Melopsittacus undulatus Budgerigar	LC		22	15	37
	Artamus minor Little Woodswallow	LC		4	21	25
	Psitteuteles versicolor Varied Lorikeet	LC		6	18	24
	Petrochelidon ariel Fairy Martin	LC		1	18	19
	Ptilotula plumula Grey-fronted Honeyeater	LC		7	7	14
	Coracina novaehollandiae Black-faced Cuckoo-shrike	LC		1	11	12
	Philemon citreogularis Little Friarbird	LC		7	3	10
	Dicaeum hirundinaceum Mistletoebird	LC		1	8	9
	Nymphicus hollandicus Cockatiel	LC			7	7
	Taeniopygia guttata Zebra Finch	LC		6	1	7
	Ptilotula keartlandi Grey-headed Honeyeater	LC		2	3	5
	Hamirostra melanosternon Black-breasted Buzzard	LC			2	2
	Artamus cinereus Black-faced Woodswallow	LC		1	1	2
	Accipiter fasciatus Brown Goshawk	LC		2		2
	Ardea alba Eastern Great Egret	LC		2		2
	Conopophila rufogularis Rufous-throated Honeyeater	LC			2	2
	Corvus coronoides Australian Raven	LC		1	1	2
	Eolophus roseicapilla Galah	LC			2	2
	Falco berigora Brown Falcon	LC		2		2
	Emblema pictum Painted Finch	LC		2		2
	Cracticus nigrogularis Pied Butcherbird	LC		1		1
	Elanus axillaris Black-shouldered Kite	LC			1	1
	Merops ornatus Rainbow Bee-eater	LC			1	1
	Philemon argenticeps Silver-crowned Friarbird	LC		1		1
	Rhipidura leucophrys Willie Wagtail	LC			1	1

* NCA = *Nature Conservation Act 1992*; EPBC = *Environment Protection and Biodiversity Conservation Act 1999*; CR = Critically Endangered; EN = Endangered; VU = Vulnerable; NT = Near Threatened; SLC = Special Least Concern; LC = Least Concern; Mig = Migratory

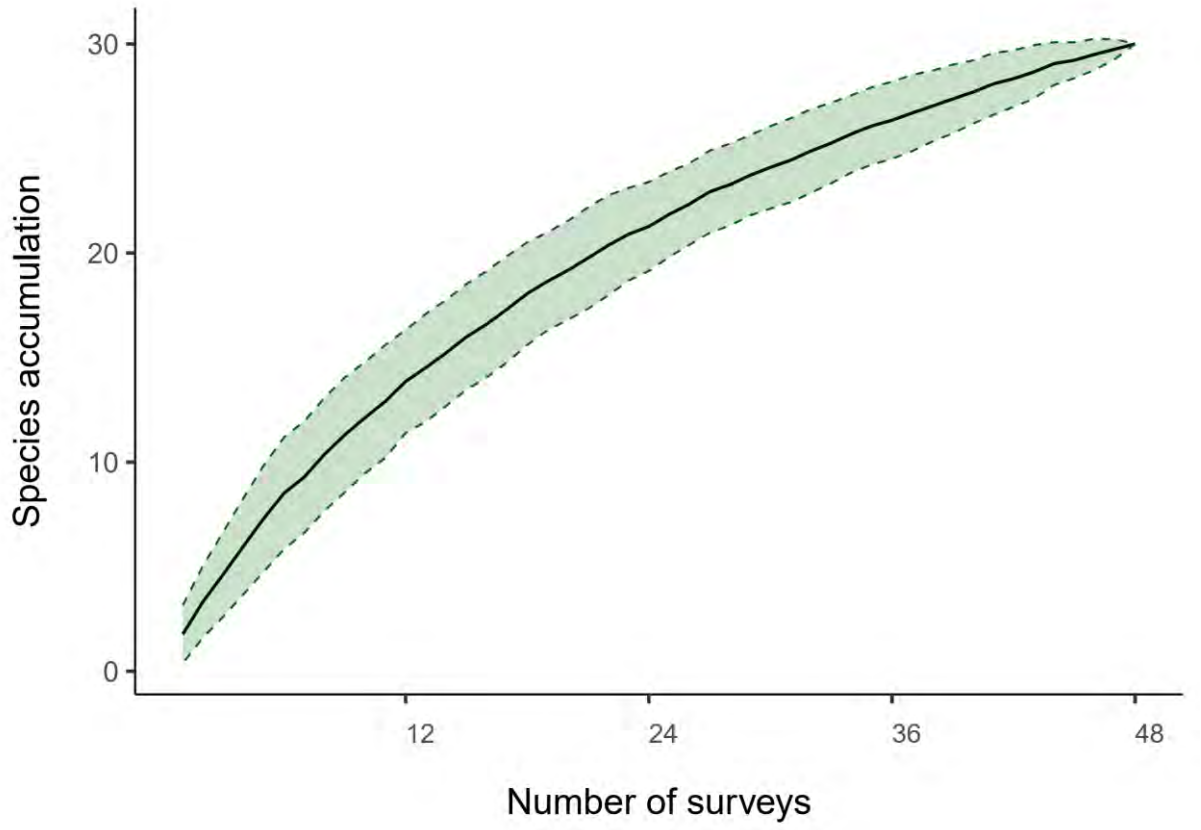


Figure 3.3. Species accumulation curve (SAC) based on bird monitoring undertaken during bird and bat utilisation surveys (BBUS) across four impact and four control sites in May and September 2023. SAC is based on "random" method, utilising random subsampling without replacement (±s.d.).

3.2.6 Bat Utilisation

A total of 13 bat calls were positively identified to genus level in at least one recording across two surveys at four impact and four control sites. A further six profiles could not be positively determined; however, possible species for all six call profiles were positively identified in other calls during surveys. Of the 13 bat taxa identified on Anabat, two taxa (*Chalinolobus gouldii* and *Taphozous* sp.) accounted for over 60% of identified calls, and 98% of calls were attributable to just six taxa.

While no data is available on how high these species fly, most microbat species are typically thought to forage within or just above the canopy. In most cases this places bat activity below the RSA, especially when turbines are as high as those proposed for Dugald River[1]. However, pilot studies using acoustic recorded attached to weather balloons tethered at 100 m have detected Eastern Bent-winged Bats (*Miniopterus orianae oceanensis*), indicating this species is at risk of collision from wind turbines (Pennay & Mills 2018 cited in Van Harten *et al.* 2022). It is conceivable other microbat species may fly at similar altitudes and will therefore occur within the RSA, at least occasionally. This is likely especially true of *Taphozous* spp. and Yellow-bellied Sheathtail Bat (*Saccolaimus flaviventris*), which often forage relatively high above the canopy

[1] Assuming final turbine size is as defined in Section 1.1.

(G. Ford pers. comm.). These taxa were also among the most recorded calls on Anabat at BBUS monitoring sites. The death of Gould's Wattled Bat (*Chalinolobus gouldii*) and White-striped Freetail Bat (*Austronomus australis*) have also been recorded at wind turbines in Victorian (Moloney *et al.* 2019), and both species are present on the Knapdale Range.

Table 3.3. Ranked list of bat species recorded across four impact and four control sites. Species are ranked by total number of calls across two surveys (NB: this is not equivalent to a total count of individuals).

Confidence	*Scientific Name* Common Name	Status*		Number of calls		
		NCA	EPBC	May	Sep	Total
Positive Identification	*Chalinolobus gouldii* Gould's Wattled Bat	LC		1204	2349	3553
	Taphozous sp.			352	1114	1466
	Chaerephon jobensis Northern Freetail Bat	LC		749	465	1214
	Saccolaimus flaviventris Yellow-bellied Sheathtail Bat	LC		79	698	777
	Scotorepens greyii Little Broad-nosed Bat	LC		51	571	622
	Vespadelus baverstocki Inland Forest Bat	LC		21	254	275
	Chalinolobus nigrogriseus Hoary Wattled Bat	LC		21	36	57
	Vespadelus finlaysoni Finlayson's Cave Bat	LC		31	10	41
	Ozimops lumsdenae Northern Free-tailed Bat	LC		30	10	40
	Scotorepens balstoni Inland Broad-nosed Bat	LC		8	14	22
	Ozimops sp.			13	3	16
	Austronomus australis White-striped Freetail Bat	LC		4	1	5
	Nyctophilus sp.			1	3	4
Uncertain Identification	*C. gouldii* or *Ozimops* sp.			505	133	638
	C. nigrogriseus or *S. greyii*			11	73	84
	S. greyii or *V. baverstocki*			21	51	72
	C. gouldii or *S. balstoni*			30	10	40
	O. lumsdenae or *Taphozous* sp.			2	6	8
	S. balstoni or *Ozimops* sp.			3	5	8

* NCA = *Nature Conservation Act 1992*; EPBC = *Environment Protection and Biodiversity Conservation Act 1999*; CR = Critically Endangered; EN = Endangered; VU = Vulnerable; NT = Near Threatened; SLC = Special Least Concern; LC = Least Concern; Mig = Migratory

Four bat roosts are known on the Knapdale Range (Figure 2.2), although there may be more to be discovered. Two are abandoned mine shafts (not associated with the DRM operation) and two are natural caves. While there has been no attempt to estimate the number of bats in these features, incidental observation suggests the two artificial roosts contain far fewer bats, possibly not exceeding 20-30 individuals. In contrast, the natural structures have many individuals, likely numbering in the low 100s. Most bats within these roosts are *Taphozous* spp., although the appearance of Finlayson's Cave Bat (*Vespadelus finlaysoni*) on Anabat recorders indicates it too is likely present.

One of the natural cave roosts is located ~300 m ENE of turbine WT4 while the second is located near PNRW monitoring site CNT04 ~2.4 km from the nearest turbine. While bats from both roosts are likely to fly through the turbine field during nighttime foraging bouts, individuals using the roost near WT4 are at far greater risk.

The presence on the Knapdale Range of potentially high-flying bat species, and unknown population sizes suggests a need for further data collection around bat presence and site utilisation.

3.3 Flora and Vegetation

3.3.1 BBUS Sites

All BBUS impact and control sites consist of open *Eucalyptus*/*Corymbia* woodland, typically with an *Acacia* spp. shrub layer, and are dominated by a ground cover of *Triodia pungens*. Complete descriptions and photos of each site are provided in Appendix E. Following comparison with Regional Ecosystem technical descriptions (Queensland Herbarium 2023), all sites have been classified as RE1.11.2a.

3.3.2 Weeds

Several weedy species have been observed or recorded across the Knapdale Range and surrounding areas. No systematic surveys have been conducted for weedy species; however, the following are the most commonly observed:

- Kapok Weed (*Aerva javanica*). Common along roadside disturbance areas and drill pads, particularly within the Dugald River Mine footprint.
- Prickly Acacia (Vachellia nilotica). An obvious feature of flat lands at the southern edge of the Knapdale Range, typically in association with drainage lines and grazing country. This species does not appear to have become established on the rocky hills of the Knapdale Range.
- Buffel Grass (*Cenchrus* spp.). Most prolific on the western side of the range, particularly in association with drainage channels and grazing country; however, occasionally occurs higher up on rocky hills. This is a similar pattern to the spread of this species that has been observed by EcoSmart Ecology within the broader Mount Isa and Cloncurry region over the past decade.
- Farmer's Friends/Cobbler's Pegs (*Bidens* spp.). Typically seen in association rocky gullies and adjacent slopes. Generally sparsely distributed but may form dense localised patches.

Weedy species are not typically observed on the rocky upper slopes and plateaux of the Knapdale Range, nor have they been recorded in association with proposed turbine pads.

3.4 Survey Adequacy

3.4.1 Fauna Surveys

Surveys conducted between 2013–2023 meet or exceed the survey effort requirements for most survey methods recommended by Eyre *et al.* (2022). Noted exceptions to this include all direct nocturnal survey methods (spotlighting, nocturnal bird call playback, nocturnal active

search), and funnel trapping, which has not been conducted. As noted in Section 2.4, while these methods may increase overall species inventory, they will not increase the likelihood of detecting any EVNT species with the potential to occur on the Knapdale Range. The surveys are adequate to assess fauna values specially protected under legislation.

3.4.2 Bird and Bat Utilisation Surveys

The species accumulation curve (SAC) indicates the rate of accumulation of bird species during BBUS monitoring at the turbine locations is approaching an asymptote. However visual inspection of the SAC suggests further species may yet be recorded. This is supported by cross-examination records from bird surveys and foot traverses (i.e., incidental observations) collected over years of ecological work at Dugald River. Not all of concern species (raptors and aerial insectivores) known from the Knapdale Range have been recorded during BBUS monitoring. However, at risk species not yet detected during BBUS have been considered on the basis of their known presence along the Knapdale Range. Due to this approach it seems unlikely any at risk species has been overlooked.

Acoustic bat monitoring provides evidence of which species are utilising a given site and provides no information on how these species use the site, specifically at what altitudes each species is foraging. Further, Anabat is not useful for estimating the abundance of species.

3.5 FURTHER WORKS

Targeted surveys from 2014-2023 have likely recorded all potential resident vertebrate fauna species across the Knapdale Range, and a high proportion of vagrants to date. No further survey effort is strictly necessary to improve understanding of which species occur at the Knapdale Range. However, ongoing bird utilisation surveys would clarify which bird species most commonly utilise the RSA airspace. Specifically, the species accumulation curve may not yet have reached an asymptote, so at least one additional monitoring period is required, although two additional monitoring periods is preferable. Two additional periods (i.e., one additional year of monitoring) will give extra power to determine which bird species most commonly occur within the potential RSA and will provide firmer insight into which species are likely to be affected by year-round operation of turbines (i.e., resident species vs. nomadic/vagrant species).

Further information is also required on how bat species utilise the airspace at future wind turbine locations. Ideally, radar telemetry would be employed to determine how bats move in 3D space at turbine sites; however, additional information may still be gained by deploying Anabat units on temporary masts at monitoring sites, ideally at heights within the RSA, or else as high as possible. Deploying Anabat detectors in such a manner will provide greater insight into which bat species, if any, are utilising the airspace within the RSA and, subsequently, determine which species, if any, are at greatest collision risk.

4.0 REFERENCES

Eyre T. J., Ferguson D. J., Smith G. C. *et al.* (2022) Terrestrial Vertebrate Fauna Survey Assessment Guidelines for Queensland, Version 4.0.

Lane and Associates B. (2005) Wind Farms and Birds: Interim Standards For Risk Assessment. [online]. Available from: https://tethys.pnnl.gov/sites/default/files/publications/BrettLane-2005.pdf.

Neldner V. J., Wilson B. A., Dillewaard H. A. *et al.* (2019) Methodology for surveying and mapping regional ecosystems and vegetation communities in Queensland.

Queensland Herbarium (2023) Regional Ecosystem Description Database (REDD). Version 13 (May 2023). [online]. Available from: https://www.qld.gov.au/environment/plants-animals/plants/ecosystems/descriptions/download.

Thompson G. G. & Thompson S. A. (2007) Using species accumulation curves to estimate trapping effort in fauna surveys and species richness. *Austral Ecology* 32 , 564–569.

Van Harten E., Lawrence R., Lumsden L. F., Reardon T., Bennett A. F. & Prowse T. A. A. (2022) Seasonal population dynamics and movement patterns of a critically endangered, cave-dwelling bat, (ed S. Parsons). *Wildlife Res.* 49 , 646–658.

Appendix A: Location of all past and ongoing monitoring locations across the Knapdale Range between 2013 and 2023

Method (Years Conducted)	Monitoring Location	Latitude (dec. deg.)	Longitude (dec. deg.)
Pest Monitoring Camera (2013 - Ongoing)	PEST1	-20.2732	140.1249
	PEST2	-20.2326	140.1503
	PEST3	-20.2088	140.1199
	PEST4	-20.2242	140.1345
Purple-necked Rock-wallaby Monitoring Camera (2014 - Ongoing)	CNT01	-20.2729	140.1312
	CNT02	-20.2609	140.1300
	CNT03	-20.2108	140.1218
	CNT04	-20.2139	140.1448
	IMP01	-20.2230	140.1335
	IMP02	-20.2257	140.1256
	IMP03	-20.2274	140.1445
	IMP04	-20.2377	140.1483
	KR01	-20.2375	140.1457
	KR05	-20.2317	140.1447
	KR07	-20.2262	140.1351
	KR10	-20.2080	140.1222
	KR13	-20.2148	140.1232
	KR14	-20.2162	140.1233
	KR16	-20.2381	140.1275
	KR18	-20.2468	140.1287
	KR19	-20.2193	140.1332
	KR20	-20.2204	140.1333
Carpentarian Pseudantechinus Initial Survey (2015)	DRM01	-20.2164	140.1330
	DRM02	-20.2189	140.1334
	DRM03	-20.2185	140.1287
	DRM04	-20.2206	140.1332
	DRM05	-20.2226	140.1335
	DRM06	-20.2263	140.1350
	DRM07	-20.2248	140.1288
	DRM08	-20.2275	140.1339
	DRM09	-20.2297	140.1403
	DRM10	-20.2245	140.1280
	KNAP01	-20.2141	140.1447
	KNAP02	-20.2279	140.1438
	KNAP03	-20.2319	140.1450
	KNAP04	-20.2376	140.1458
	KNAP05	-20.2261	140.1255

Method (Years Conducted)	Monitoring Location	Latitude (dec. deg.)	Longitude (dec. deg.)
	KNAP06	-20.2079	140.1222
	KNAP07	-20.2107	140.1217
	KNAP08	-20.2148	140.1231
	KNAP09	-20.2468	140.1286
	KNAP10	-20.2725	140.1311
	KNAP11	-20.2004	140.1385
	KNAP12	-20.1958	140.1320
	KNAP13	-20.2635	140.1302
	KNAP14	-20.2816	140.1305
	KNAP15	-20.2642	140.1498
	KNAP16	-20.2340	140.1267
	KNAP17	-20.2418	140.1279
	KNAP18	-20.2382	140.1276
	KNAP19	-20.2562	140.1291
	KNAP20	-20.2376	140.1483
	KNAP21	-20.2046	140.1221
	REG01	-20.3127	140.2463
	REG02	-20.3140	140.2455
	REG03	-20.3553	140.2685
	REG04	-20.3644	140.2781
	REG05	-20.2590	140.1843
	REG06	-20.3466	140.2579
	REG07	-20.3639	140.2712
	REG08	-20.7216	140.4780
	REG09	-20.7126	140.4803
Carpentarian Pseudantechinus Monitoring Camera (2016 - 2021)	PSEUD01	-20.2166	140.1327
	PSEUD02	-20.2193	140.1333
	PSEUD03	-20.2183	140.1291
	PSEUD04	-20.2210	140.1333
	PSEUD05	-20.2231	140.1338
	PSEUD06	-20.2261	140.1345
	PSEUD07	-20.2258	140.1254
	PSEUD08	-20.2271	140.1335
	PSEUD09	-20.2469	140.1287
	PSEUD10	-20.2245	140.1279
	PSEUD11	-20.2377	140.1457
	PSEUD12	-20.2320	140.1453

Method (Years Conducted)	Monitoring Location	Latitude (dec. deg.)	Longitude (dec. deg.)
	PSEUD13	-20.2279	140.1434
	PSEUD14	-20.2448	140.1282
	PSEUD15	-20.2483	140.1293
	PSEUD16	-20.2350	140.1276
	PSEUD17	-20.2420	140.1278
	PSEUD18	-20.2377	140.1276
	PSEUD19	-20.2562	140.1291
	PSEUD20	-20.2376	140.1483
	PSEUD21	-20.2607	140.1299
	PSEUD22	-20.2722	140.1310
	PSEUD23	-20.2640	140.1300
	PSEUD24	-20.2149	140.1227
	PSEUD25	-20.2109	140.1218
	PSEUD26	-20.2081	140.1220
	PSEUD27	-20.2046	140.1222
	PSEUD28	-20.2132	140.1470
	PSEUD29	-20.2004	140.1385
	PSEUD30	-20.2139	140.1450
Bird Survey Transect (2019 - Ongoing)	BRD01	-20.2734	140.1252
	BRD02	-20.2263	140.1221
	BRD03	-20.2064	140.1205
BBUS Monitoring Site (Bird and Bat Monitoring) (2023 - Ongoing)	BBUS-CNT01	-20.2112	140.1324
	BBUS-CNT02	-20.2299	140.1372
	BBUS-CNT03	-20.2642	140.1484
	BBUS-CNT04	-20.3054	140.1320
	BBUS-IMP01	-20.2369	140.1283
	BBUS-IMP02	-20.2478	140.1313
	BBUS-IMP03	-20.2533	140.1442
	BBUS-IMP04	-20.2643	140.1415

Appendix B: Timing of vertebrate fauna surveys across the Knapdale Range from 2014–2023

All monitoring conducted during each survey was conducted between the dates shown under "Start" and "End", but were not necessarily conducted over this entire period (e.g., bird surveys typically only conducted on one morning per survey).

Year	Period	Monitoring conducted*	Start	End
2014	Post-Wet Season	PNRW, PEST	11/04/2014	17/04/2014
	Pre-Wet Season	PNRW, PEST	7/08/2014	13/08/2014
2015	Post-Wet Season	PNRW, PEST	7/05/2015	14/05/2015
	Carpentarian Pseudantechinus Initial Survey		30/06/2015	10/07/2015
	Pre-Wet Season	PNRW, PEST	7/09/2015	14/09/2015
2016	Post-Wet Season	PNRW, PEST, PSEUD	11/05/2016	18/05/2016
	Pre-Wet Season	PNRW, PEST, PSEUD	18/09/2016	25/09/2016
2017	Post-Wet Season	PNRW, PEST, PSEUD	2/05/2017	11/05/2017
	Pre-Wet Season	PNRW, PEST, PSEUD	14/08/2017	23/08/2017
2018	Post-Wet Season	PNRW, PEST, PSEUD	2/05/2018	11/05/2018
	Pre-Wet Season	PNRW, PEST, PSEUD	10/10/2018	19/10/2018
2019	Post-Wet Season	PNRW, PEST, PSEUD	8/04/2019	17/04/2019
	Pre-Wet Season	PNRW, PEST, PSEUD, BIRD	1/10/2019	11/10/2019
2020	Post-Wet Season	PNRW, PEST, PSEUD, BIRD	7/04/2020	16/04/2020
	Pre-Wet Season	PNRW, PEST, PSEUD, BIRD	8/09/2020	17/09/2020
2021	Post-Wet Season	PNRW, PEST, PSEUD, BIRD	7/04/2021	16/04/2021
	Pre-Wet Season	PNRW, PEST, PSEUD, BIRD	27/08/2021	5/09/2021
2022	Post-Wet Season	PNRW, PEST, BIRD	17/05/2022	23/05/2022
	Pre-Wet Season	PNRW, PEST, BIRD, PIT	27/09/2022	3/10/2022
2023	Post-Wet Season	PNRW, PEST, BIRD, BBUS, PIT	2/05/2023	11/05/2023
	Pre-Wet Season	PNRW, PEST, BIRD, BBUS	5/09/2023	16/09/2023

* PNRW = Purple-necked Rock-wallaby monitoring; PEST = Pest monitoring; PSEUD = Carpentarian Pseudantechinus monitoring; BIRD = Bird survey transects; PIT = Pitfall traps; BBUS = Bird and Bat Utilisation Survey monitoring

Appendix C: Species recorded across the Knapdale Range and surrounding areas during surveys conducted between 2013 and 2023

Method of detection for each species is denoted by an 'X' in the relevant "Survey Method" column(s).

Scientific Name Common Name	Conservation Status*		Survey Method^					
	NCA	EPBC	BBUS	Bird Survey	Elliot Trap	Incidental	White-flash Camera	Black-flash Camera
AMPHIBIANS								
Cyclorana sp.							X	
Litoria caerulea Green Tree Frog	LC					X	X	
Litoria rubella Little Red Tree Frog	LC					X	X	
Litoria spaldingi Spalding's Rocket Frog	LC					X		
Rhinella marina *Cane Toad*	I	I				X	X	
REPTILES								
Aspidites melanocephalus Black-headed Python	LC					X		
Carlia amax Bauxite Rainbow-skink	LC					X		
Ctenophorus slateri Slater's Ring-tailed Dragon	LC					X	X	
Ctenotus lateralis Gravelly-soil Ctenotus	LC					X	X	
Ctenotus pantherinus Leopard Ctenotus	LC					X		
Ctenotus saxatilis Stony-soil Ctenotus	LC					X		
Delma borea Rusty-topped Delma	LC					X		
Delma nasuta Sharp-snouted Delma	LC					X		
Demansia quaesitor Sombre Whipsnake	LC					X		
Egernia hosmeri Hosmer's Skink	LC					X	X	

Scientific Name Common Name	Conservation Status*		Survey Method^					
	NCA	EPBC	BBUS	Bird Survey	Elliot Trap	Incidental	White-flash Camera	Black-flash Camera
Eremiascincus isolepis Northern Bar-lipped Skink	LC						X	
Gehyra robusta Robust Dtella	LC						X	
Heteronotia binoei Bynoe's Gecko	LC					X		
Lialis burtonis Burton's Legless Lizard	LC					X		
Liasis olivaceus Olive Python	LC					X	X	
Lophognathus horneri Horner's Dragon	LC					X		
Morethia ruficauda Lined Firetail Skink	LC					X	X	
Morethia taenioplura Firetail Skink	LC					X		
Proablepharus tenuis Northern Soil-crevice Skink	LC					X		
Pseudechis australis Mulga Snake	LC					X	X	
Pygopus steelescotti Northern Hooded Scaly-foot	LC					X		
Varanus acanthurus Ridge-tailed Monitor	LC						X	
Varanus glebopalma Black-palmed Rock Monitor	LC						X	
Varanus mertensi Mertens' Water Monitor	EN					X		
Varanus panoptes Yellow-spotted Monitor	LC					X		
Varanus sp.							X	
Varanus tristis Black-headed Monitor	LC					X	X	
AVES (birds)								

Scientific Name Common Name	Conservation Status*		Survey Method^					
	NCA	EPBC	BBUS	Bird Survey	Elliot Trap	Incidental	White-flash Camera	Black-flash Camera
Acanthagenys rufogularis Spiny-cheeked Honeyeater	LC					X	X	
Acanthiza chrysorrhoa Yellow-rumped Thornbill	LC			X		X		
Accipiter cirrocephalus Collared Sparrowhawk	LC					X		
Accipiter fasciatus Brown Goshawk	LC		X[B]	X		X		
Aegotheles cristatus Australian Owlet-nightjar	LC		X[B]			X	X	
Amytornis ballarae Kalkadoon Grasswren	LC		X[B]			X	X	
Anhinga novaehollandiae Australasian Darter	LC					X		
Aprosmictus erythropterus Red-winged Parrot	LC		X[B]	X		X		
Aquila audax Wedge-tailed Eagle	LC		X[B]	X		X		
Ardea alba Eastern Great Egret	LC		X[B]					
Ardea pacifica White-necked Heron	LC		X[B]					
Ardeotis australis Australian Bustard	LC					X		
Artamus cinereus Black-faced Woodswallow	LC		X[B]	X		X	X	
Artamus minor Little Woodswallow	LC		X[B]	X		X		
Artamus personatus Masked Woodswallow	LC			X		X		
Artamus superciliosus White-browed Woodswallow	LC			X		X		
Barnardius zonarius macgilvrayi Cloncurry Ringneck	LC			X		X		

Scientific Name Common Name	Conservation Status*		Survey Method^					
	NCA	EPBC	BBUS	Bird Survey	Elliot Trap	Incidental	White-flash Camera	Black-flash Camera
Cacatua galerita Sulphur-crested Cockatoo	LC		X[B]	X		X		
Cacomantis pallidus Pallid Cuckoo	LC			X				
Centropus phasianinus Pheasant Coucal	LC			X				
Certhionyx variegatus Pied Honeyeater	LC					X		
Chalcites basalis Horsefield's Bronze Cuckoo	LC			X				
Chlamydera maculata Spotted Bowerbird	LC		X[B]	X		X		
Circus assimilis Spotted Harrier	LC			X		X		
Cissomela pectoralis Banded Honeyeater	LC		X[B]	X		X		
Climacteris melanurus Black-tailed Treecreeper	LC		X[B]	X		X		
Colluricincla harmonica Grey Shrike-thrush	LC		X[B]	X		X	X	
Colluricincla megarhyncha Little Shrike-thrush	LC			X				
Conopophila rufogularis Rufous-throated Honeyeater	LC		X[B]	X		X		
Coracina novaehollandiae Black-faced Cuckoo-shrike	LC		X[B]	X		X		
Coracina papuensis White-bellied Cuckoo-shrike	LC			X		X		
Corvus coronoides Australian Raven	LC		X[B]	X		X	X	
Corvus sp.							X	
Cracticus nigrogularis Pied Butcherbird	LC		X[B]	X		X	X	
Cracticus torquatus Grey Butcherbird	LC			X				

Scientific Name Common Name	Conservation Status*		Survey Method^					
	NCA	EPBC	BBUS	Bird Survey	Elliot Trap	Incidental	White-flash Camera	Black-flash Camera
Cygnus atratus Black Swan	LC					X		
Daphoenositta chrysoptera Varied Sittella	LC					X		
Dicaeum hirundinaceum Mistletoebird	LC		X[B]	X		X		
Dromaius novaehollandiae Emu	LC			X				
Egretta novaehollandiae White-faced Heron	LC					X		
Elanus axillaris Black-shouldered Kite	LC		X[B]	X		X		
Elseyornis melanops Black-fronted Dotterel	LC					X		
Emblema pictum Painted Finch	LC		X[B]	X		X	X	
Eolophus roseicapilla Galah	LC		X[B]	X		X		
Epthianura tricolor Crimson Chat	LC					X		
Eudynamys orientalis Common Koel	LC					X		
Eurostopodus argus Spotted Nightjar	LC					X		
Falco berigora Brown Falcon	LC		X[B]	X		X		
Falco cenchroides Nankeen Kestrel	LC					X		
Falco longipennis Australian Hobby	LC					X		
Falco subniger Black Falcon	LC					X		
Gavicalis virescens Singing Honeyeater	LC			X		X		

Scientific Name Common Name	Conservation Status*		Survey Method^					
	NCA	EPBC	BBUS	Bird Survey	Elliot Trap	Incidental	White-flash Camera	Black-flash Camera
Geopelia cuneata Diamond Dove	LC		X[B]	X		X	X	
Geopelia placida Peaceful Dove	LC		X[B]	X		X	X	
Geophaps plumifera Spinifex Pigeon	LC		X[B]	X		X	X	
Gerygone fusca Western Gerygone	LC					X		
Grallina cyanoleuca Magpie Lark	LC		X[B]	X		X		
Gymnorhina tibicen Australian Magpie	LC		X[B]	X		X		
Haliastur sphenurus Whistling Kite	LC		X[B]			X		
Hamirostra melanosternon Black-breasted Buzzard	LC		X[B]			X		
Heteromunia pectoralis Pictorella Mannikin	LC					X		
Himantopus leucocephalus Pied Stilt	LC					X		
Lalage tricolor White-winged Triller	LC			X		X		
Lichenostomus penicillatus White-plumed Honeyeater	LC					X		
Lichmera indistincta Brown Honeyeater	LC		X[B]	X		X		
Malurus assimilis Purple-backed Fairy-wren	LC		X[B]	X		X		
Malurus melanocephalus Red-backed Fairy-wren	LC			X		X		
Manorina flavigula Yellow-throated Miner	LC			X		X		
Megalurus mathewsi Rufous Songlark	LC		X[B]	X		X		

Scientific Name Common Name	Conservation Status*		Survey Method^					
	NCA	EPBC	BBUS	Bird Survey	Elliot Trap	Incidental	White-flash Camera	Black-flash Camera
Melanodryas cucullata picata Northern Inland Hooded Robin	LC			X		X		
Melithreptus brevirostris Brown-headed Honeyeater	LC					X		
Melithreptus gularis Black-chinned Honeyeater	LC		X[B]	X		X		
Melopsittacus undulatus Budgerigar	LC		X[B]	X		X		
Merops ornatus Rainbow Bee-eater	LC		X[B]	X		X		
Microeca fascinans Jacky Winter	LC			X		X		
Milvus migrans Black Kite	LC		X[B]			X		
Myiagra nana Paperbark Flycatcher	LC			X		X		
Ninox boobook Southern Boobook	LC						X	
Nymphicus hollandicus Cocaktiel	LC		X[B]	X		X		
Ocyphaps lophotes Crested Pigeon	LC			X		X		
Oreoica gutturalis Crested Bellbird	LC		X[B]	X		X		
Oriolus sagittatus Olive-backed Oriole	LC		X[B]	X				
Pachycephala rufiventris Rufous Whistler	LC		X[B]	X		X		
Pardalotus rubricatus Red-browed Pardalote	LC		X[B]	X		X		
Pardalotus striatus Striated Pardalote	LC			X		X		
Petrochelidon ariel Fairy Martin	LC		X[B]			X		

Scientific Name Common Name	Conservation Status*		Survey Method^					
	NCA	EPBC	BBUS	Bird Survey	Elliot Trap	Incidental	White-flash Camera	Black-flash Camera
Petroica goodenovii Red-capped Robin	LC					X		
Phaps chalcoptera Common Bronzewing	LC		X[B]	X		X		
Philemon argenticeps Silver-crowned Friarbird	LC		X[B]	X		X		
Philemon citreogularis Little Friarbird	LC		X[B]	X		X		
Plegadis falcinellus Glossy Ibis	SLC	Mig				X		
Podargus strigoides Tawny Frogmouth	LC						X	
Poephila acuticauda Long-tailed Finch	LC			X		X		
Pomatostomus temporalis Grey-crowned Babbler	LC		X[B]	X		X		
Poodytes carteri Spinifexbird	LC		X[B]	X		X		
Psitteuteles versicolor Varied Lorikeet	LC		X[B]	X		X		
Ptilotula flavescens Yellow-tinted Honeyeater	LC					X		
Ptilotula keartlandi Grey-headed Honeyeater	LC		X[B]	X		X	X	
Ptilotula plumula Grey-fronted Honeyeater	LC		X[B]	X		X		
Rhipidura fuliginosa Grey Fantail	LC			X				
Rhipidura leucophrys Willie Wagtail	LC		X[B]	X		X	X	
Smicrornis brevirostris Weebill	LC		X[B]	X		X		
Synoicus ypsilophorus Brown Quail	LC			X		X		

Scientific Name Common Name	Conservation Status*		Survey Method^					
	NCA	EPBC	BBUS	Bird Survey	Elliot Trap	Incidental	White-flash Camera	Black-flash Camera
Tachybaptus novaehollandiae Australasian Grebe	LC					X		
Taeniopygia bichenovii Double-barred Finch	LC			X		X		
Taeniopygia guttata Zebra Finch	LC		X[B]	X		X		
Todiramphus pyrrhopygius Red-backed Kingfisher	LC		X[B]	X		X		
Turnix velox Little Button-quail	LC					X		
Tyto alba Eastern Barn Owl	LC					X		
MAMMALS								
Austronomus australis White-striped Freetail Bat	LC		X[A]					
Canis dingo Dingo	LC					X	X	X
Chaerephon jobensis Northern Freetail Bat	LC		X[A]					
Chalinolobus gouldii Gould's Wattled Bat	LC		X[A]					
Chalinolobus nigrogriseus Hoary Wattled Bat	LC		X[A]					
Felis catus Feral Cat	I	I					X	X
Notamacropus agilis Agile Wallaby	LC					X		
Nyctophilus sp.	LC		X[A]					
Osphranter robustus Common Wallaroo	LC					X	X	
Osphranter rufus Red Kangaroo	LC					X		
Ozimops lumsdenae Northern Free-tailed Bat	LC		X[A]					

Scientific Name Common Name	Conservation Status*		Survey Method^					
	NCA	EPBC	BBUS	Bird Survey	Elliot Trap	Incidental	White-flash Camera	Black-flash Camera
Ozimops sp.			X[A]					
Petrogale purpureicollis Purple-necked Rock-wallaby	NT					X	X	
Pseudantechinus mimulus Carpentarian False Antechinus	LC				X	X	X	
Saccolaimus flaviventris Yellow-bellied Sheathtail Bat	LC		X[A]					
Scotorepens balstoni Inland Broad-nosed Bat	LC		X[A]					
Scotorepens greyii Little Broad-nosed Bat	LC		X[A]					
Sus scrofa Feral Pig	I	I				X	X	X
Tachyglossus aculeatus Short-beaked Echidna	SLC					X	X	
Taphozous sp.			X[A]			X		
Taphozous troughtoni Troughton's Sheath-tailed Bat	LC					X		
Vespadelus baverstocki Inland Forest Bat	LC		X[A]					
Vespadelus finalysoni Finlayson's Cave Bat	LC		X[A]					
Zyzomys argurus Common Rock Rat	LC				X		X	

Appendix D: Likelihood assessment for threatened vertebrate species

Likelihood assessment for threatened vertebrate species either known from within 25 km of the Knapdale Range or identified as having the potential to occur within 25 km of the Knapdale Range based on EPBC Protected Matters search, Wildnet search, and Atlas of Living Australia search. The likelihood assessment relates directly to the species likelihood of occurrence on the Knapdale Range, not within 25 km of the Knapdale Range. Mobile fauna species which could occur on the Knapdale Range but are unlikely to represent a permanent population or a population relying on the site for long-term viability (vagrants) are assessed as 'Transient'.

Scientific Name Common Name	STATUS		Typical Habitat	Habitat at Knapdale Range	Local Records	Likelihood Assessment
	NCA	EPBC				
FISH						
Pristis pristis Freshwater Sawfish	LC	Vul	Channels of large freshwater rivers with permanent water	None present	No records within 25km of the Knapdale Range	Will not occur
REPTILES						
Acanthophis hawkei Plains Death Adder	Vul	Vul	Cracking soils on treeless floodplains across northern Australia	None present	No records within 25km of the Knapdale Range	Will not occur
Elseya lavarackorum Gulf Snapping Turtle	Vul	End	Deep, permanent pools of the Gregory and Nicholson River systems	None present	No records within 25km of the Knapdale Range	Will not occur
Varanus mertensi Mertens' Water Monitor	End		Freshwater bodies such as rivers, swamps and rocky waterholes, with overhanging trees and large rocks for basking	None present. Known suitable habitat exists on the Dugald River ~5km E.	Recorded during surveys at Longamundi on the Dugald River	Will not occur
AVES (birds)						

Scientific Name Common Name	STATUS		Typical Habitat	Habitat at Knapdale Range	Local Records	Likelihood Assessment
	NCA	EPBC				
Amytornis dorothaea Carpentarian Grasswren	End	End	Long-unburnt open woodland or grassland dominated by hummock grass (*Triodia* spp.) on stony soils or, in the north of its distribution, rocky outcrops. Appears to preference large, dense, mature clumps of hummock grass rather than small, sparse clumps.	None present. While visually suitable, the species preferred *Triodia longiceps* is not present and habitat is not representative of the species' typical habitat in the south of its range (i.e. stony, skeletal soils on valley floors).	No records within 25km of the Knapdale Range, nor within 10 y of survey effort	Will not occur
Calidris ferruginea Curlew Sandpiper	End	Cr End	Saline and freshwater wetlands, saltmarshes, estuaries, mudflats. Prefers areas with exposed mud for foraging.	None present	No records within 25km of the Knapdale Range. Only very rarely recorded in the broader region, most records associated with Lake Moondarra near Mount Isa	Will not occur
Erythrotriorchis radiatus Red Goshawk	End	Vul	Open forests, woodlands, wetlands, rainforest fringes, particularly along watercourses with large trees suitable for nesting	None suitable. Potential habitat may be present on the Dugald River.	No records within 25km of the Knapdale Range. Sparse regional records, almost always in association with major waterways, but all very old or undated, typically with poor spatial resolution.	Will not occur

Scientific Name Common Name	STATUS		Typical Habitat	Habitat at Knapdale Range	Local Records	Likelihood Assessment
	NCA	EPBC				
Erythrura gouldiae Gouldian Finch	End	End	Grassy *Eucalyptus* woodland close to water. Native grasses form important foraging habitat, and hollow-bearing eucalypts are used for breeding.	The entire Knapdale Range theoretically provides suitable foraging, breeding and watering habitat; however, most waterholes are ephemeral and hollow-bearing trees are relatively sparse. Large, persistent waterholes on the Dugald River (e.g., Longamundi), probably provide the most likely habitat for any vagrant birds.	No records within 25km of Knapdale Range. All QLD records have been subject to coordinate rounding, and the majority are undated. The most reliable recent records are >10y old from Chidna Station, near Gunpowder ~125km northwest of the Knapdale Range.	Will not occur
Falco hypoleucos Grey Falcon	NT	-	Lightly treed inland plains, gibber deserts, pastoral lands	Potential to occur across the entire Knapdale Range; however, the Range is more heavily treed, has more topographical relief, and is less arid than those habitats in which the species is typically recorded.	No records within 25km of the Knapdale Range. Many records undated, nearest recent record from 2019 near Cloncurry; however, other *Falco* species are often be confused by inexperienced observers for *F. hypoleucos* and records by inexperienced observers and/or without photographic evidence should be treated as circumspect.	Transient

Scientific Name Common Name	STATUS		Typical Habitat	Habitat at Knapdale Range	Local Records	Likelihood Assessment
	NCA	EPBC				
Grantiella picta Painted Honeyeater	Vul	Vul	Found mainly in dry open woodlands and forests, particularly box-ironbark woodlands. It may also occur in riparian forest, on plains with scattered eucalypts and in remnant trees on farmland and their occurrence is strongly associated with mistletoe.	Sparse trees with collared mistletoe (*Lysiana spathulata*), but these are scarce and neither *L. spathulate* nor its host trees are reported as being known habitat values for Painted Honeyeater	A single record from 2012 at Quamby Rodeo Grounds ~20km southeast. More distant records in the region are sparse and mostly >10y old, suggesting the species does not occur with any regularity in the broader region.	Unlikely
Numenius madagascariensis Eastern Curlew	End	Cr End	Coastal and intertidal zone	None present	No records within 25km of the Knapdale Range.	Will not occur
Plegadis falcinellus Glossy Ibis	SLC	Mig	Natural and artificial freshwater waterbodies including lakes, rivers, swamps, sewage ponds and irrigated crop fields. Can also occur on coastal water bodies e.g., estuaries, deltas and lagoons	TSF provided wading habitat in 2021 on beached tailings. Tailings were unlikely to support foraging resources and have since been inundated. It is highly unlikely that this area continues to provide habitat amenity.	A single record from the TSF dam in 2021 on beached tailings.	Present (Unlikely post-2021)
Pezoporus occidentalis Night Parrot	End	End	Relatively poorly understood, generally considered to favour spinifex grassland and chenopod shrubland on sandy or skeletal soils. In QLD known from breakaway habitats in and around Diamantina NP and Pullen Pullen Nature Refuge	Unlikely to be any present. Spinifex abounds but species is not known from rocky range country.	No records within 25km of the Knapdale Range. Nearest records from Diamantina NP and Pullen Pullen Nature Refuge >350km south.	Will not occur

Scientific Name Common Name	STATUS		Typical Habitat	Habitat at Knapdale Range	Local Records	Likelihood Assessment
	NCA	EPBC				
Rostratula australis Australian Painted Snipe	Vul	End	Found in a wide range of habitats including ephemeral swamps, dams, rice paddocks, waterlogged grasslands, roadside drains and even brackish waterways (Marchant and Higgins 1993).	None present	No records within 25km of the Knapdale Range	Will not occur
MAMMALS						
Macroderma gigas Ghost Bat	End	Vul	Habitats used for foraging vary from dry open woodlands to tropical rainforests (Wilmer 2012). Caves, rock crevices and old mines are used for roosting.	Two known abandoned mines within close proximity to the Range, and two known bat roosts in narrow caves. All locations are known to be inhabited by other microchiropterans, notably *Taphozous* spp.	No records within 25km of the Knapdale Range. Very sparse regional records, all >10y, most much older. Cluster of records associated with Camooweal Caves, and most recent regional record from 2011 just south of Chidna Station, ~125km northwest of the Knapdale Range. Species is likely regionally extinct.	Will not occur
Macrotis lagotis Greater Bilby	Vul	End	Soils which can be excavated for deep burrows. Largely confined to inland sandy deserts in NT and WA, with a restricted distribution in QLD on clay and stony soils in the Channel Country.	None present. Soils are skeletal and rocky, not suited to excavation.	No records within 25km of Knapdale Range	Will not occur
Petrogale purpureicollis Purple-necked Rock-wallaby	Vul	-	Massive rocky landforms, especially boulder piles, cliffs and gorges, with abundant caves and overhangs for daylight sheltering.	All large rocky outcrops, especially cliffs and rocky gullies dropping off the edge of the Range	Recorded annually during surveys at multiple known, monitored locations across the Knapdale Range	Present

Scientific Name Common Name	STATUS		Typical Habitat	Habitat at Knapdale Range	Local Records	Likelihood Assessment
	NCA	EPBC				
Sminthopsis douglasi Julia Creek Dunnart	End	Vul	Restricted to blacksoil clays with deep, wide cracks in Mitchell grass (*Astrebla* spp.) grasslands	None present	No records with 25km of the Knapdale Range	Will not occur
Tachyglossus aculeatus Short-beaked Echidna	SLC	-	Occurs in almost all terrestrial habitats except intensively managed farms.	Entire Knapdale Range	Regularly recorded on the Knapdale Range on survey cameras and during foot traverses	Present

Appendix E: Vegetation and landscape descriptions of impact (IMP) and control (CNT) BBUS survey sites

Vegetation and landscape descriptions of impact (IMP) and control (CNT) BBUS survey sites. Crown cover percentage and height range of trees and shrubs and percent cover of the ground stratum is given in parentheses after species list. Relevant notes pertaining to each site is given in square brackets after the description. Regional Ecosystem (RE) is provided based on the recorded description and comparison with technical descriptions in Kelman (2019).

<table>
<tr><th>Site</th><th>Description</th><th>RE</th></tr>
<tr><td>BBUS-IMP01</td><td>Open woodland of Corymbia capricornia/terminalis and occasional Eucalyptus leucophloia (25%, 3–5m) with Acacia monticola and sparse A. holosericea, Grevillea dryandri and Dodonaea dodecandra shrubs (30%, 0.5–3m) and Triodia pungens ground cover (90%) on rocky hill.
<table>
<tr><th>North</th><th>East</th><th>South</th><th>West</th></tr>
<tr><td>  </td><td>  </td><td>  </td><td>  </td></tr>
</table></td><td>1.11.2a</td></tr>
<tr><td>BBUS-IMP02</td><td>Open woodland of Eucalyptus leucophloia and occasional Corymbia capricornia/terminalis (15%, 4–5m) with Acacia monticola and sparse Santalum lanceolatum, Grevillea dryandri and A. gonoclada shrubs (25%, 1–2m) and Triodia pungens ground cover (80%) on rocky hill.
<table>
<tr><th>North</th><th>East</th><th>South</th><th>West</th></tr>
<tr><td>  </td><td>  </td><td>  </td><td>  </td></tr>
</table></td><td>1.11.2a</td></tr>
</table>

<table>
<tr><th>Site</th><th>Description</th><th>RE</th></tr>
<tr><td>BBUS-IMP03</td><td>Open woodland of Corymbia capricornia/terminalis, Eucalyptus leucophloia and sparse Grevillea mimosoides (15%, 4–6m) with Acacia monticola, A. holosericea, Tephrosia sp. and Santalum lanceolatum shrubs (15%, 2–4m) and ground cover of Triodia pungens and Cassytha sp. (90%) with sparse Cymbopogon bombicynus and Trichodesma zeylanicum on rocky hill.
<table>
<tr><th>North</th><th>East</th><th>South</th><th>West</th></tr>
<tr><td>  </td><td>  </td><td>  </td><td>  </td></tr>
</table></td><td>1.11.2a</td></tr>
<tr><td>BBUS-IMP04</td><td>Open woodland of Corymbia capricornia/terminalis and occasional Eucalyptus leucophloia (15%, 4–6m) with Acacia monticola and sparse A. retivenea, Tephrosia sp. and A. asperulacea shrubs (35%, 0.5–3m) and Triodia pungens ground cover (80%) on rocky hill adjacent steep gorge. [Vegetation gives way to open woodland of E. leucophloia, A. retivenea and T. pungens just south of turbine pad.]
<table>
<tr><th>North</th><th>East</th><th>South</th><th>West</th></tr>
<tr><td>  </td><td>  </td><td>  </td><td>  </td></tr>
</table></td><td>1.11.2a</td></tr>
</table>

<table>
<tr><th>Site</th><th colspan="4">Description</th><th>RE</th></tr>
<tr><td rowspan="3">BBUS-CNT01</td><td colspan="4">Open woodland of Corymbia capricornia/terminalis (10%, 4–5m) with Acacia monticola, A. retivenea and sparse Eremophila latrobei, Tephrosia sp., Grevillea dryandra and A. asperulacea shrubs (20%, 0.5–3m) and Triodia pungens ground cover (75%) on rocky hill.</td><td rowspan="3">1.11.2a</td></tr>
<tr><td>North</td><td>East</td><td>South</td><td>West</td></tr>
<tr><td>  </td><td>  </td><td>  </td><td>  </td></tr>
<tr><td rowspan="3">BBUS-CNT02</td><td colspan="4">Open Corymbia capricornia/terminalis woodland (10%, 2–4m) with Acacia monticola, Dodonaea dodecandra, Eremophila latrobei, Grevillea dryandri and sparse A. retivenea and Santalum lanceolatum shrubs (60%, 0.5–3m) and Triodia pungens ground cover (75%) on rocky hill.</td><td rowspan="3">1.11.2a</td></tr>
<tr><td>North</td><td>East</td><td>South</td><td>West</td></tr>
<tr><td>  </td><td>  </td><td>  </td><td>  </td></tr>
<tr><td rowspan="3">BBUS-CNT03</td><td colspan="4">Open woodland of Eucalyptus leucophloia (15%, 4–6m) with Acacia retivenea and Tephrosia sp. shrubs (5%, 1–2m) and Triodia pungens ground cover (90%) on rocky hill. [A. monticola dominates shrub layer on slopes just east of turbine pad.]</td><td rowspan="3">1.11.2a</td></tr>
<tr><td>North</td><td>East</td><td>South</td><td>West</td></tr>
<tr><td>  </td><td>  </td><td>  </td><td>  </td></tr>
</table>

<table>
<tr><th>Site</th><th>Description</th><th>RE</th></tr>
<tr><td rowspan="3">BBUS-CNT04</td><td colspan="3">Open woodland of Eucalyptus leucophloia (30%, 4–5m) with Acacia retivenea and Crotalaria sp. shrubs (15%, 1-3m) and Triodia pungens ground cover (80%) on rocky ridge. [Tephrosia sp. occurs in nearby gully, Acacia monticola joins shrub/tree strata on eastern slope of ridge.]</td><td rowspan="3">1.11.2a</td></tr>
<tr><td>North</td><td>East</td><td>South</td><td>West</td></tr>
<tr><td>  </td><td>  </td><td>  </td><td>  </td></tr>
</table>

APPENDIX O: Erosion and Sediment Control Plan (WTS, 2023)



EROSION AND SEDIMENT CONTROL PLAN

DUGALD RIVER MINE

MMG DUGALD RIVER PTY LTD

JUNE 2023

WULGURU TECHNICAL SERVICES

Contact Details	
Company	Wulguru Technical Services Pty Ltd
Project Manager	Matthew Ayre
Email	matthew@wulgurutechservices.com.au
Mail	PO Box 2553 IDALIA QLD 4810
ABN	79 644 301 655

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1. Introduction

MMG Dugald River Pty Ltd (MMG) operate the Dugald River Mine (DRM), a Zinc mining operation situated 62km north west of Cloncurry, northwest Queensland. Zinc is mined at DRM via underground diamond drilling techniques, processed at the DRM process plant and exported as concentrate via the Port of Townsville.

DRM operates in accordance with Environmental Authority (EA) EPML00731213. EA EPML00731213 Condition C33 specifies that an Erosion and Sediment Control Plan (ESCP) must be prepared by an appropriately qualified person and implemented for all stages of the mining activity. The ESCP must be prepared to provide the following functions (EA Condition C33):

a. Prevent or minimise the contamination of receiving waters and stormwater;

b. Divert uncontaminated stormwater run-off around areas disturbed by the mining activity or where contaminants or wastes are stored or handled;

c. Collect treat reuse and/or release contaminated stormwater runoff, incident rainfall and leachate in accordance with conditions of the environmental authority;

d. Minimise the size of areas or cover areas where contaminants or wastes are stored or handled;

e. Erosion and sediment control structures are placed to minimise erosion of disturbed areas and prevent the contamination of any waters;

f. Provide procedures to ensure that erosion and sediment control structures are maintained, and adequate storage is available in sediment dams in accordance with design criteria; and

g. Provide training of staff that will be responsible for maintenance and operation of sediment and erosion control structures.

This ESCP has been prepared by Wulguru Technical Services (WTS) on behalf of MMG to achieve compliance with EA Conditions C32, C33 and C34.

1.1. Purpose

The purpose of this document is to prepare an ESCP which achieves the requirements of EA EPML00731213 Condition C32, C33 and C34. This ESCP has been prepared by suitably qualified persons who hold qualifications in erosion and sediment control practices and/or are qualified as a Registered Professional Engineer in Queensland (RPEQ). Requirements of the ESCP are detailed in

Table 1. MMG ESCP Requirements

	Description	Where Addressed in ESCP
	EA EPML00731213 Condition C33 specifies that an Erosion and Sediment Control Plan (ESCP) must be prepared by an appropriately qualified person and implemented for all stages of the mining activity. The ESCP must be prepared to provide the following functions (EA Condition C33):	
a.	Prevent or minimise the contamination of receiving waters and stormwater;	Section 2.1.3, 2.1.4, 2.2.1
b.	Divert uncontaminated stormwater run-off around areas disturbed by the mining activity or where contaminants or wastes are stored or handled;	2.2
c.	Collect treat reuse and/or release contaminated stormwater runoff, incident rainfall and leachate in accordance with conditions of the environmental authority;	2.2.2
d.	Minimise the size of areas or cover areas where contaminants or wastes are stored or handled;	2.1.4
e.	Erosion and sediment control structures are placed to minimise erosion of disturbed areas and prevent the contamination of any waters;	2.3.2
f.	Provide procedures to ensure that erosion and sediment control structures are maintained, and adequate storage is available in sediment dams in accordance with design criteria; and	3.1
g.	Provide training of staff that will be responsible for maintenance and operation of sediment and erosion control structures.	3, 3.1

1.2. DRM Climate and Erosion Risk

DRM is situated within the northwest highlands biogeographic region. The region is characterised by distinctive wet and dry seasons with hot conditions and periods of rainfall between November to April, and relatively dry & mild conditions between May to October. The average rainfall for the Cloncurry region is 483.1 mm.

The International Erosion Control Association's (IECA) Best Practice Erosion and Sediment Control Guidelines (IECA 2008) sets erosion hazard based on average rainfalls for regions around Australia (Table 2). DRM monthly erosion risk is detailed in Table 3.

Table 2. Erosion Risk Rating Based on Average Monthly Rainfall Depth (IECA,2008)

Erosion Risk Rating	Average Monthly Rainfall Depth (mm)
Very Low	0 – 30
Low	30 – 45
Moderate	45 – 100
High	100 – 225
Extreme	>225

Table 3. Monthly Average Rainfall and Erosion Risk

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec
Mm	122.8	113.7	67.3	17.7	13.5	12.0	7.4	3.9	7.0	16.1	31.5	69.1
Risk	**H**	**H**	**M**	**VL**	**VL**	**VL**	**VL**	**VL**	**VL**	**VL**	**L**	**M**

H – High
M - Moderate
L – Low
VL – Very Low

1.3. DRM Project Soils

Soil investigations were conducted at DRM as a part of the Environmental Impact Assessment (AARC, 2010). The investigations determined 6 soil types across DRM. Soil types and descriptions are detailed in Table 4.

Table 4. Soil Types (AARC, 2010)

SMU	Description
Red Plain	Rudosol – Red sandy loam to sandy clay loam, neutral to slightly acidic, weak to moderate structure, shallow (0.5m) k factor – 0.045, occurs on flat plain areas
Miners	Rudosol – dark yellowish brown, sandy clay loam, slightly alkaline, weak structure, shallow (20cm), K Factor – 0.045, occurs on moderate slopes of 10 - 20º
Knapdale	Tenosol – Brown, sandy clay loam, neutral to slightly acid, weak structure, shallow (20cm) K Factor – 0.045, occurs on slopes of 30-40º
Dale	Rudosol – Brown, sandy loam, slightly acid (increasing pH with depth), weak to moderate structure, moderate depth (50 – 70cm), K Factor – 0.030, occurs in depressions.
Prospectors	Rudosol – Dark yellowish brow, clay loam, slightly acidic, weak structure, shallow (<20cm) depth. K Factor 0.030 occurs at the toe of the Knapdale ranges.
Pocket	Calcarosol –Grey, c lay loam, alkaline, weak structure, shallow (<20cm). Situated on slopes <5º

400 0 400 800 1,200 1,600 m

1:20,000

Client: Dugald River Pty Ltd
Project number: 2022.02002
CRS: GDA2020 EPSG: 7844
Date: 9 August 2022

Print as A3

Figure 1. Soil Management Units

Legend

- Mine Lease
- Mine Features

ESRI Satellite

Soil Management Unit

- Dale
- Knapdale
- Miners
- Pocket
- Prospectors
- Red Plain

Disclaimer:
Whilst every effort and care has been taken to ensure the accuracy of this report, Wulguru Technical Services Pty Ltd makes no representations or warranties about its accuracy, reliability, completeness or suitability for any particular purpose and disclaims all responsibility and all liability (including without limitation, liability in negligence) for all expenses, losses, damages (including indirect or inconsequential damage) and costs which you might incur as a result of the product being inaccurate or incomplete in any way and for any reason.
Digital data for this report is available on the Queensland Government Spatial Portal at https://qldspatial.information.qld.gov.au.

WULGURU TECHNICAL SERVICES

2. Erosion and Sediment Control Implementation

2.1. General Erosion and Sediment Control Principles

2.1.1. ESC Purpose

ESC measures are designed to control/manage erosion and sediment that may result from mining and other related activities. General ESC principles include:

- Implementing ESCs prior to land disturbance;
- Minimising all disturbed areas and stabilisation as much as possible by conducting progressive rehabilitation/stabilisation as soon as practical;
- Maintaining vegetative buffer zones where possible;
- Regular maintenance of ESCs; and
- Revegetation of final landforms as soon as possible.

2.1.2. ESC Installation

ESCs fall into three groups:

1. **Type 1**: Sediment trap designed to collect particles <0.045mm.Includes Sediment Basins and other filtration systems used in de-watering operations (IECA, 2008).
2. **Type 2**: Sediment containment systems designed to capture sediment to between 0.045 and 0.14mm. Includes Rock Filter Dams, Sediment Weirs and Filter Ponds (IECA, 2008).
3. **Type 3**: Sediment containment systems primarily designed to trap sediment particles <0.14mm. Includes sediment fences, buffer zones and some stormwater inlet protection systems (IECA, 2008).

The determination of the ESC to be implemented primarily depends on the area of disturbance and the estimated soil loss rate (t/ha/year) and erosion hazard (See Appendix C).

2.1.3. Disturbance Minimisation

It is recommended the following disturbance minimisation methods be implemented at DRM:

- Limiting land clearing to the area specifically required for mining and construction activities.
- Land disturbances are to be carried out 50m from a watercourse.
- Survey of areas to be disturbed are required to be conducted prior to disturbance to ensure areas are not over cleared.
- Limiting the amount of access points to a working area.
- Minimising the of areas where contaminates or waste area stored or handled.

2.1.4. Management of Runoff

It is recommended that runoff from disturbed areas of DRM be managed using the following management principles:

1. **Diversion of clean water** – Clean water diversion bunds/drains installed and maintained around disturbed areas. Clean water diversions (including roofing) direct clean waters away from DRM activities to ensure that waters do not become contaminated and in turn, impact the receiving environment.
2. **Capture & treatment of runoff** – Sediment basins installed and maintained within the disturbance areas. Waters are conveyed towards sediment basins and containment dams. Where sediment basins reach capacity, they may be discharged to the receiving environment where they meet the criteria of EA EPML00731213 Schedule C Table 2. Where waters do not meet the requirements of Schedule C Table 2, additional treatment of waters may be required to ensure discharge compliance (Flocculation, dilution etc.).

2.2. Site Specific Control Measures

2.2.1. Operational Areas

Operational areas include areas of the MLs which are required for the mining, processing of ore, and tailing storage facility (TSF) (process plant, waste rock dumps, TSF etc.). These operation areas have existing containment dams and sediment basins, which have previously been sized and designed by RPEQs, and have since been constructed. These water storages are currently managed under the DRM EA and as a certified regulated structure where required. This section provides detail of operational ESC features. ESC designs are included in Appendix A. There are no changes to existing designed structures as a part of this ESCP.

The main objective of structures installed within operational areas of DRM is to control/manage stormwater runoff, manage sediment loss, minimise the risk of erosion throughout all phases of the mine and contain potential contaminants produced by mining/processing activities. Structures used within operational areas to manage sediment loss and erosion include:

- water culverts;
- water inlet channels;
- Sediment basins; and
- Containment Dams

2.2.1.1. Culverts

Culverts have been installed within operational area catchments to concentrate flow and direct runoff towards storages. The culverts are often installed at the low point of each operational subcatchment which then direct runoff into storage inlet channels.

2.2.1.2. Inlet Channels

Inlet channels have been constructed to convey concentrated runoff from culverts towards storages. Structures with inlet channels include the process plant containment pond, process plant runoff dam, and ROM runoff dam. Inlets are constructed as concrete aprons with low batter angles. Waters conveyed by culverts flow over the inlet channels and into storages A typical concrete inlet design is detailed in Figure 2.

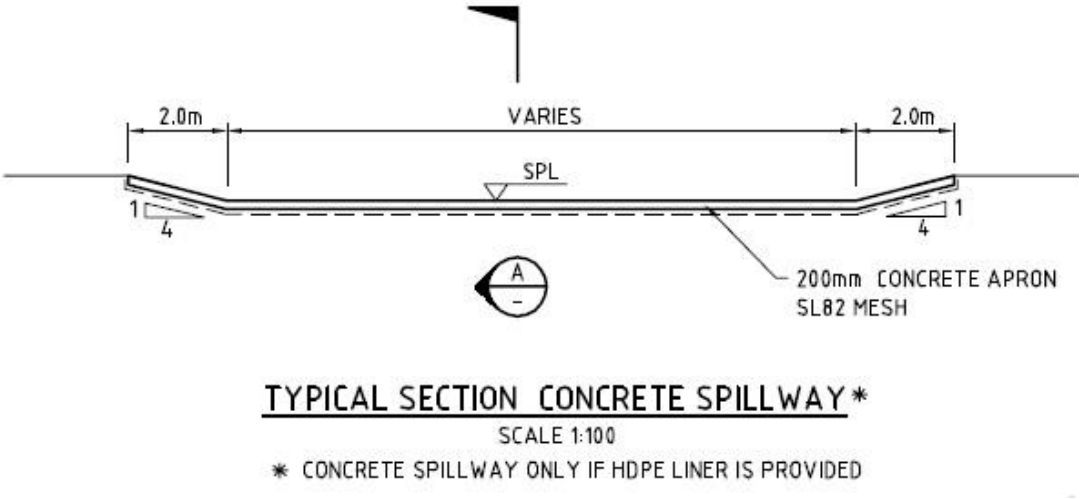


Figure 2. Typical Concrete Inlet

2.2.2. Sediment Control

2.2.2.1. Sediment Basins

Sediment basins are utilised to reduce the sediment discharged into waterways as a result of runoff from disturbed areas. These sediment basins are considered to be Type D or Type F basins under the IECA ESC best practice guidelines.

Treatment of sediment basins is primarily via natural sediment drop out within the water column. However, where dispersive soils exist, flocculation may be required to assist in the drop out of finer particles. Retained dirty runoff is able to be treated and discharged where the quality of discharge meets the requirements of EPML00731213 Table 2.

2.2.2.2. Containment Dams

Containment Dams have been constructed to manage stormwater from catchments with a potential for contaminates Each containment dam has been constructed taking into consideration the types of contaminates most likely to be captured and the size of the catchment.

2.2.2.3. Spillway Design

Sediment basins and containment dams have spillways designed and approved for discharge during wet weather events. Spillways at DRM are constructed out of 50-150 mm diameter rip rap material to a depth of 300 mm. Discharged either flows into the receiving environment directly via the spillway or via an outflow channel.

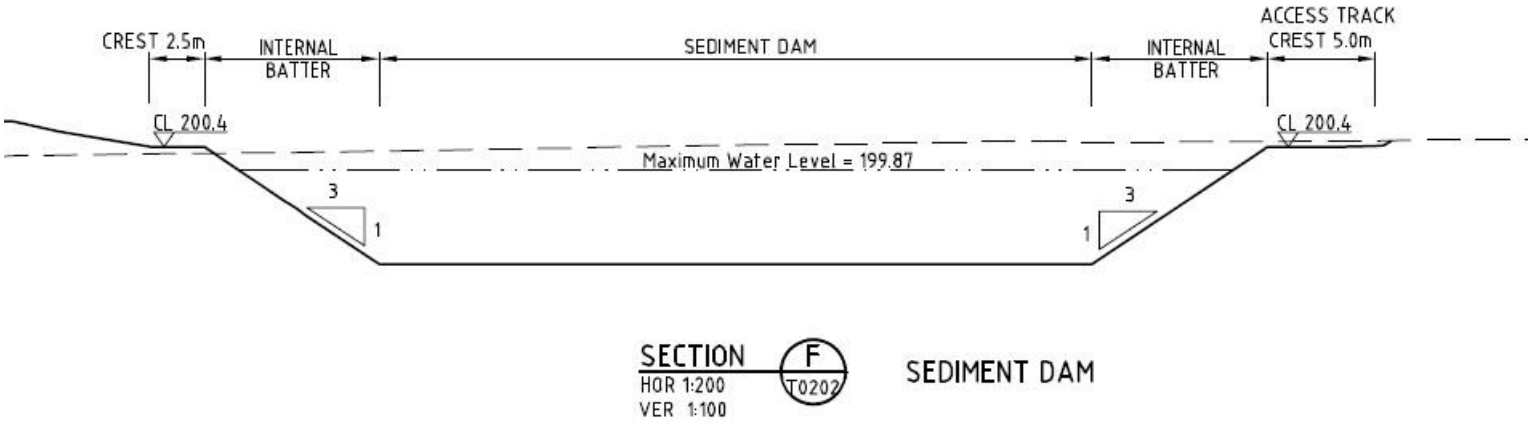


Figure 3. Typical Sediment Basin Design

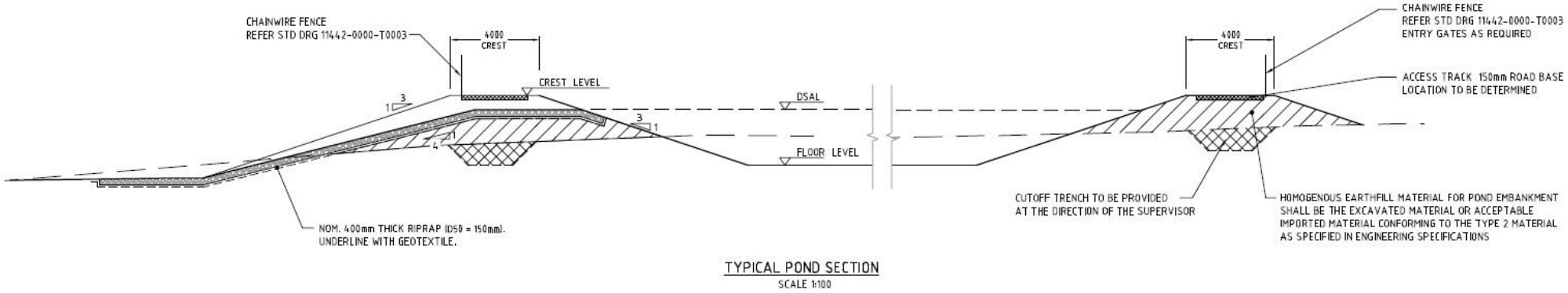


Figure 4. Typical Runoff Dam Design

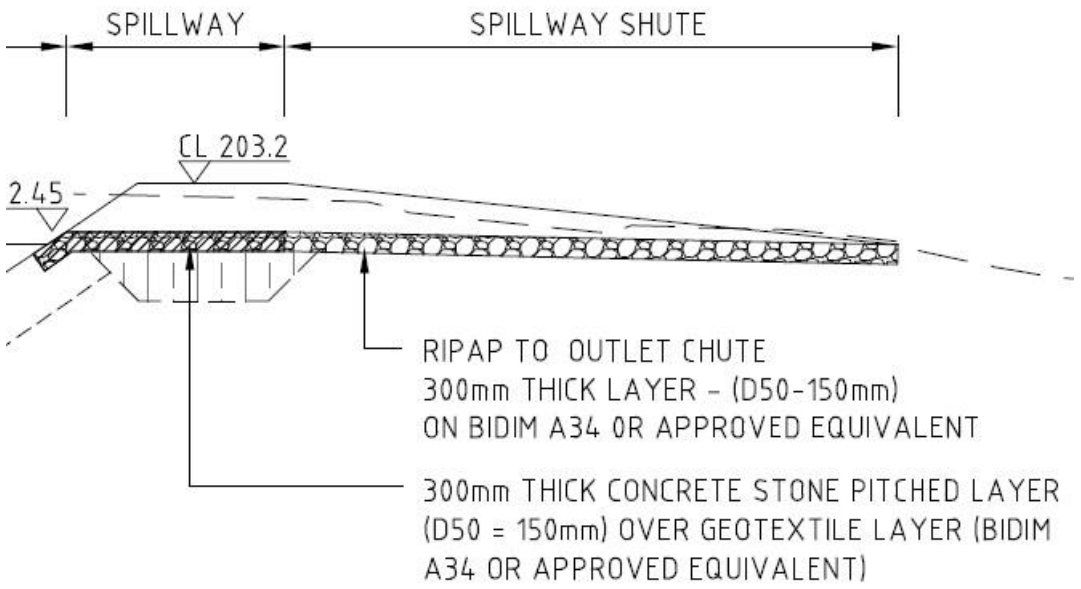


Figure 5. Typical Spillway Design

2.2.2.4. Type 3 Controls

Type 3 ESCs are considered temporary and usually implemented during initial disturbance, focussing on capturing particle size fractions > 0.14mm (IECA, 2008). These measures may be installed during earthworks to prevent sediment laden water from entering clean water catchments.

Type 3 ESCs which may be used within DRM operational areas include:

- Sediment fences;
- Coir logs;
- Rock check dams;
- Buffer Zones; and
- Berms.

2.3. Non-Operational Areas

Non-operational areas are domains of DRM which are not a direct part of the mining or process activities and include areas such as exploration pads, tracks, laydowns, workers accommodation and wind farm pads. This section details the calculations used to assess erosion risk, the types of ESCs required and ESC details for non-operational areas of DRM. Detailed designs have been prepared by Civil IQ Pty Ltd (Civil IQ) and are included in Appendix B.

2.3.1. ESC Controls Requirements

The type of control to be installed is dependent on soil loss (t/ha/year) over the catchment. Soil loss within a catchment is calculated using the Revised Universal Soil Loss Equation (RUSLE) as follows:

$$\mathbf{A = R \times K \times LS \times P \times C}$$

Where:

A = Computed soil loss (t/ha/year)

R = Rainfall erosivity factor

K = Soil erodibility factor

LS = Slope length/gradient factor

P = Erosion control practice factor

C = Ground cover and management factor

RUSLE calculations determine the soil loss (t/ha/year) and erosion hazards for each of the Subcatchments at DRM. The soil loss rate determines the type of ESCs required to be installed.

Sediment control type standards and corresponding soil loss rates are detailed in Figure 6.

Table B1 – Sediment control standard (default) based on soil loss rate

Catchment Area (m^2) [1]	Soil loss (t/ha/yr) [2]			Soil loss (t/ha/month) [3]		
	Type 1	Type 2	Type 3	Type 1	Type 2	Type 3
250	N/A	N/A	[4]	N/A	N/A	[4]
1000	N/A	N/A	All cases	N/A	N/A	All cases
2500	N/A	> 75	75	N/A	> 6.25	6.25
>2500	> 150	150	75	> 12.5	12.5	6.25
> 10,000	> 75	N/A	75	> 6.25	N/A	6.25

Notes:

[1] Area is defined by the catchment area draining to a given site discharge. Sub-dividing a given drainage catchment shall not reduce its 'effective area' if runoff from these sub-areas ultimately discharges from the site at the same general location. The 'area' does not include any 'clean' water catchment that bypasses the sediment trap. The catchment area shall be defined by the 'worst case' scenario, i.e. the largest effective area that exists at any instance during the soil disturbance.

[2] Soil loss defines the maximum allowable soil loss rate (based on RUSLE analysis) from a given catchment area. A slope length of 80 m should be adopted within the RUSLE analysis unless permanent drainage or landscape features reduce this length.

[3] RUSLE analysis on a monthly basis shall only apply in circumstances where the timing of the soil disturbance is/shall be regulated by enforceable development approval conditions. When conducting monthly RUSLE calculations, use the worst-case monthly R-Factor during the nominated period of disturbance.

[4] Refer to the relevant regulatory authority for assessment procedures. The default standard is a Type 3 sediment trap.

[5] Exceptions to the use of *Sediment Basins* shall apply in circumstances where it can be demonstrated that the construction and/or operation of a *Sediment Basin* is not practical, such as in many forms of linear construction where the available work space or Right of Way does not provide sufficient land area. In these instances, the focus must be erosion control using techniques to achieve an equivalent outcome. The 'intent' shall always be to take all reasonable and practicable measures to prevent or minimise potential environmental harm.

Figure 6. Sediment Control Standard based on Soil Loss Rates

Soil loss and erosion hazard have been calculated using the RUSLE calculation above for the 24 sub-catchments identified outside of DRM operational areas. Soil loss calculations are detailed in Appendix C.

2.3.2.Drainage Controls

2.3.2.1. Clean Water Diversions

It is recommended that clean water diversions are constructed on the upstream perimeter of disturbance to convey clean water runoff away from disturbed areas and reduce the catchment of runoff requiring retention and treatment. Clean water diversions may consist of a bund which will concentrate flow along the tow of the bund away from disturbance areas or catch drains can be installed upslope of the disturbance area. Where subsoils are sodic, catch drains are not recommended and bunds are preferred to be installed to limit the risk of dispersive material being exposed to runoff.

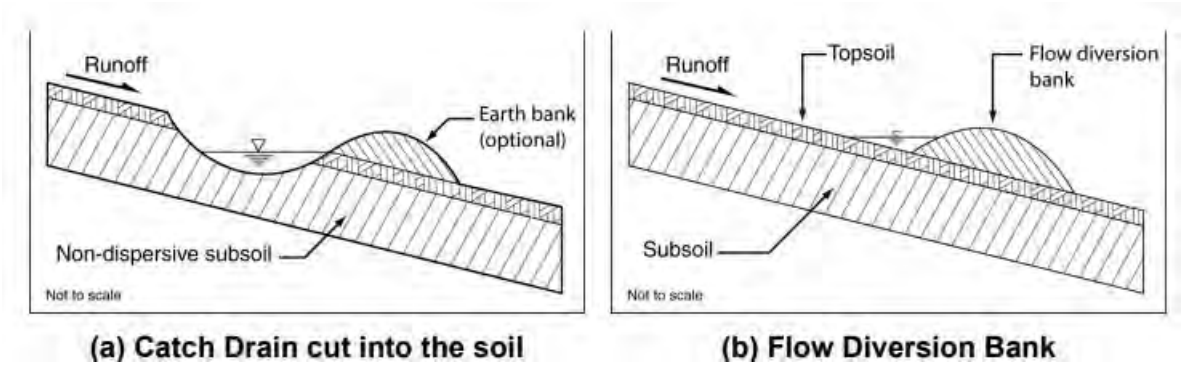


Figure 7. Diversion Bank Options (IECA,2008)

2.3.2.2. Cross Bank Drainage

Cross bank drains may be installed on unsealed tracks to divert water to roadside table drains. Cross bank drains divert waters off the road or access track at designated intervals. Cross bank drains are recommended to be installed at a height that adequately diverts runoff while also being wide enough to allow for comfortable vehicle passage. IECA Best practice in ESC guideline (2008) outlines that Cross-bank drains are to be sized dependant on Erosion Risk (Table 5).

Table 5 Cross Bank Drain Spacing (IECA,2008)

Road Grade	Horizontal Spacing (m)
1%	100
2%	60
3%	50
5%	40
10%	30
>14%	20

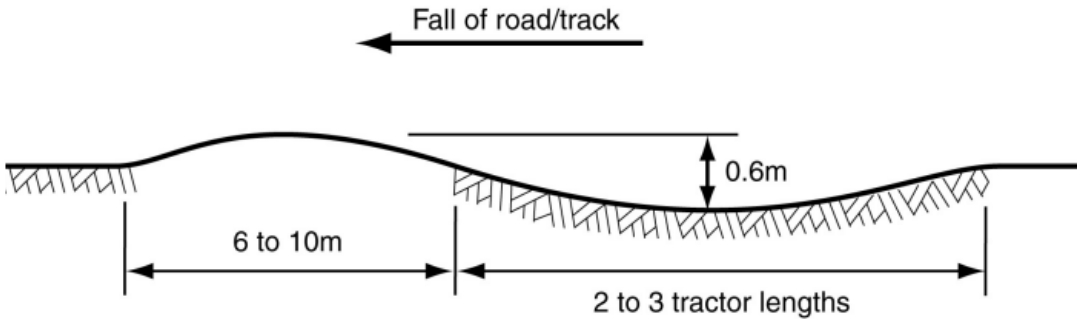


Figure 8. Typical Cross Bank Drain Design

The following is to be considered when installing cross bank drains as cross bank drainage features:

- Material used in construction must be cohesive and material such as sands and bull dust should be avoided.
- Direction of should ensure discharge does not impact lower potions of roads/tracks.
- Should be positioned away from intersections.
- Should not be > 4H:1V.

2.3.2.3. Table Drains

It is recommended that table drains be installed parallel to roads and tracks and convey waters downstream to Mitre drains for disposal. These drains are designed to have sufficient capacity to convey waters without eroding. The type of drain (parabolic vs “v” shape) is dependent on the substrate in which the drain is being installed however, parabolic drains are preferred. Typical drain design is displayed in Figure 9.

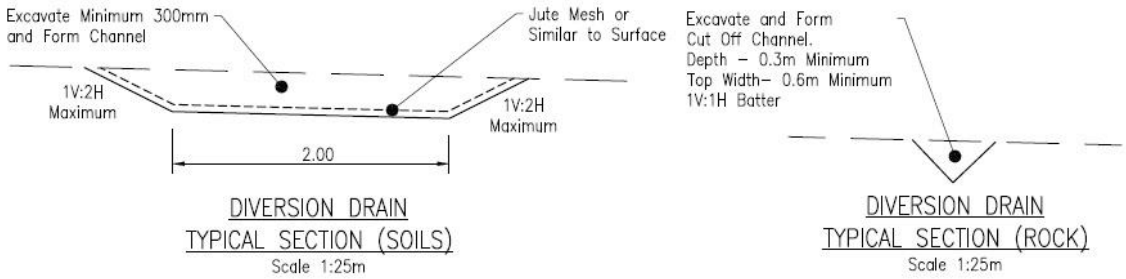


Figure 9. Typical Diversion Drain Designs (Civil IQ, 2022)

2.3.2.4. Mitre Drains

Mitre drains are open channels built parallel to roads and tracks which direct runoff from cross bank drains for disposal. Mitre drains convey waters to an energy dissipater at the mitre drain outlet which will allow waters to discharge as sheet flow into the receiving environment. The spacing of Mitre drains is dependent on the spacing of cross bank drains however, standard spacing for Mitre drains are detailed in Table 6.

Table 6. Mitre Drain Spacings Along Roadside Table Drains (IECA,2008)

Road Grade	Horizontal Spacing (m)
<1%	>150
2%	100
5%	60
10%	40
>10%	15

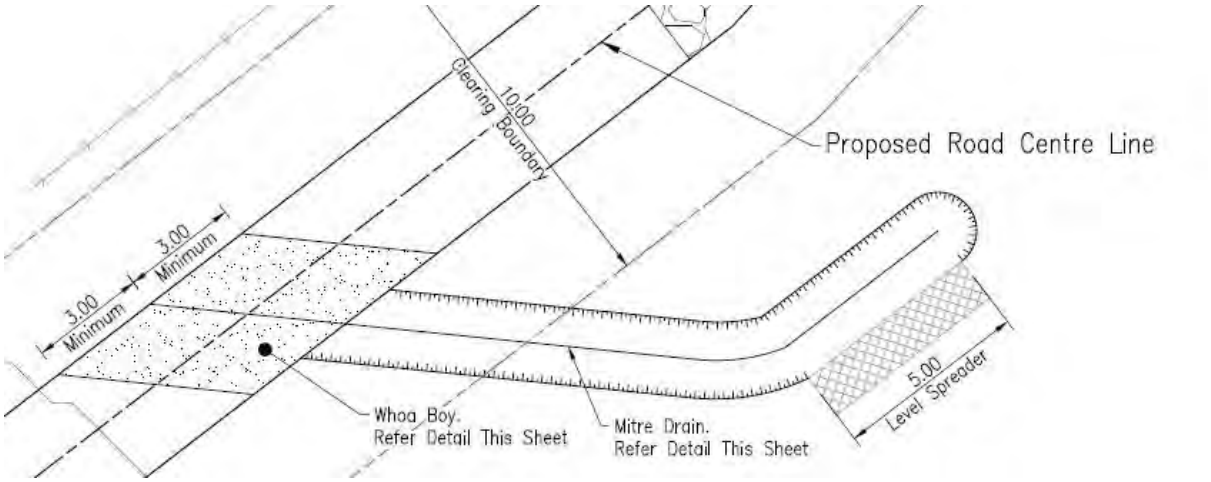


Figure 10. Typical Cross Bank & Mitre Drain Design (Civil IQ, 2022)

2.3.2.5. Waterway Crossings

Waterway crossings are required at DRM where access tracks cross watercourses. Waterway crossings will be installed as “dry” and “wet’” waterway crossings as per the schematics below. The following is to be considered when installing waterway crossings:

- Soil is not stockpile in watercourses.
- Disturbance of stream bed is to be minimised as much as practical.
- Disturbance of the stream bed is kept to a minimum.

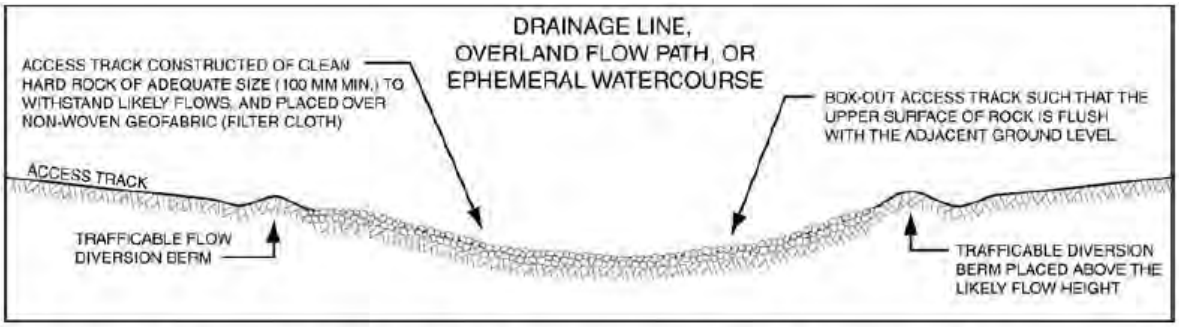


Figure 16. Typical profile of a bed-level vehicle crossing for a 'dry' drainage line (IECA, 2015).

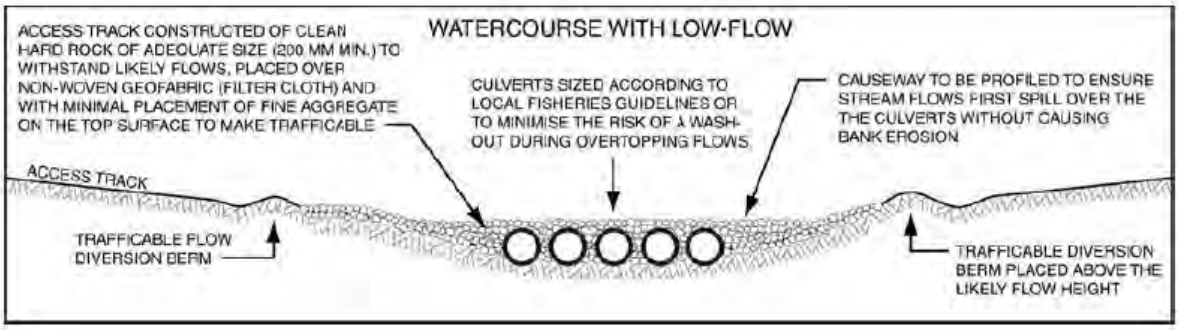


FIGURE 11. BED LEVEL CROSSING OPTIONS (LANDLOCH, 2018)

2.3.3. Sediment Controls

2.3.3.1. Sediment Basins

Sediment basins have been designed for non-operational areas of DRM (Appendix E). Sediment basins have been designed for IFD: 2-year, 6-hour storm. Typical Sediment Basin design is included in Figure 12. Sediment Basin sizings detailed in Appendix D.

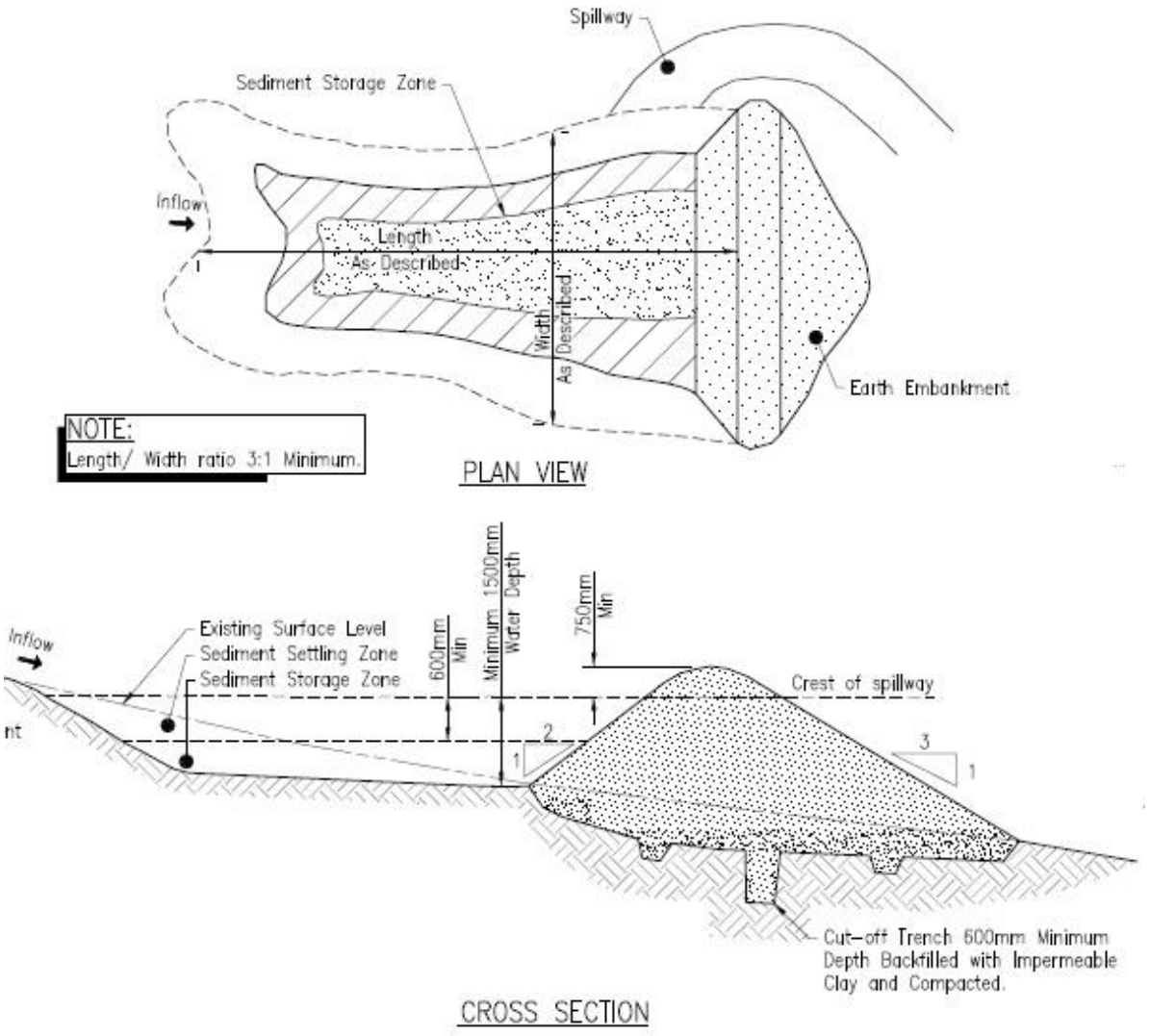


Figure 12. Typical Sediment Basin Design (Civil IQ, 2022)

2.3.4. Sediment Weir

Where soil loss calculations have determined that type 2 ESCs are required, sediment weirs should be installed. Sediment Weirs are self-supporting vertical rock weirs constructed from riprap, with a filter medium placed upstream of the weir. Sediment weirs can be installed at the low point of the catchment. Dirty runoff flows through the outer geotextile fabric and aggregate into the sump where sediment will drop from suspension. When waters within the sump exceed the natural elevation of the lower wall, runoff will continue to flow through the geotextile fabric and aggregate, and into the receiving environment. A weir may be installed on the outfall wall of the sediment weir when flows exceed capacity. Typical Sediment Weir design is below.

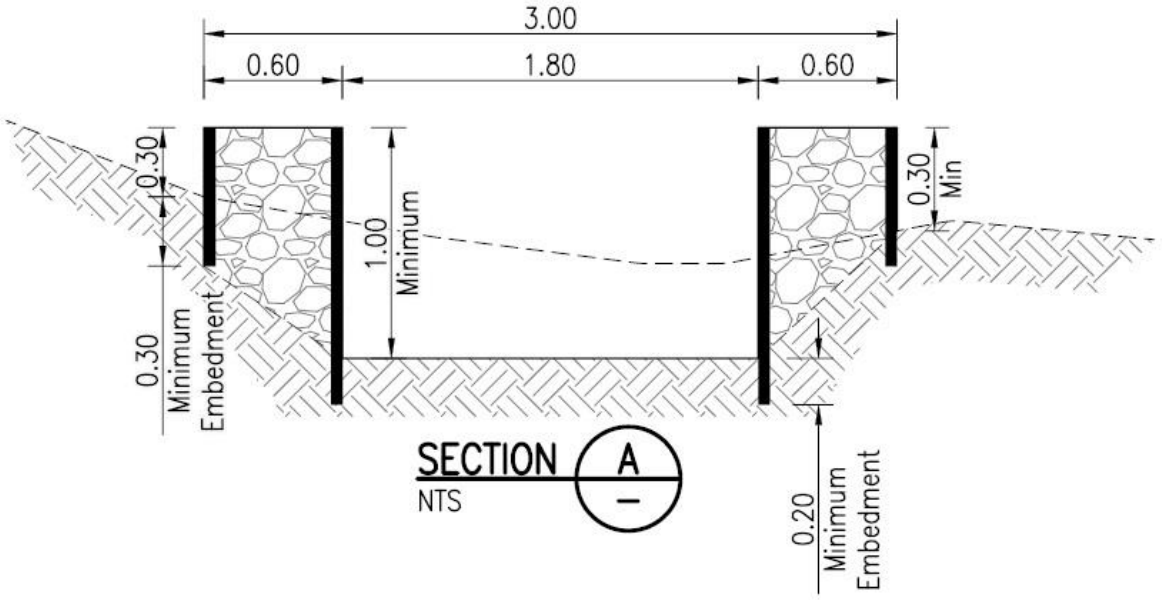


Figure 13. Typical Sediment Weir

2.3.4.1. Level Spreader

Where there is a low to very low erosion risk within a sub-catchment, level spreaders may to be installed. Level spreaders convert concentrated flow to sheet flow to avoid high velocity waters entering the environment and causing erosion and sediment loss. Level spreaders can be installed at the outfall of a subcatchment. The slope of the landform must be <1% and the landform receiving discharged runoff must be stable and non-sodic. Typical Level spreader design is displayed in Figure 14.

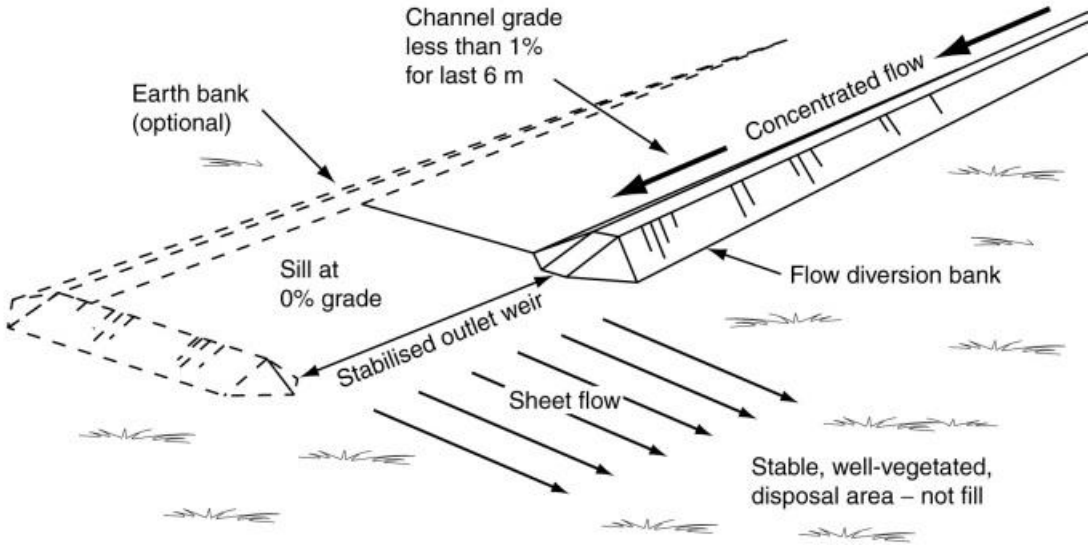


Figure 14. Typical Level Spreader

2.3.5. Type 3 ESCs

Type 3 ESCs should be implemented where there is a low to very low erosion hazard. Type 3 controls at DRM may be constructed as sediment fences. Sediment fences are constructed using geotextile filter fabric with steel pickets to be spaced no more than 2.5 metres apart. Sediment fences are to be installed on the downstream of the areas disturbed and are to be installed parallel to the landform contours, with the upslope catchment is to grade of no more than 1V: 2H. Sediment fences should not be installed in high velocity flows and where upstream catchments exceed 0.6 hectares. Where practicable, catchment areas are to be reduced by constructing fences with returns at 20 metres to create smaller catchments.

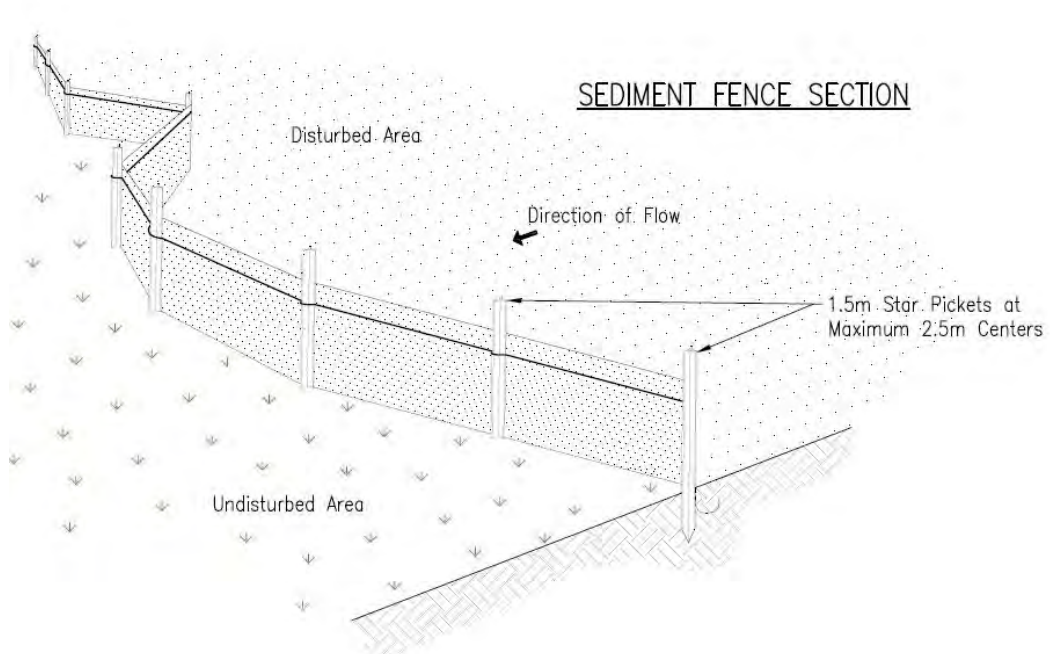


Figure 15. Typical Sed Fence Design

3. ESC Management

3.1. Inspections

Inspections of erosion and sediment control structures is designed to assess the condition and performance of the structures. Inspections are carried out in accordance with applicable site inspection procedures to review any maintenance requirements and assess storage availability.

3.2. Staff Training

Training in ESC is recommended to be completed by the DRM environmental team and other personnel who are conducting works under a DRM LDP. Basic ESC training for these workers is aimed at ensuring that these workers understand the importance of ESC and the types of ESCs to be implemented within their work areas. Training will include:

- Land disturbance processes;
- ESC used at DRM; and
- Erosion hazards of their work areas.

4. References

BUCHANAN S, 2018. Erosion and Sediment Control Strategy. Landloch Pty Ltd. Toowomba

BUREAU OF METEOROLOGY. 2021a. Climate statistics for Australian locations - Cloncurry Airport (029141) [Online]. Available: http://www.bom.gov.au/jsp/ncc/cdio/weatherData/av?p_nccObsCode=136&p_display_type=dailyDataFile&p_startYear=&p_c=&p_stn_num=029141 [Accessed 01/012/2022].

ECA 2008, Best Practice Erosion and Sediment Control. Book 1. International Erosion Control Association (Australasia), Picton NSW

ECA 2008, Best Practice Erosion and Sediment Control. Book 2. International Erosion Control Association (Australasia), Picton NSW

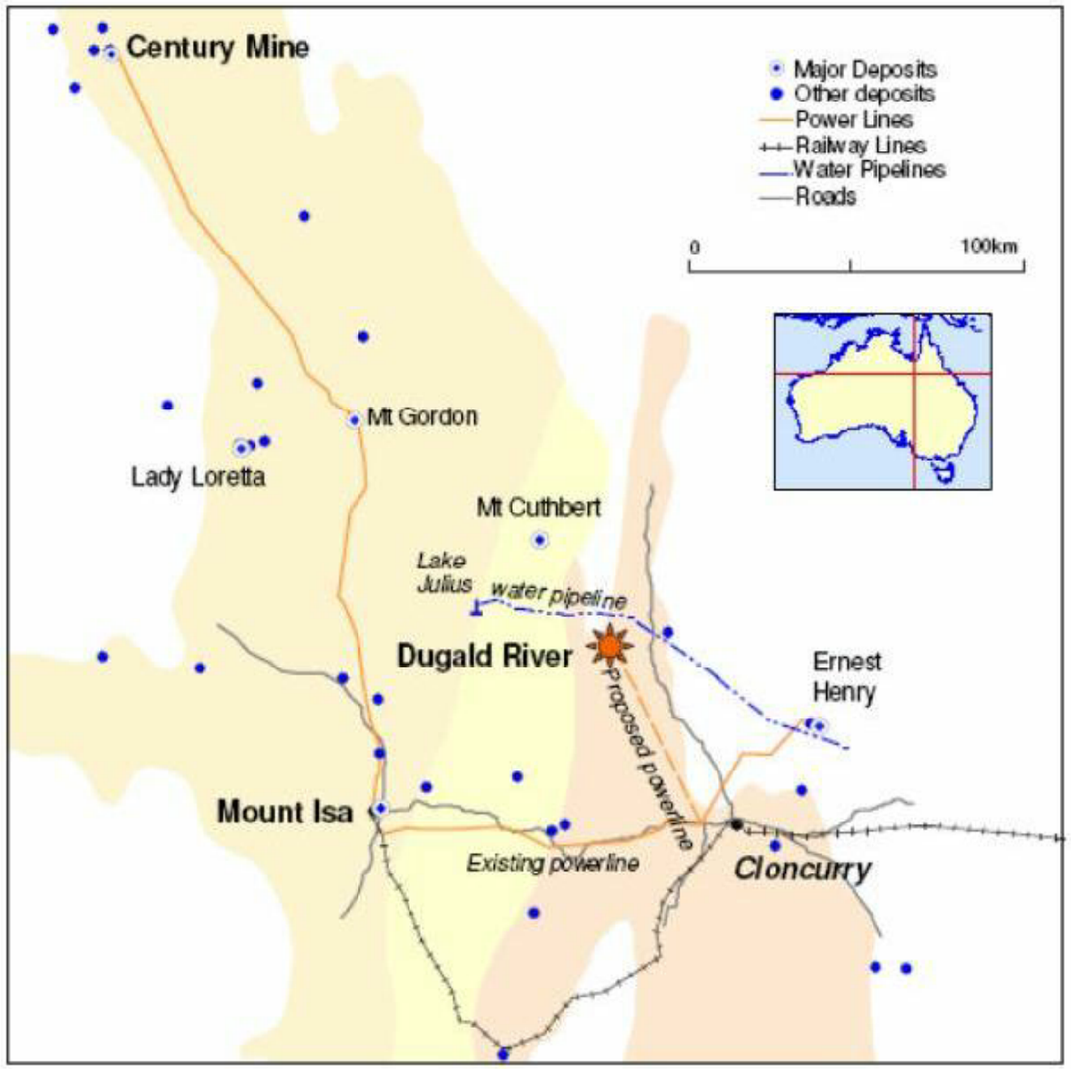
ECA 2008, Best Practice Erosion and Sediment Control. Book 3. International Erosion Control Association (Australasia), Picton NSW

GLENCORE – ULAN COAL 2021. Erosion and Sediment Control Plan

Appendix A – Operational Area ESCP Plans

MMG DUGALD RIVER
DUGALD RIVER PROJECT

ADMINISTRATION AREA SEDIMENTATION AND EROSION CONTROL



LOCALITY PLAN
SCALE: NTS

ISSUED FOR CONSTRUCTION

DRAWING LIST

MMG DRAWING #	ATCW DRAWING #	DRAWING TITLE
0016-DWG-2160-C-0067	108003.26-000	DRAWING LIST
0016-DWG-2160-C-0068	108003.26-001	SITE PLAN
0016-DWG-2160-C-0069	108003.26-002	SED DAM C - GENERAL LAYOUT
0016-DWG-2160-C-0070	108003.26-003	SED DAM C - SEDIMENT COLLECTION DRAINS AND 'CLEAN WATER' DIVERSION CHANNEL LONG SECTIONS
0016-DWG-2160-C-0071	108003.26-004	SED DAM C - SEDIMENT COLLECTION DRAINS AND 'CLEAN WATER' DIVERSION CHANNEL SECTIONS AND DETAILS
0016-DWG-2160-C-0072	108003.26-005	SED DAM C - DETAIL PLAN AND SECTIONS
0016-DWG-2160-C-0073	108003.26-006	SED DAM C - SECTIONS AND DETAILS (SHEET 1 OF 2)
0016-DWG-2160-C-0074	108003.26-007	SED DAM C - SECTIONS AND DETAILS (SHEET 2 OF 2)
0016-DWG-2160-C-0075	108003.26-008	SED DAM D - GENERAL LAYOUT, DETAIL PLAN AND SECTIONS
0016-DWG-2160-C-0076	108003.26-009	SED DAM D - SEDIMENT COLLECTION DRAIN LONG SECTIONS AND DETAILS
0016-DWG-2160-C-0077	108003.26-010	SED DAM D - SECTIONS AND DETAILS

GENERAL CONSTRUCTION NOTES

1. THESE NOTES APPLY TO ALL PROJECT DRAWINGS IN THE SET UNLESS NOTED OTHERWISE AND SHALL BE READ IN CONJUNCTION WITH THE WORK METHOD.
2. ALL LEVELS ARE IN METRES TO AUSTRALIAN HEIGHT DATUM (AHD).
3. ALL COORDINATES ARE IN METRES TO MAP GRID OF AUSTRALIA (MGA).
4. ALL DIMENSIONS ARE IN METRES UNLESS OTHERWISE NOTED.
5. DIMENSIONS AND LOCATIONS OF EXISTING STRUCTURES SHALL BE CONFIRMED ON SITE BY THE CONTRACTOR PRIOR TO COMMENCEMENT OF WORKS.
6. LOCATION AND DEPTH OF ALL SERVICES TO BE VERIFIED BY THE CONTRACTOR PRIOR TO THE COMMENCEMENT OF WORKS.
7. DIMENSIONS SHALL NOT BE SCALED OFF DRAWINGS.
8. SECTION REFERENCING RELATES TO THE MMG DRAWING NUMBERS.

No.	DESCRIPTION	DATE	DRAWN	CHECKD	APPRD
1	ISSUED FOR CONSTRUCTION	05.10.16	LL	AVK	MD

SCALE NTS | JOB No. 108003.26 | DATE 06.07.16 | DESIGN AVK | DRAWN HR | CHECKED AVK | APPROVED MD

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MMG DUGALD RIVER
DUGALD RIVER PROJECT

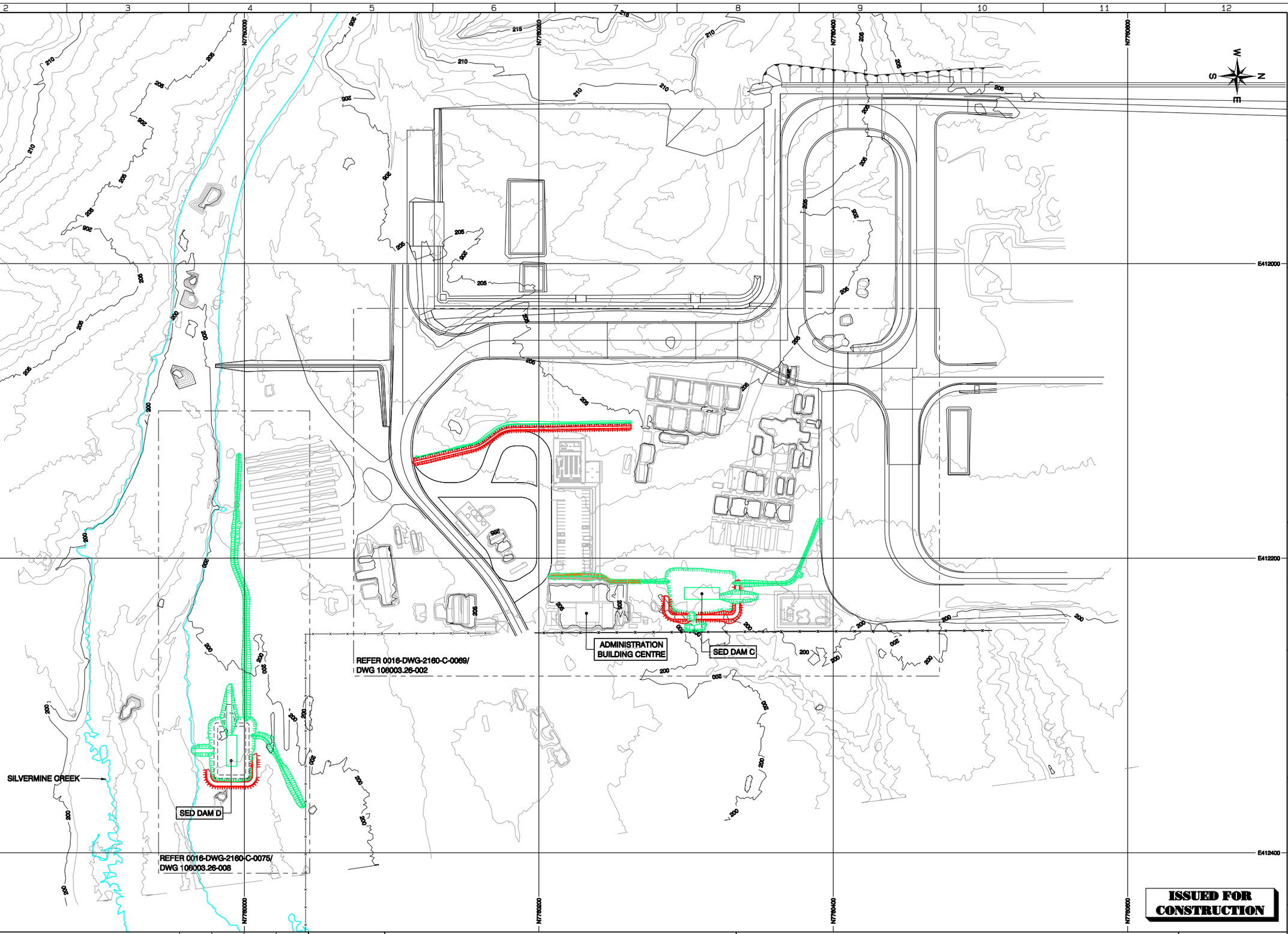
ADMINISTRATION AREA
SEDIMENTATION AND EROSION CONTROL
DRAWING LIST

108003.26-000

MMG DWG NO. 0016-DWG-2160-C-0067

REV. 1 | SHT SIZE A3

SHEET 1 OF 1



No.	DESCRIPTION	DATE	DRAWN	CHECKD	APPRD
1	ISSUED FOR CONSTRUCTION	05.10.16	LL	AVK	MD

SCALE	1:2500
JOB No.	108003.26
DATE	08.07.16
DESIGN	AVK
DRAWN	HR
CHECKED	AVK
APPROVED	MD

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brisbane@atcwilliams.com.au
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MMG DUGALD RIVER
DUGALD RIVER PROJECT

ADMINISTRATION AREA
SEDIMENTATION AND EROSION CONTROL
SITE PLAN

108003.26-001

MMG DWG NO.
0016-DWG-2160-C-0068

REV. 1 | SHT SIZE A3

SHEET 1 OF 1

REFER DETAIL ON PLAN 0016-DWG-2160-C-0069/
DWG 108003.26-005

LEASE BOUNDARY

WASTE WATER TREATMENT PLANT

SED DAM C (PRELIMINARY)

BACKFILL OF CREEK AREA

ADMINISTRATION BUILDING CENTRE

Q=0.5m³/s

Q=0.8m³/s

EXISTING SURFACE TO BE RESHAPED TO SOUTHERN SEDIMENT COLLECTION DRAIN

8:1

3:1

SOUTHERN SEDIMENT COLLECTION DRAIN LINED WITH ROCK EROSION PROTECTION.

NORTHERN SEDIMENT COLLECTION DRAIN LINED WITH ROCK EROSION PROTECTION

GRADE 0.8% / GRADE 0.8%

NPI CONTRACTOR TO DESIGN DRAIN IN AREA ADJACENT TO SITE BUILDINGS AND CAR PARKS

CAR PARK

VEHICLE WASH BAY

CHANGE HOUSE

LOCATION OF 'CLEAN WATER' DIVERSION CHANNEL

EXISTING CAMP

EXISTING CAMP

GRADE 1.2%

EXISTING CULVERT C19 (Ø1200)

PATHWAY AND CROSSING DESIGN BY NPI CONTRACTOR

LINED WITH ROCK EROSION PROTECTION

WEIGH BRIDGE

N7760400 N7760300 N7760200 N7760100

E412200 E412100

Coordinate Table - Drains			
Pt #	Easting	Northing	Elevation / Radius
1	412173.92	7760390.92	200.80
2	412199.60	7760379.90	200.61
3	412211.06	7760374.97	200.55
4	412207.12	7760365.76	R = 10.0
5	412217.12	7760365.72	200.49
6	412216.89	7760331.46	200.32
7	412215.87	7760269.19	200.90
8	412215.87	7760288.80	200.70
9	412107.96	7760262.30	204.24
10	412109.15	7760181.89	203.27
11	412129.15	7760182.19	R = 20.0
12	412113.08	7760170.29	203.12
13	412119.30	7760161.88	202.99
14	412103.22	7760149.99	R = 20.0
15	412122.70	7760154.54	202.89
16	412131.85	7760115.44	202.41

ISSUED FOR CONSTRUCTION

No.	DESCRIPTION	DATE	DRAWN	CHECK'D	APPR'D
1	ISSUED FOR CONSTRUCTION	05.10.16	LL	AVK	MD

SCALE	1:1000
JOB No.	108003.26
DATE	06.07.16
DESIGN	AVK
DRAWN	DR
CHECKED	AVK
APPROVED	MD

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MMG DUGALD RIVER
DUGALD RIVER PROJECT

ADMINISTRATION AREA
SEDIMENTATION AND EROSION CONTROL
SED DAM C
GENERAL LAYOUT

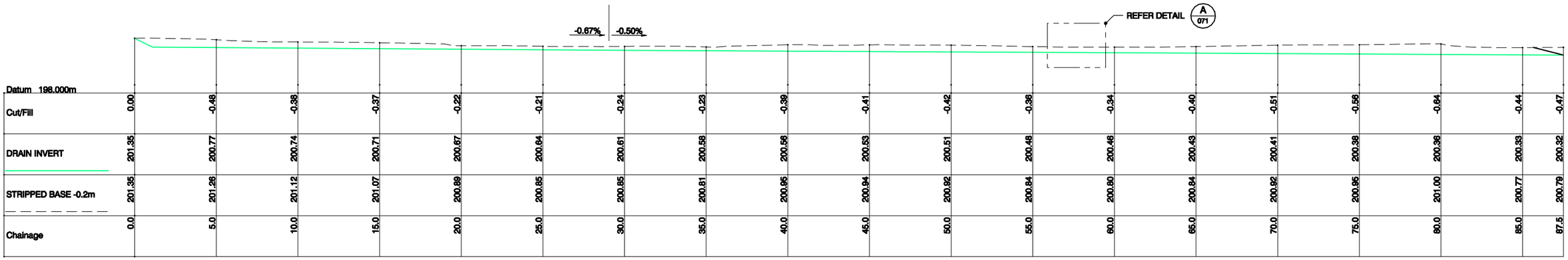
108003.26-002

MMG DWG NO.
0016-DWG-2160-C-0069

REV. 1 | SHT SIZE A3

SHEET 1 OF 1

J:\2008\108003 Dugald River\26 NAF and Sed Ponds\Terramodel\Detailed Design IFC.pro (Terramodel) Wed 5 Oct 2016 17:35:42

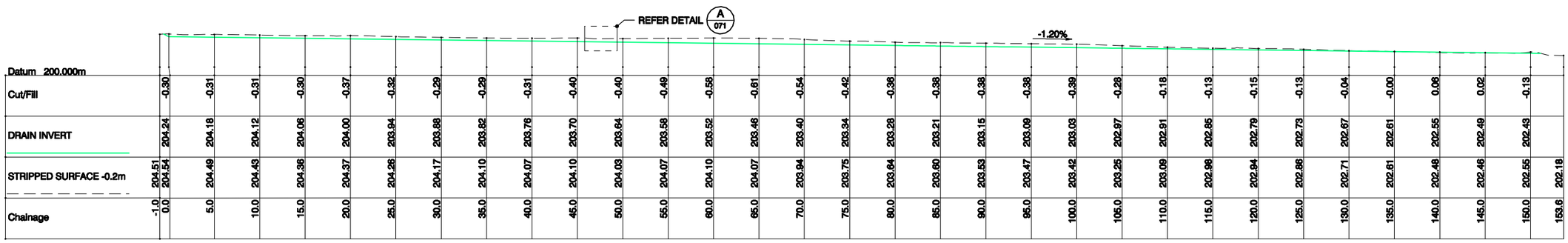


Datum 198.000m																								
Cut/Fill	0.00	-0.48	-0.38	-0.37	-0.22	-0.21	-0.24	-0.23	-0.39	-0.41	-0.42	-0.38	-0.34	-0.40	-0.51	-0.58	-0.64	-0.44	-0.47					
DRAIN INVERT	201.35	200.77	200.74	200.71	200.67	200.64	200.61	200.58	200.56	200.53	200.51	200.48	200.46	200.43	200.41	200.38	200.36	200.33	200.32					
STRIPPED BASE -0.2m	201.35	201.26	201.12	201.07	200.89	200.85	200.85	200.81	200.85	200.94	200.92	200.84	200.80	200.84	200.92	200.95	201.00	200.77	200.79					
Chainage	0.0	5.0	10.0	15.0	20.0	25.0	30.0	35.0	40.0	45.0	50.0	55.0	60.0	65.0	70.0	75.0	80.0	85.0	87.5					

LONG SECTION (1/069)

NORTHERN SEDIMENT COLLECTION DRAIN

SCALE 1:250



Datum 200.000m																								
Cut/Fill	-0.30	-0.31	-0.31	-0.30	-0.37	-0.32	-0.29	-0.29	-0.31	-0.40	-0.40	-0.49	-0.58	-0.61	-0.54	-0.42	-0.38	-0.38	-0.38	-0.38	-0.39	-0.28	-0.18	-0.13
DRAIN INVERT	204.24	204.18	204.12	204.06	204.00	203.94	203.88	203.82	203.76	203.70	203.64	203.58	203.52	203.46	203.40	203.34	203.28	203.21	203.15	203.09	203.03	202.97	202.91	202.85
STRIPPED SURFACE -0.2m	204.54	204.49	204.43	204.36	204.37	204.26	204.17	204.10	204.07	204.10	204.03	204.07	204.10	204.07	203.94	203.75	203.64	203.60	203.53	203.47	203.42	203.25	203.09	202.98
Chainage	0.0	5.0	10.0	15.0	20.0	25.0	30.0	35.0	40.0	45.0	50.0	55.0	60.0	65.0	70.0	75.0	80.0	85.0	90.0	95.0	100.0	105.0	110.0	115.0

Datum 200.000m																								
Cut/Fill	-0.30	-0.31	-0.31	-0.30	-0.37	-0.32	-0.29	-0.29	-0.31	-0.40	-0.40	-0.49	-0.58	-0.61	-0.54	-0.42	-0.38	-0.38	-0.38	-0.38	-0.39	-0.28	-0.18	-0.13
DRAIN INVERT	204.24	204.18	204.12	204.06	204.00	203.94	203.88	203.82	203.76	203.70	203.64	203.58	203.52	203.46	203.40	203.34	203.28	203.21	203.15	203.09	203.03	202.97	202.91	202.85
STRIPPED SURFACE -0.2m	204.54	204.49	204.43	204.36	204.37	204.26	204.17	204.10	204.07	204.10	204.03	204.07	204.10	204.07	203.94	203.75	203.64	203.60	203.53	203.47	203.42	203.25	203.09	202.98
Chainage	0.0	5.0	10.0	15.0	20.0	25.0	30.0	35.0	40.0	45.0	50.0	55.0	60.0	65.0	70.0	75.0	80.0	85.0	90.0	95.0	100.0	105.0	110.0	115.0

Datum 200.000m																								
Cut/Fill	-0.13	-0.15	-0.13	-0.04	-0.00	0.06	0.02	-0.13																
DRAIN INVERT	202.79	202.73	202.67	202.61	202.55	202.49	202.43																	
STRIPPED SURFACE -0.2m	202.94	202.86	202.71	202.61	202.48	202.46	202.55	202.18																
Chainage	120.0	125.0	130.0	135.0	140.0	145.0	150.0	153.6																

LONG SECTION (2/069)

'CLEAN WATER' DIVERSION CHANNEL

SCALE 1:500

ISSUED FOR CONSTRUCTION

No.	DESCRIPTION	DATE	DRAWN	CHECKD	APPRD
1	ISSUED FOR CONSTRUCTION	05.10.16	HR	AVK	MD

SCALE AS SHOWN	
JOB No.	108003.26
DATE	04.07.16
DESIGN	AVK
DRAWN	HR
CHECKED	AVK
APPROVED	MD

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DUGALD RIVER PROJECT

ADMINISTRATION AREA SEDIMENTATION AND EROSION CONTROL
SED DAM C
SEDIMENT COLLECTION DRAINS AND 'CLEAN WATER'
DIVERSION CHANNEL LONG SECTIONS

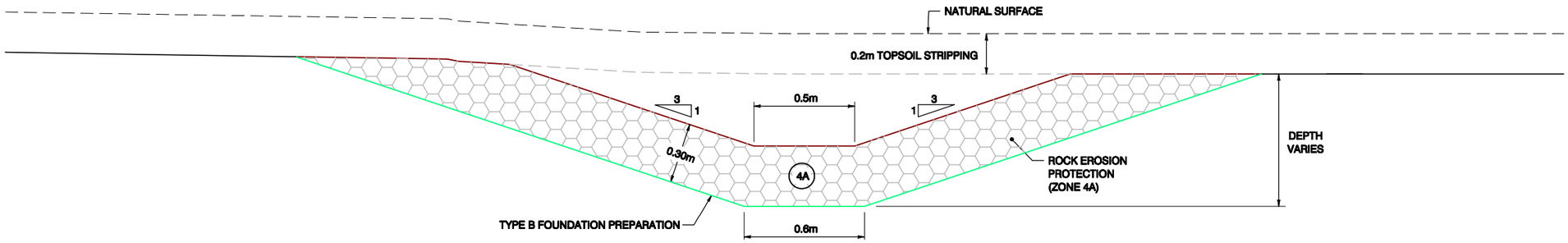
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MMG DWG NO. 0016-DWG-2160-C-0070

REV. 1 | SHT SIZE A3

SHEET 1 OF 1

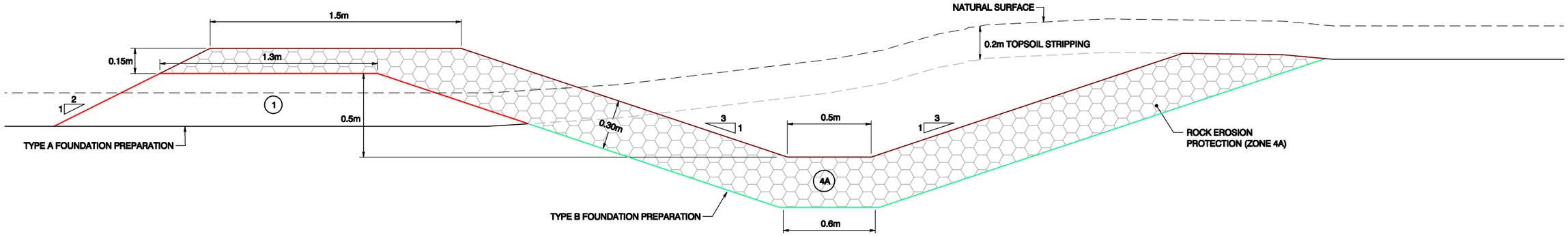
J:\2008\108003 Dugald River\26 NAF and Sed Ponds\Terramodel\Detailed Design IFC.pro (Terramodel) Wed 5 Oct 2016 17:35:34



TYPICAL SECTION 3/069 3/075

SEDIMENT COLLECTION DRAINS

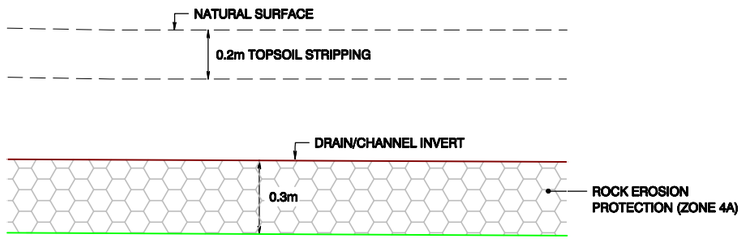
SCALE 1:25



SECTION 4/069

'CLEAN WATER' DIVERSION CHANNEL

SCALE 1:25



DETAIL A/070

SEDIMENT COLLECTION DRAINS & 'CLEAN WATER' DIVERSION CHANNEL

SCALE 1:25

ISSUED FOR CONSTRUCTION

No.	DESCRIPTION	DATE	DRAWN	CHECKD	APPRD
1	ISSUED FOR CONSTRUCTION	05.10.16	HR	AVK	MD

SCALE AS SHOWN	
JOB No.	108003.26
DATE	01.07.16
DESIGN	AVK
DRAWN	DR
CHECKED	AVK
APPROVED	MD

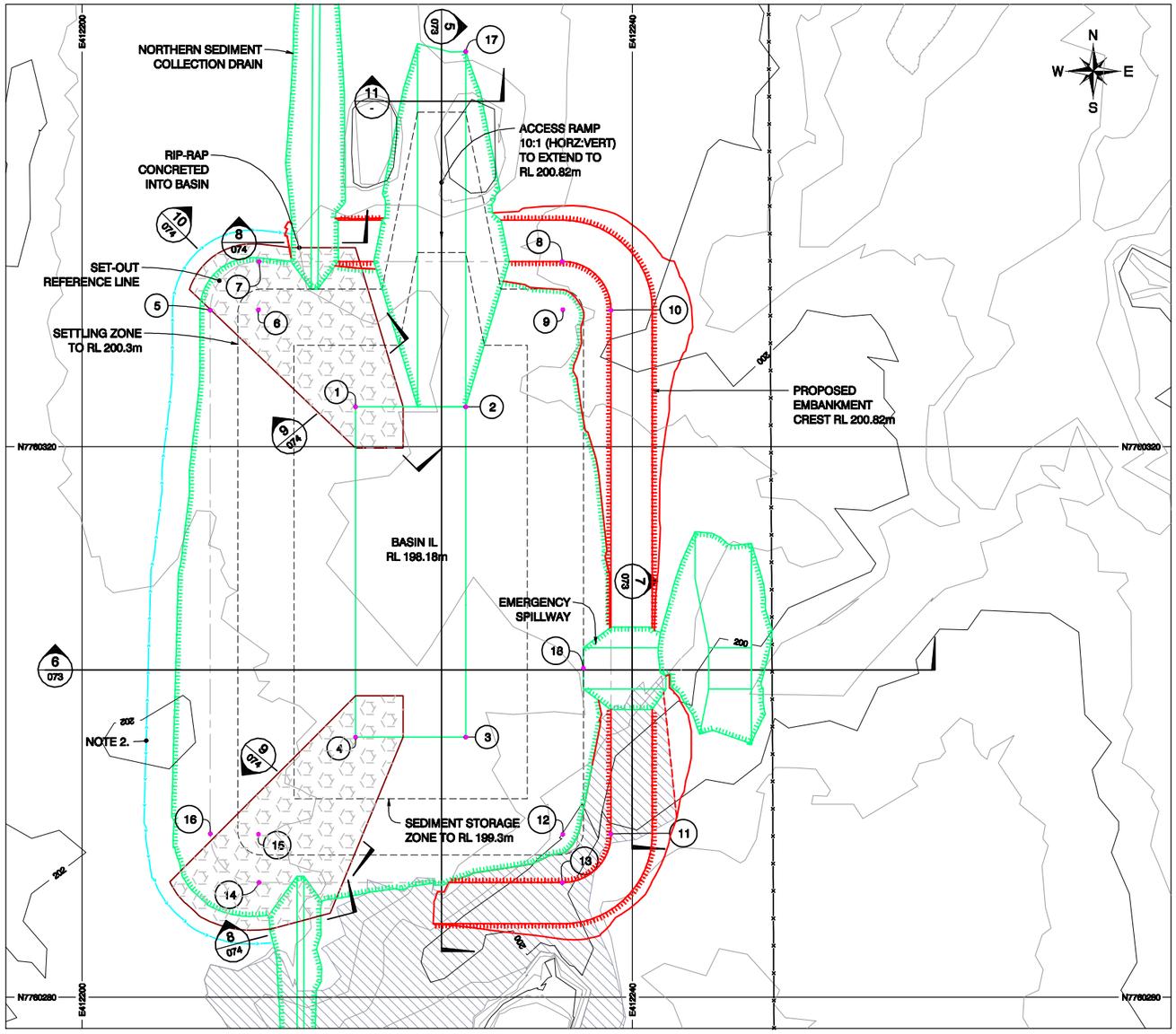
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MMG DUGALD RIVER
DUGALD RIVER PROJECT

108003.26-004

ADMINISTRATION AREA SEDIMENTATION AND EROSION CONTROL
SED DAM C
SEDIMENT COLLECTION DRAINS AND 'CLEAN WATER' DIVERSION CHANNEL
SECTIONS AND DETAILS

MMG DWG NO. 0016-DWG-2160-C-0071
REV. 1 | SHT SIZE A3
SHEET 1 OF 1



ISSUED FOR CONSTRUCTION

Coordinate Table - Sedimentation Dam C, Ramp & Spillway							
Pt #	Easting	Northing	Elevation / Radius	Pt #	Easting	Northing	Elevation / Radius
1	412219.877	7760322.895	198.820	11	412238.438	7760291.874	200.820
2	412227.878	7760322.895	198.820	12	412234.938	7760291.835	R = 3.5m
3	412227.878	7760298.895	198.820	13	412234.898	7760288.335	200.820
4	412219.878	7760298.895	198.820	14	412212.857	7760288.335	200.820
5	412209.317	7760329.916	200.820	15	412212.818	7760291.835	R = 3.5m
6	412212.817	7760329.955	R = 3.5m	16	412209.318	7760291.874	200.820
7	412212.856	7760333.455	200.820	17	412227.878	7760348.710	200.760
8	412234.898	7760333.455	200.820	18	412236.438	7760303.894	200.320
9	412234.938	7760329.955	R = 3.5m				
10	412238.438	7760329.916	200.820				

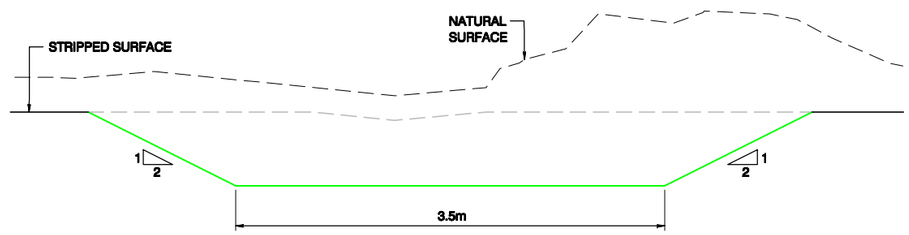
DETAIL PLAN

SED DAM C

SCALE 1:400

NOTES:

1. FINAL SURFACE TO BE TRIMMED AND ROLLED WITH A 10 TONNE SMOOTH DRUM ROLLER TO PRESENT A SMOOTH HARD WEARING SURFACE.
2. CONSTRUCTION OF 300mm DEEP SWALE DRAINS (3:1 SIDE SLOPES) WITH LOCAL RESHAPING OF GROUND SURFACE TO DIRECT WATER TO INLET DRAINS.



SECTION 11/- 11/075 (TYPICAL)

SED DAM ACCESS RAMP

SCALE 1:50

No.	DESCRIPTION	DATE	DRAWN	CHECKD	APPRD
1	ISSUED FOR CONSTRUCTION	05.10.16	LL	AVK	MD

SCALE AS SHOWN	
JOB No.	108003.26
DATE	06.07.16
DESIGN	AVK
DRAWN	HR
CHECKED	AVK
APPROVED	MD

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DUGALD RIVER PROJECT

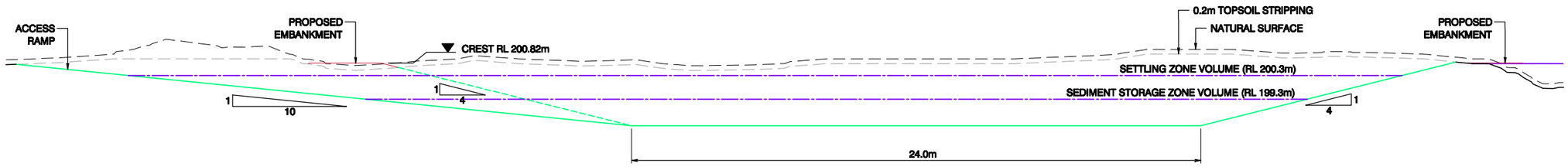
108003.26-005

ADMINISTRATION AREA SEDIMENTATION AND EROSION CONTROL
SED DAM C
DETAIL PLAN & SECTIONS

MMG DWG NO. 0016-DWG-2160-C-0072

REV. 1 | SHT SIZE A3

SHEET 1 OF 1

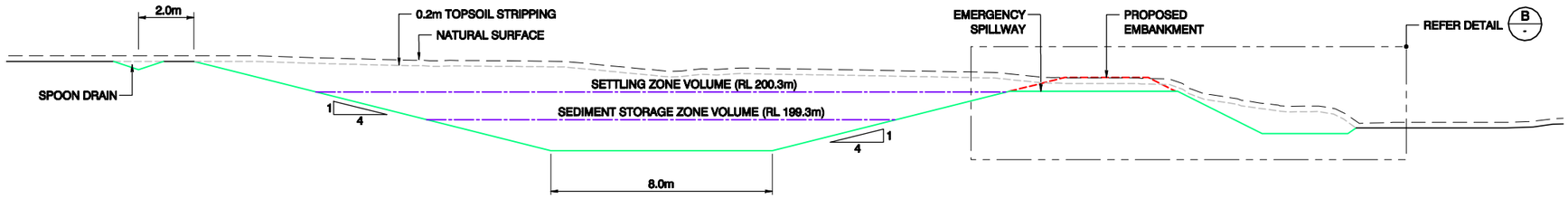


SECTION 5/072

SED DAM C (SHOWING ACCESS RAMP)

SCALE 1:200

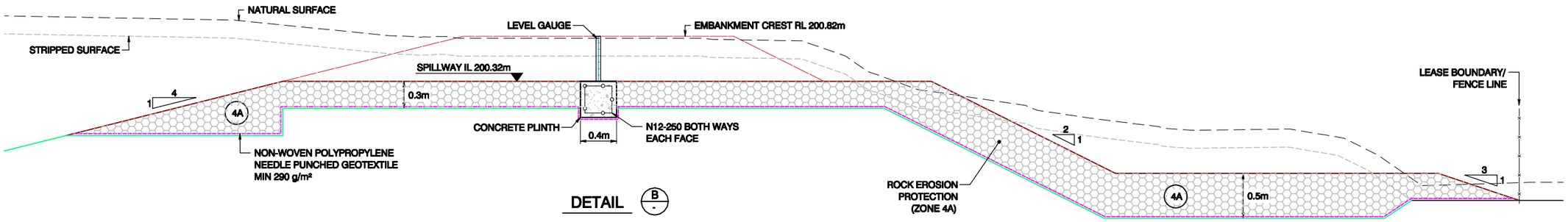
NOTE:
FINAL SURFACE TO BE TRIMMED AND ROLLED WITH A 10 TONNE SMOOTH DRUM ROLLER TO PRESENT A SMOOTH HARD WEARING SURFACE



SECTION 6/072

SED DAM C (THROUGH CONTROLLED RELEASE OUTLET)

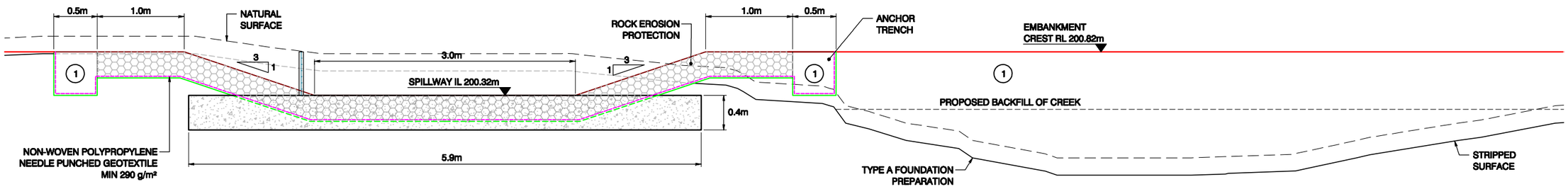
SCALE 1:200



DETAIL B/-

SED DAM C (THROUGH SPILLWAY AND OUTLET CHANNEL)

SCALE 1:50



SECTION 7/072

SED DAM C SPILLWAY

SCALE 1:50

ISSUED FOR CONSTRUCTION

No.	DESCRIPTION	DATE	DRAWN	CHECK'D	APPR'D
1	ISSUED FOR CONSTRUCTION	05.10.16	LL	AVK	MD

SCALE	AS SHOWN
JOB No.	108003.26
DATE	10.07.16
DESIGN	AVK
DRAWN	DR
CHECKED	AVK
APPROVED	MD

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DUGALD RIVER PROJECT

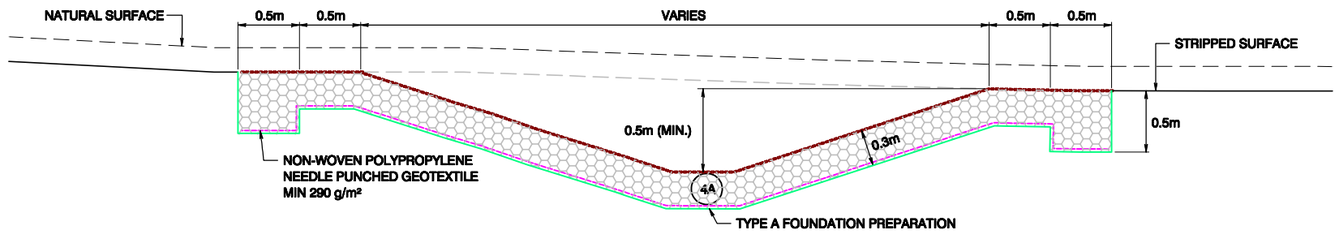
108003.26-006

ADMINISTRATION AREA SEDIMENTATION AND EROSION CONTROL
SED DAM C
SECTIONS & DETAILS (SHEET 1 OF 2)

MMG DWG NO. 0016-DWG-2160-C-0073

REV. 1 | SHT SIZE A3

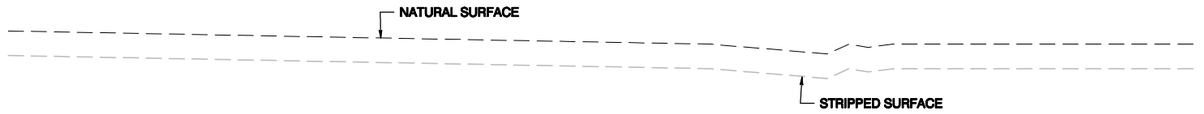
SHEET 1 OF 1

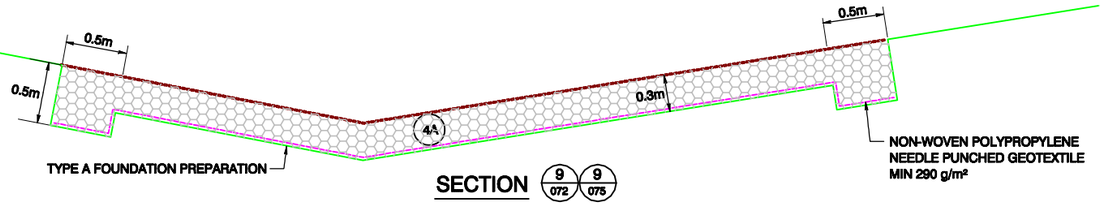


SECTION 8/072 8/075

SED DAM C & D INLET DRAINS

SCALE 1:50

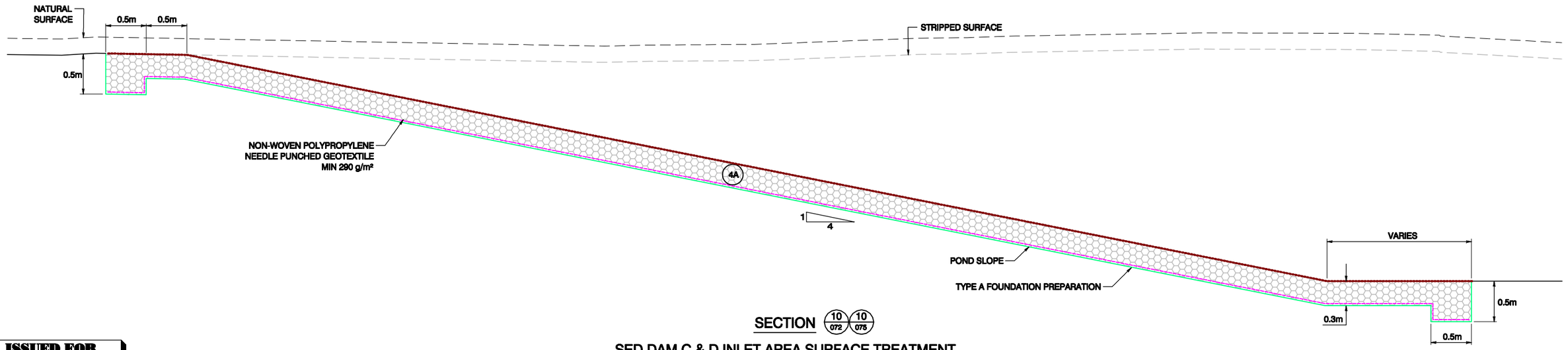




SECTION 9/072 9/075

SED DAM C & D INLET AREA SURFACE TREATMENT

SCALE 1:50



SECTION 10/072 10/075

SED DAM C & D INLET AREA SURFACE TREATMENT

SCALE 1:50

ISSUED FOR CONSTRUCTION

No.	DESCRIPTION	DATE	DRAWN	CHECKD	APPR'D
1	ISSUED FOR CONSTRUCTION	05.10.16	LL	AVK	MD

SCALE AS SHOWN	
JOB No.	108003.26
DATE	08.07.16
DESIGN	AVK
DRAWN	HR
CHECKED	AVK
APPROVED	MD

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MMG DUGALD RIVER
DUGALD RIVER PROJECT

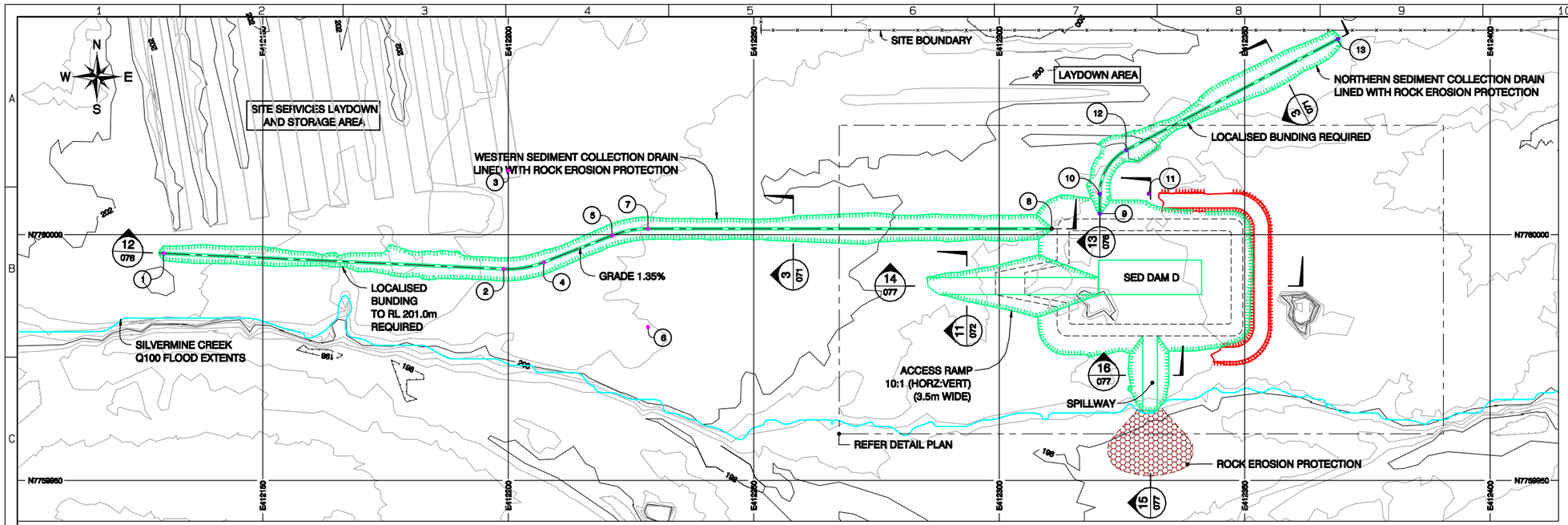
ADMINISTRATION AREA
SEDIMENTATION AND EROSION CONTROL
SED DAM C
SECTIONS AND DETAILS (SHEET 2 OF 2)

108003.26-007

MMG DWG NO.
0016-DWG-2160-C-0074

REV. B | SHT SIZE A3

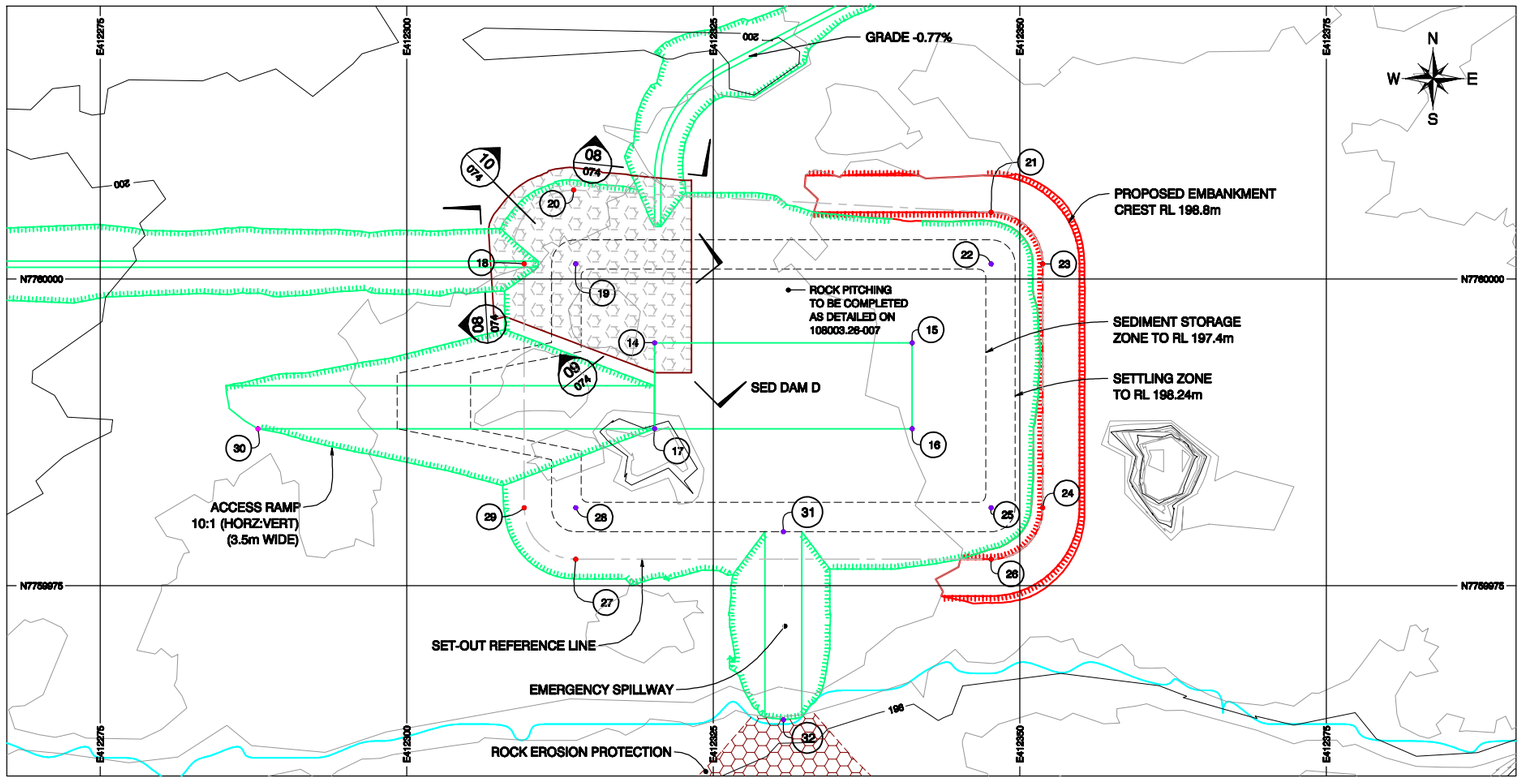
SHEET 1 OF 1



LAYOUT - SEDIMENT DAM D

SCALE 1:1000

Coordinate Table - Water Collection Drain West & North			
Pt #	Easting	Northing	Elevation
1	412129.768	7759996.199	200.985
2	412199.020	7759993.011	200.047
3	412199.939	7760012.990	R = 20.0m
4	412207.242	7759994.371	199.932
5	412221.146	7759999.824	199.730
6	412228.448	7759981.205	R = 20.0m
7	412228.448	7760001.205	199.628
8	412310.713	7760001.205	198.515
9	412320.463	7760004.265	198.508
10	412320.463	7760008.306	198.540
11	412330.463	7760008.306	R = 10.0m
12	412325.819	7760017.163	198.624
13	412368.910	7760039.759	199.000



DETAIL PLAN - SEDIMENT DAM D

SCALE 1:500

Coordinate Table - Sedimentation Dam D, Ramp & Spillway			
Pt #	Easting	Northing	Elevation / Radius
14	412320.213	7759994.792	196.140
15	412341.213	7759994.792	196.140
16	412341.213	7759987.792	196.140
17	412320.203	7759987.795	196.140
18	412309.573	7760001.232	198.800
19	412313.773	7760001.232	R = 4.2m
20	412313.598	7760007.253	198.800
21	412347.653	7760005.432	198.800
22	412347.653	7760001.232	R = 4.2m
23	412351.853	7760001.232	198.800
24	412351.853	7759981.352	198.800
25	412347.653	7759981.352	R = 4.2m
26	412347.653	7759977.152	198.800
27	412313.773	7759977.152	198.800
28	412313.773	7759981.352	R = 4.2m
29	412309.573	7759981.352	198.800
30	412287.859	7759987.792	199.377
31	412330.713	7759979.392	198.240
32	412330.713	7759964.067	198.240

ISSUED FOR CONSTRUCTION

No.	DESCRIPTION	DATE	DRAWN	CHECKD	APPRD
1	ISSUED FOR CONSTRUCTION	05.10.16	LL	AVK	MD

SCALE AS SHOWN
JOB No. 108003.26
DATE 08.07.16
DESIGN AVK
DRAWN HR
CHECKED AVK
APPROVED MD

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MMG DUGALD RIVER
DUGALD RIVER PROJECT

ADMINISTRATION AREA
SEDIMENTATION AND EROSION CONTROL
SED DAM D
GENERAL LAYOUT AND DETAIL PLAN

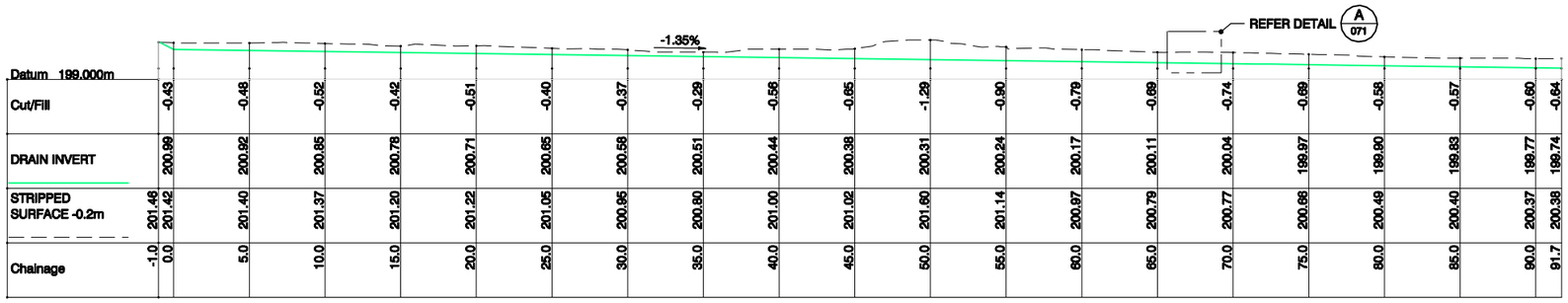
108003.26-008

MMG DWG NO. 0016-DWG-2160-C-0075

REV. 1 | SHT SIZE A3

SHEET 1 OF 1

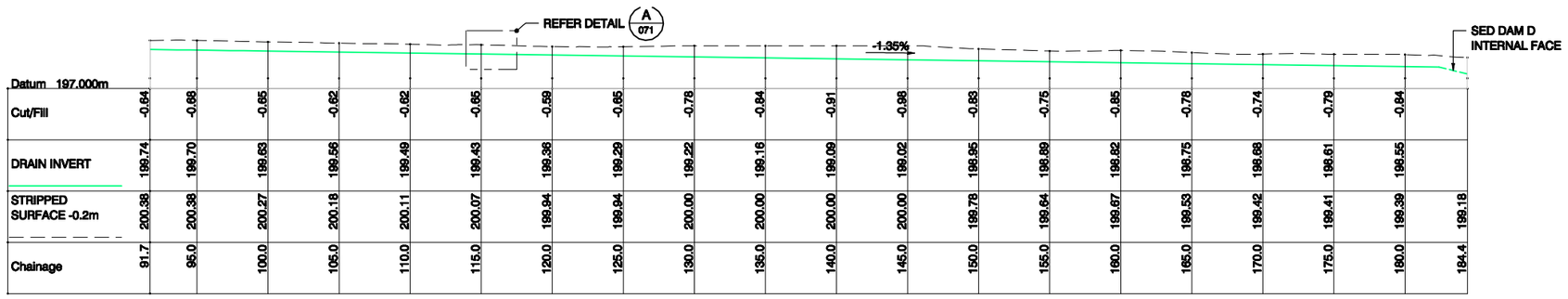
ISSUED FOR CONSTRUCTION



LONG SECTION 12/075

WESTERN SEDIMENT COLLECTION DRAIN

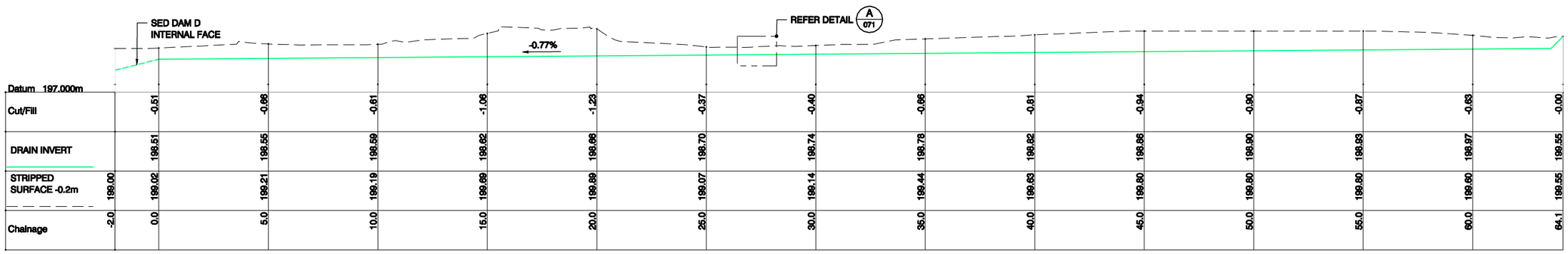
SCALE 1:400



LONG SECTION 12/075

WESTERN SEDIMENT COLLECTION DRAIN

SCALE 1:400



LONG SECTION 13/075

NORTHERN SEDIMENT COLLECTION DRAIN

SCALE 1:200

No.	DESCRIPTION	DATE	DRAWN	CHECKD	APPRD
1	ISSUED FOR CONSTRUCTION	05.10.16	LL	AVK	MD

SCALE AS SHOWN	
JOB No.	108003.26
DATE	06.07.16
DESIGN	AVK
DRAWN	HR
CHECKED	AVK
APPROVED	MD

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MMG DUGALD RIVER
DUGALD RIVER PROJECT

108003.26-009

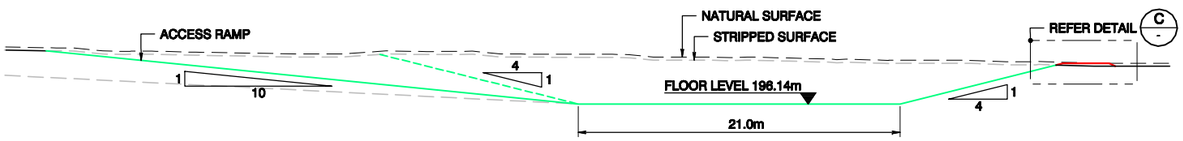
ADMINISTRATION AREA
SEDIMENTATION AND EROSION CONTROL
SED DAM D
SEDIMENT COLLECTION DRAIN LONG SECTION AND DETAILS

MMG DWG NO. 0016-DWG-2160-C-0076

REV. 1 | SHT SIZE A3

SHEET 1 OF 1

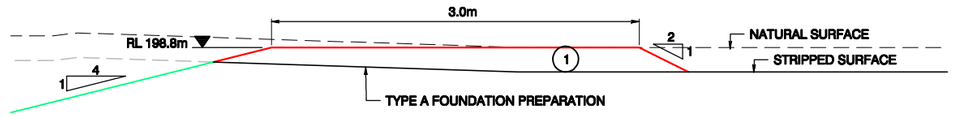
NOTE:
FINAL SURFACE TO BE TRIMMED AND ROLLED WITH A 10 TONNE SMOOTH DRUM ROLLER TO PRESENT A SMOOTH HARD WEARING SURFACE



SECTION 14 / 076

SED DAM D (THROUGH RAMP)

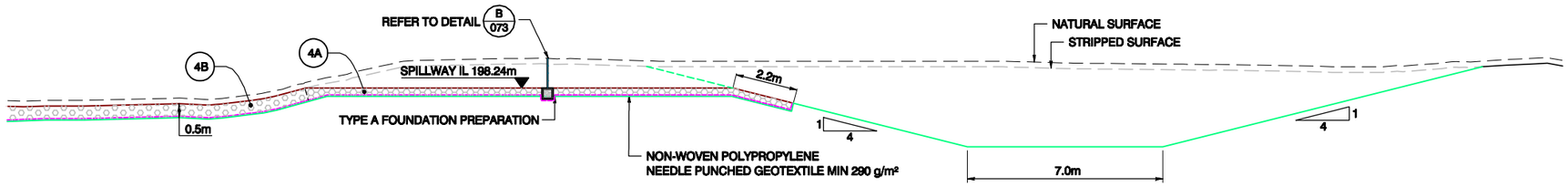
SCALE 1:400



DETAIL C -

SED DAM D (THROUGH EMBANKMENT)

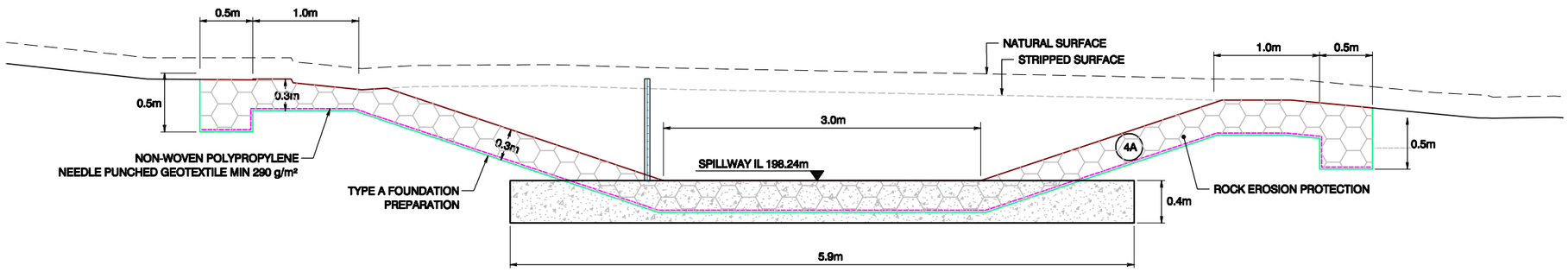
SCALE 1:50



SECTION 15 / 075

SED DAM D (THROUGH SPILLWAY)

SCALE 1:200



SECTION 16 / 075

SED DAM D SPILLWAY

SCALE 1:50

ISSUED FOR CONSTRUCTION

No.	DESCRIPTION	DATE	DRAWN	CHECK'D	APPR'D
1	ISSUED FOR CONSTRUCTION	05.10.16	HR	AVK	MD

SCALE AS SHOWN	
JOB No.	108003.26
DATE	08.07.16
DESIGN	AVK
DRAWN	HR
CHECKED	AVK
APPROVED	MD

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MMG DUGALD RIVER
DUGALD RIVER PROJECT

108003.26-010

ADMINISTRATION AREA
SEDIMENTATION AND EROSION CONTROL
SED DAM D
SECTIONS & DETAILS

MMG DWG NO.
0016-DWG-2160-C-0077

REV. 1 | SHT SIZE A3

SHEET 1 OF 1

SPILLWAY REFER TO DETAILS DRG. 11442-2200-T0209

OUTFLOW CHANNEL REFER TO DETAILS DRG. 11442-2200-T0219

OUTFLOW CHANNEL REFER TO DETAILS DRG. 11442-2200-T0219

7761 000m N MGA

412 200m E MGA

RAW WATER PIPE LINE

MINE LEASE BOUNDARY

RIPRAP TO SUIT SIDE CHANNEL

CREST RL 200.000

BASE RL 196.300

R12.0

R7.5

GRADE DRAINAGE CHANNEL TO OUTFLOW CHANNEL

RAW WATER PIPE LINE REFER TO DRG. 11442-3110

RAW WATER MEASURING STRUCTURAL REFER TO DRG. 11442-2200-T0217

FALL 0.22%

100 YEAR FLOOD LINE

B T0205

DOUBLE LINED BASIN

RL 194.50

RL 194.60

RL 195.40

195.50

200

196.9

RAW WATER DAM

(HDPE LINED BASIN)

ROM AREA RUN-OFF DAM (HDPE LINED)

SEEPAGE COLLECTION SYSTEM REFER TO DETAILS DRG. 11442-2200-T0217

RAW WATER ACCESS TRACK TO BE CONSTRUCTED WHEN PIPE METERS AND VALVE FITINGS ARE INSTALLED (BY OTHERS)

197.0

2

ROM DAM ACCESS TRACK REFER TO DETAILS DRG. 11442-2200-T0215

CREST RL 200.000

195.40

100ø DRAINCOIL/ SLOTTED PIPE AND TOE COLLECTION DRAIN REFER TO DETAIL E DRG. T0217

FALL 0.20%

FALL 0.16%

CONCRETE INLET No.2 REFER TO DETAILS DRG. 11442-2200-T0208

195.50

ROAD A

CH 620

CH 540

CH 640

CH 660

CH 680

ROADWAY CULVERTS BY OTHERS

RAW WATER PIPE LINE

CONCRETE INLET No.1 REFER TO DETAILS DRG. 11442-2200-T0208

ACCESS TRACK (BY OTHERS)

CREST RL 200.000

C T0205

FUTURE CHANNEL (BY OTHERS)

LAYOUT PLAN

SCALE 1 : 500

ROM PAD RUN OFF DAM SETOUT

No.	EASTING	NORTHING	LEVEL
1	412040.445	7761123.328	195.550
2	412027.095	7761129.178	200.000
3	412022.595	7761129.178	200.000
4	412034.595	7761141.178	200.000
5	412034.473	7761136.677	200.000
6	412213.048	7761141.178	200.000
7	412213.048	7761136.678	200.000
8	412207.198	7761123.328	195.550
9	412220.548	7761129.178	200.000
10	412225.048	7761129.178	200.000
11	412225.048	7761004.180	200.000
12	412220.548	7761004.180	200.000
13	412207.198	7761010.030	195.550
14	412213.048	7760996.680	200.000
15	412213.048	7760992.180	200.000
16	412089.039	7760992.180	200.000
17	412089.039	7760996.680	200.000
18	412091.301	7761010.030	195.550
19	412083.992	7760998.631	200.000
20	412080.965	7760995.302	200.000
21	412026.522	7761044.815	200.000
22	412029.549	7761048.145	200.000
23	412040.445	7761056.280	195.550
24	412027.095	7761053.693	200.000
25	412022.595	7761053.693	200.000
26	412131.153	7761072.178	195.400

DOUBLE BASIN AND COLLECTION SYSTEM

27	412133.553	7761074.578	194.600
28	412179.753	7761074.578	194.600
29	412182.153	7761072.178	195.400
30	412182.153	7761117.978	195.300
31	412182.016	7761120.178	195.300
32	412182.028	7761123.328	195.550
33	412179.722	7761123.334	195.550
34	412179.753	7761120.181	194.500
35	412179.753	7761117.978	194.500
36	412133.553	7761117.978	194.500
37	412133.553	7761120.176	194.500
38	412133.532	7761123.324	195.550
39	412131.185	7761123.328	195.550
40	412131.206	7761120.178	195.300
41	412131.153	7761117.978	195.300
42	412066.308	7761123.325	195.550
43	412027.095	7761081.504	200.000

CONCRETE INLET SPILLWAY

44	412027.095	7761074.304	200.000
45	412019.045	7761074.304	200.000
46	412019.045	7761081.504	200.000
47	412073.093	7761008.544	200.000
48	412078.420	7761003.699	200.000
49	412073.004	7760997.744	200.000
50	412067.677	7761002.588	200.000

LEGEND

- 300mm RIPRAP ON bIDMIN A34
- EXTENT OF DOUBLE LINER BASIN
- 100 YEAR FLOOD LEVEL
- TOE COLLECTION DRAIN AND PIPE
- PROPOSED DESIGN CONTOURS
- EXISTING CONTOURS
- DRAINAGE PIPE LINES (BY OTHERS)

NOTE:

1. FOR GENERAL NOTES REFER DRG No. 11442-2200-T0200

ISSUED FOR CONSTRUCTION

5 0 10 20 30 40 50m

1:500

DRAWING No.	REFERENCE DRAWING TITLE	REVISION DESCRIPTION	REV.	BY	CHECKED	APPROVED	PROJ. ENG.	DATE
		ATCW REVISION (IN RED)	3	CN	MD			24.07.13
		SUMP BATTER/LOCATION/EXTENTS MODIFIED	2	MK	DS	AN	AN	02.04.13
		SUMP ADDED	1	MK	SRT	AN	AN	22.03.13
		ISSUED FOR CONSTRUCTION	0	DM	SU	AY	BH	28/09/12

APPROVED BY DATE — CLIENT APPROVED — ISS'D FOR CONSTR.

CLIENT: MMG

SCALE: 1:500

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STATUS: ISSUED FOR CONSTRUCTION

JACOBS

CLIENT No. DUG-DWG-2200-EC-0211 REV. 3

DRG. No. 11442-2200-T0201 REV. 3

DUGALD RIVER PROJECT
EARTHWORKS - PROCESS PLANT AREA
PROCESS PLANT DAMS - ROM AREA RUN-OFF DAM LAYOUT

A1

FORGE

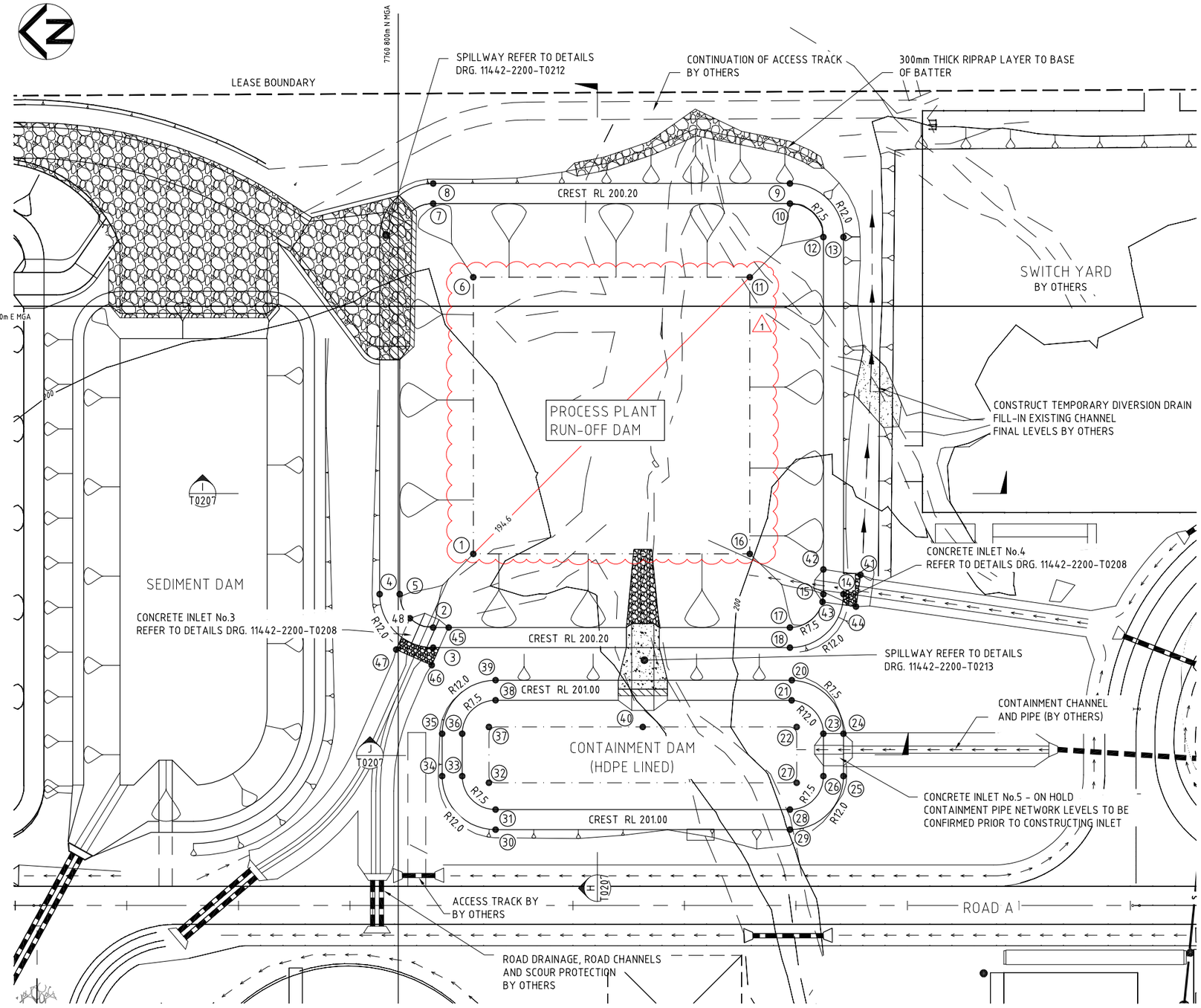
Forge Group Minerals and Resources Pty Ltd
45 Stirling Hwy, Nedlands, Western Australia 6009
Ph 61 (8) 6222 6400 Fax 61 (8) 6222 6499 Info@forgegroup.com.au

Revised by Forge Group Minerals and Resources Rev-No. 1 on 12.09.2013

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Date: 02-Apr-13 08:32 Plotted By:thomcs Plot Size: A3 Layer.ctb

File: \\Transfer to Doc Control\30177 Dugald River\DUG-DWG-2200-EC-0211_R2.dwg



LAYOUT PLAN
SCALE 1 : 500

NOTE: PROCESS PLANT RUNOFF DAM INVERT LEVEL REVISED BY HYDER AS INSTRUCTED BY MMG (1)

PROCESS DAM SETOUT

No.	EASTING	NORTHING	LEVEL
1	412144.550	7760783.200	194.600
2	412128.050	7760792.200	199.554
3	412123.550	7760792.200	199.880
4	412135.550	7760804.200	200.200
5	412135.550	7760799.700	200.200
6	412206.550	7760783.200	194.500
7	412223.050	7760792.200	200.200
8	412227.550	7760792.200	200.200
9	412227.550	7760712.200	200.200
10	412223.050	7760712.200	200.200
11	412206.550	7760721.200	194.600
12	412215.550	7760704.700	200.200
13	412215.550	7760700.200	200.200
14	412135.550	7760700.200	199.618
15	412135.560	7760704.711	199.768
16	412144.550	7760721.200	194.700
17	412128.050	7760712.211	200.200
18	412123.550	7760712.200	200.200

CONTAINMENT DAM SETOUT

No.	EASTING	NORTHING	LEVEL
20	412116.270	7760712.200	201.000
21	412111.770	7760712.200	201.000
22	412104.999	7760711.497	198.800
23	412104.270	7760704.700	201.000
24	412104.270	7760700.200	201.000
25	412094.770	7760700.200	201.000
26	412094.770	7760704.700	201.000
27	412094.037	7760711.464	198.800
28	412087.270	7760712.200	201.000
29	412082.770	7760712.200	201.000
30	412082.770	7760778.195	201.000
31	412087.270	7760778.195	201.000
32	412094.023	7760778.919	198.800
33	412094.770	7760785.695	201.000
34	412094.770	7760790.195	201.000
35	412104.270	7760790.195	201.000
36	412104.270	7760785.695	201.000
37	412105.011	7760778.929	198.800
38	412111.770	7760778.195	201.000
39	412116.270	7760778.195	201.000
40	412105.020	7760745.130	198.700

CONCRETE INLETS SETOUT

No.	EASTING	NORTHING	LEVEL
41	412139.871	7760696.363	200.200
42	412141.067	7760704.700	200.200
43	412133.822	7760704.902	200.200
44	412132.744	7760697.385	200.200
45	412128.050	7760788.812	200.200
46	412119.634	7760792.511	200.200
47	412123.135	7760800.475	200.200
48	412130.141	7760797.396	200.200

LEGEND

- 300mm RIPRAP ON BIDMIN A34
- 100 YEAR FLOOD LEVEL
- TOE COLLECTION DRAIN AND PIPE
- PROPOSED DESIGN CONTOURS
- EXISTING CONTOURS
- DRAINAGE PIPE LINES (BY OTHERS)

NOTE:
1. FOR GENERAL NOTES REFER DRG No. 11442-2200-T0200

ISSUED FOR CONSTRUCTION

5 0 10 20 30 40 50m
1:500

DRAWING No.	REFERENCE DRAWING TITLE

REVISION DESCRIPTION	REV.	BY	CHECKED	APPROVED	PROJ. ENG.	DATE
RUN-OFF DAM SETOUT POINTS CHANGED - BY HYDER	1	GBM	FP	FP	FP	26/10/12
ISSUED FOR CONSTRUCTION	0	DM	AU	AY	BH	28/09/12

	BY	DATE
APPROVED		
CLIENT APPROVED		
ISS'D FOR CONSTR.		

CLIENT: MMG

SCALE 1:500

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STATUS: ISSUED FOR CONSTRUCTION

JACOBS

CLIENT No. DUG-DWG-2200-EC-0213 REV. 1

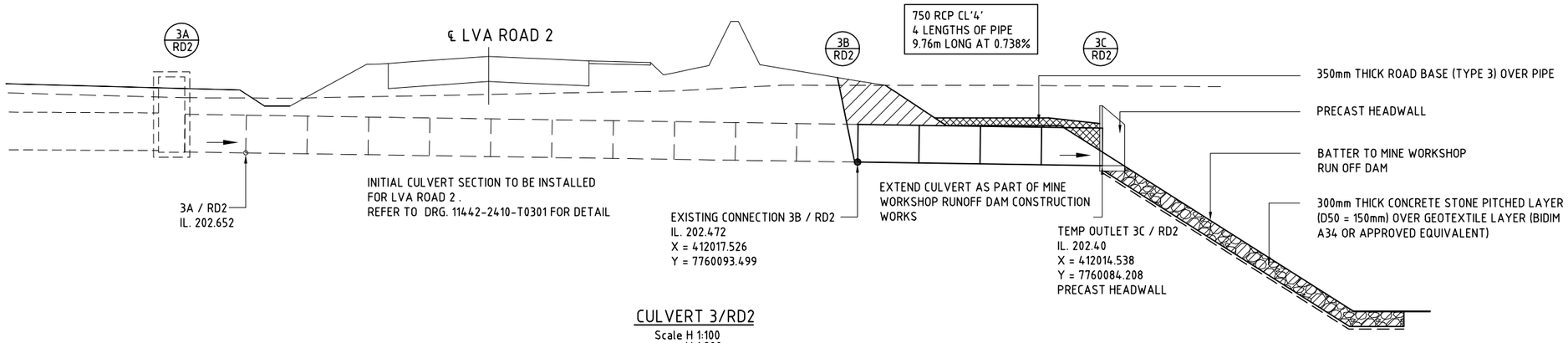
DRG. No. 11442-2200-T0203 REV. 1

DUGALD RIVER PROJECT
EARTHWORKS - PROCESS PLANT AREA
PROCESS DAMS - PROCESS PLANT RUN-OFF AND CONTAINMENT DAM LAYOUT

A1

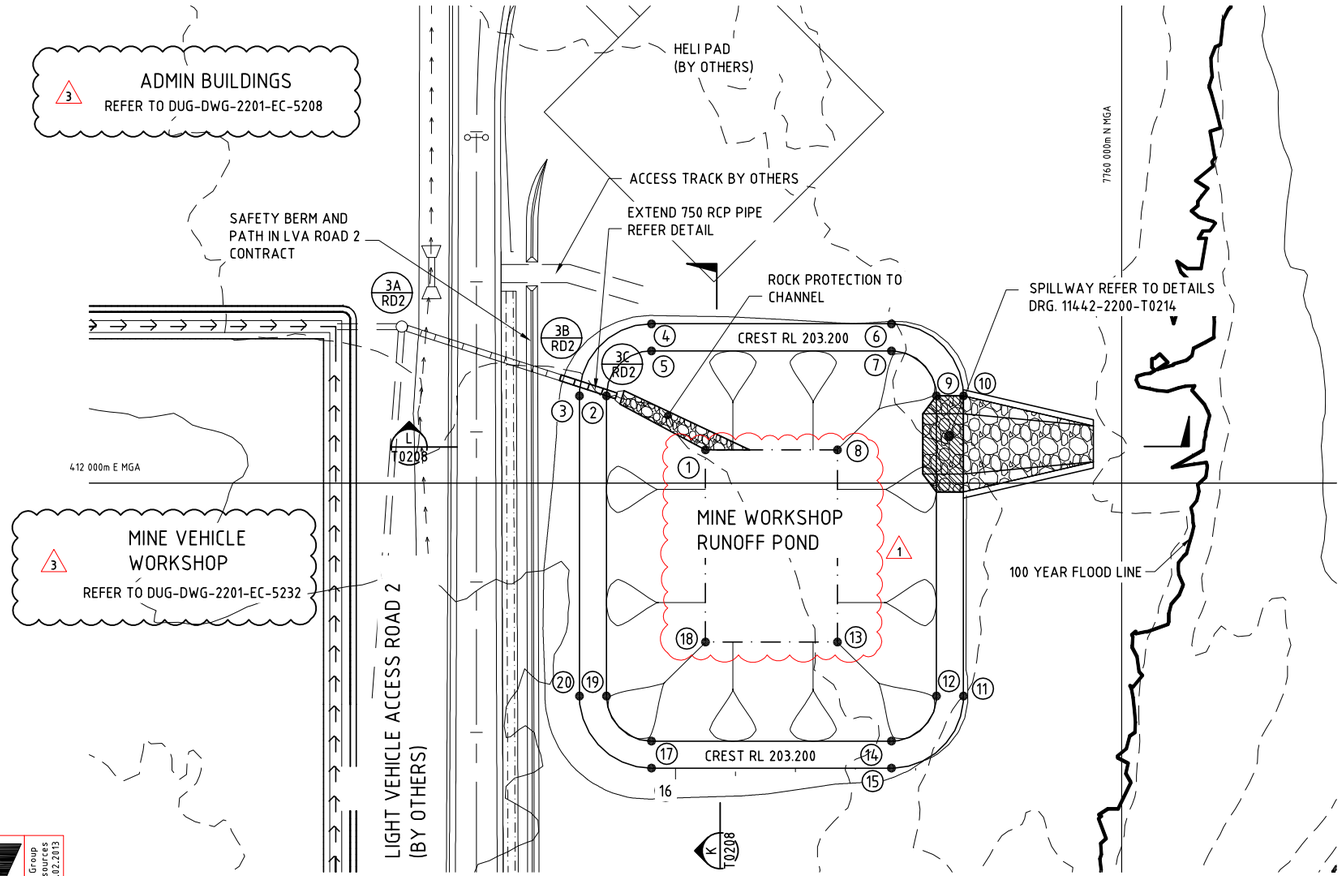
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CULVERT 3/RD2

Scale H 1:100
V 1:200



NOTE: MINE WORKSHOP RUNOFF DAM INVERT LEVEL
REVISED BY HYDER AS INSTRUCTED BY MMG

LAYOUT PLAN
SCALE 1 : 500

MINE WORKSHOP DAM SETOUT

No.	EASTING	NORTHING	LEVEL
1	412005.520	7760069.350	197.700
2	412014.520	7760085.850	203.200
3	412014.520	7760090.350	203.200
4	412026.520	7760078.350	203.200
5	412022.020	7760078.350	203.200
6	412026.520	7760038.350	203.200
7	412022.020	7760038.350	203.200
8	412005.520	7760047.350	197.600
9	412014.520	7760030.850	203.200
10	412014.509	7760026.350	203.200
11	411964.520	7760026.350	203.200
12	411964.520	7760030.850	203.200
13	411973.520	7760047.350	197.700
14	411957.020	7760038.350	203.200
15	411952.520	7760038.350	203.200
16	411952.520	7760078.350	203.200
17	411957.020	7760078.350	203.200
18	411973.520	7760069.350	197.800
19	411964.520	7760085.850	203.200
20	411964.520	7760090.350	203.200

LEGEND

- 300mm RIPRAP ON bIDMIN A34
- 100 YEAR FLOOD LEVEL
- TOE COLLECTION DRAIN AND PIPE
- PROPOSED DESIGN CONTOURS
- EXISTING CONTOURS
- DRAINAGE PIPE LINES (BY OTHERS)

NOTE:
1. FOR GENERAL NOTES REFER DRG No. 11442-2200-T0200

ISSUED FOR CONSTRUCTION

FORGE
Forge Group MInerals and Resources Pty Ltd
45 Stirling Hwy, Nedlands, Western Australia 6009
Ph 61 (8) 6222 6400 Fax 61 (8) 6222 6499 Info@forgegroup.com.au

Revised by Forge Group Minerals and Resources Rev-No. 1 on 12.02.2013

5 0 10 20 30 40 50m
1:500

DRAWING No.	REFERENCE DRAWING TITLE	REVISION DESCRIPTION	REV.	BY	CHECKED	APPROVED	PROJ. ENG.	DATE
		ADD REV 1 AND REV 2 ONTO ONE DRAWING.	3	MK	MK	AN	GR	20.03.2013
		DRAWING REFERENCE NUMBERS ADDED	2	DS	MK	AN	GR	12/03/13
		RUN-OFF POND SETOUT POINTS CHANGES - BY HYDER	1	GBM	FP	FP	FP	26/10/12
		ISSUED FOR CONSTRUCTION	0	DM	SU	AY	BH	28/09/12

	BY	DATE
APPROVED		
CLIENT APPROVED		
ISS'D FOR CONSTR.		

CLIENT MMG

JACOBS

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DRG. No. 11442-2200-T0204 REV. 3

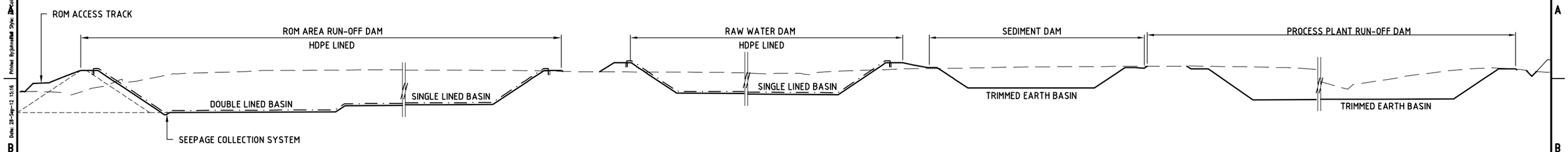
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DUGALD RIVER PROJECT
EARTHWORKS - PROCESS PLANT AREA
PROCESS DAMS - MINE WORKSHOP RUN-OFF DAM LAYOUT

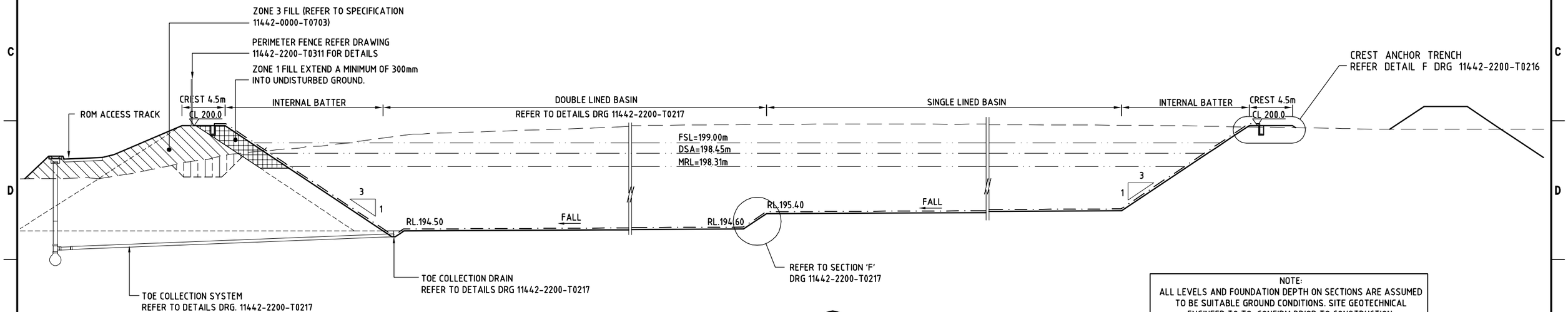
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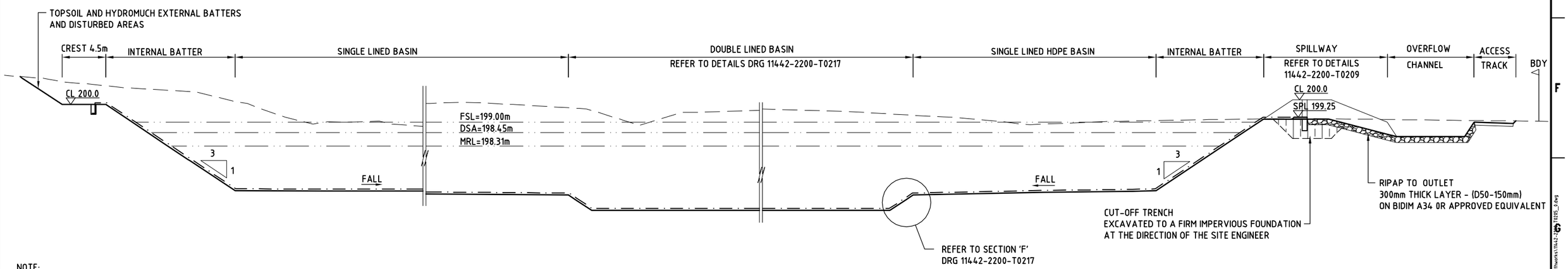


SECTION A T0200 SECTION ALL DAMS
HOR 1:500
VER 1:250



NOTE:
ALL LEVELS AND FOUNDATION DEPTH ON SECTIONS ARE ASSUMED TO BE SUITABLE GROUND CONDITIONS. SITE GEOTECHNICAL ENGINEER TO TO CONFIRM PRIOR TO CONSTRUCTION.

SECTION B T0201 ROM AREA RUN-OFF DAM
HOR 1:200
VER 1:100



NOTE:
DSA – DESIGN STORAGE LEVEL
MRL – MANDATORY REPORTING LEVEL
FSL – FULL SUPPLY LEVEL
CL – CREST LEVEL
SPL – SPILLWAY LEVEL

SECTION C T0201 ROM AREA RUNOFF DAM
HOR 1:200
VER 1:100

ISSUED FOR CONSTRUCTION

1:100 1 0 1 2 3 4 5 6 7 8 9 10m
1:200 2 0 2 4 6 8 10 12 14 16 18 20m

DRAWING No.	REFERENCE DRAWING TITLE	REVISION DESCRIPTION	REV.	BY	CHECKED	APPROVED	PROJ. ENG.	DATE
		ISSUED FOR CONSTRUCTION	0	DM	SU	AY	BH	28/09/12

	BY	DATE
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DRG. No. 11442-2200-T0205 REV. 0

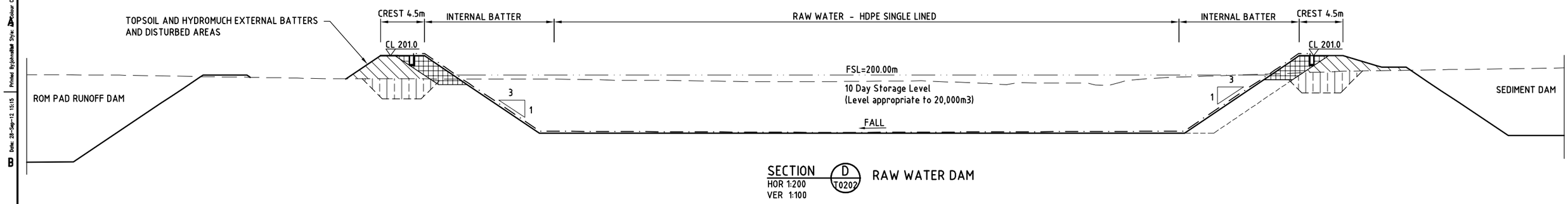
DUGALD RIVER PROJECT
EARTHWORKS - PROCESS PLANT AREA
PROCESS DAM SECTIONS SHEET 1 OF 4

A1

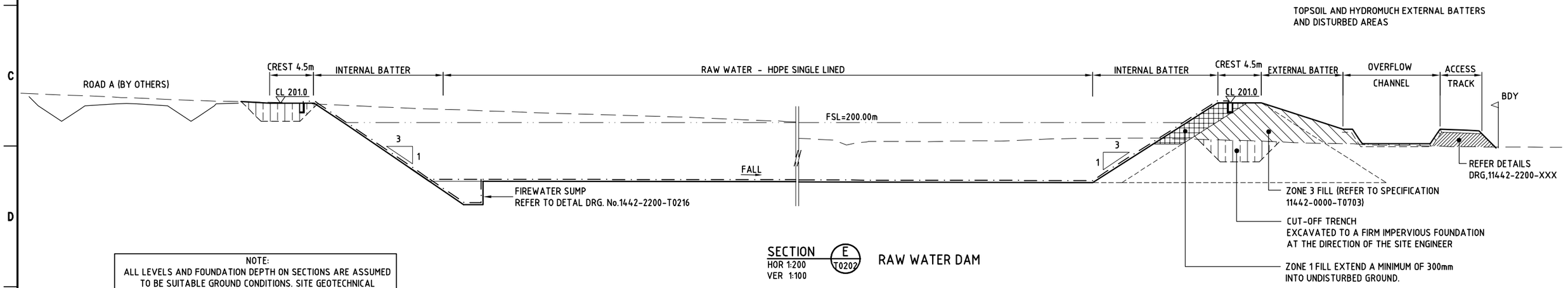
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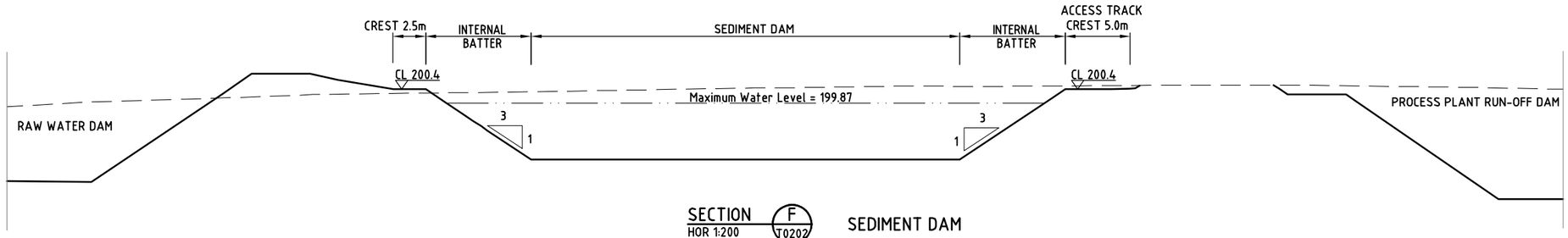


SECTION D HOR 1:200 VER 1:100 T0202 — RAW WATER DAM

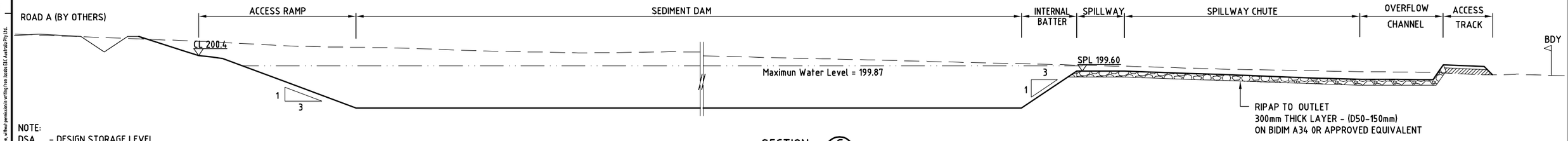


SECTION E HOR 1:200 VER 1:100 T0202 — RAW WATER DAM

NOTE:
ALL LEVELS AND FOUNDATION DEPTH ON SECTIONS ARE ASSUMED TO BE SUITABLE GROUND CONDITIONS. SITE GEOTECHNICAL ENGINEER TO TO CONFIRM PRIOR TO CONSTRUCTION.



SECTION F HOR 1:200 VER 1:100 T0202 — SEDIMENT DAM



SECTION G HOR 1:200 VER 1:100 T0202 — SEDIMENT DAM

NOTE:
DSA - DESIGN STORAGE LEVEL
MRL - MANDATORY REPORTING LEVEL
FSL - FULL SUPPLY LEVEL
CL - CREST LEVEL
SPL - SPILLWAY LEVEL

ISSUED FOR CONSTRUCTION

1:100 (1 0 1 2 3 4 5 6 7 8 9 10m)
1:200 (2 0 2 4 6 8 10 12 14 16 18 20m)

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		ISSUED FOR CONSTRUCTION	0	DM	SU	AY	BH	28/09/12

APPROVED	BY	DATE	CLIENT: MMG
CLIENT APPROVED			
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STATUS: ISSUED FOR CONSTRUCTION			

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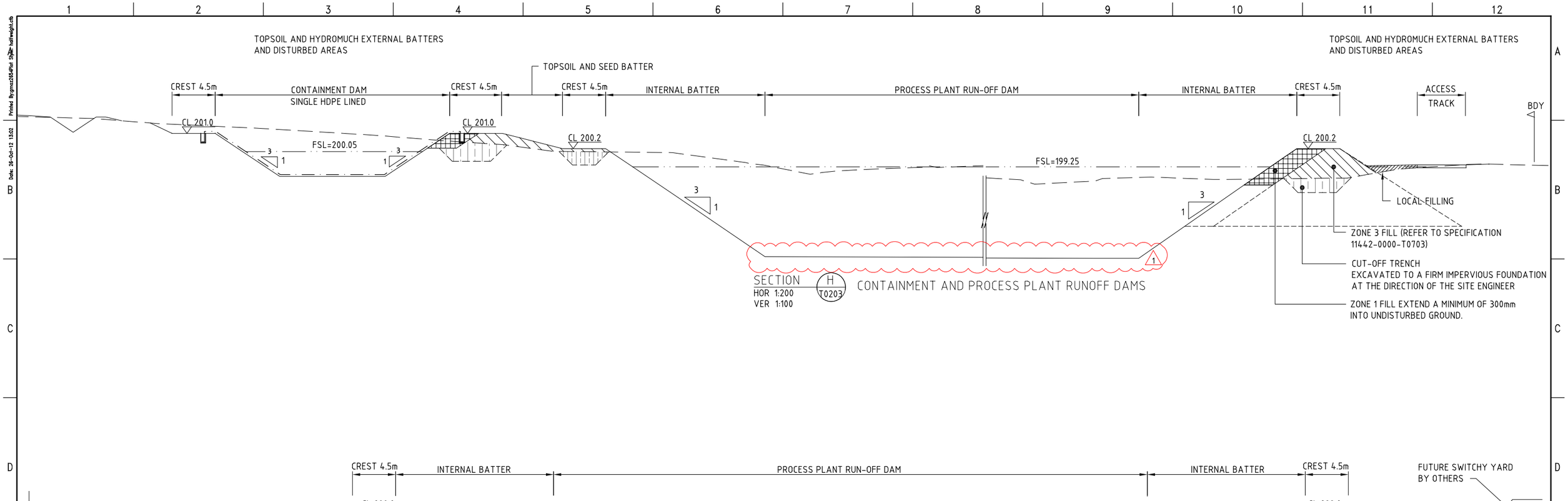
DUGALD RIVER PROJECT
EARTHWORKS - PROCESS PLANT AREA
PROCESS DAM SECTIONS SHEET 2 OF 4

A1

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NOTE:
ALL LEVELS AND FOUNDATION DEPTH ON SECTIONS ARE ASSUMED TO BE SUITABLE GROUND CONDITIONS. SITE GEOTECHNICAL ENGINEER TO TO CONFIRM PRIOR TO CONSTRUCTION.

NOTE: PROCESS PLANT RUNOFF DAM INVERT LEVEL REVISED BY HYDER AS INSTRUCTED BY MMG (1)

NOTE:
DSA - DESIGN STORAGE LEVEL
MRL - MANDATORY REPORTING LEVEL
FSL - FULL SUPPLY LEVEL
CL - CREST LEVEL
SPL - SPILLWAY LEVEL

ISSUED FOR CONSTRUCTION

1:100 — 1 0 1 2 3 4 5 6 7 8 9 10m
1:200 — 2 0 2 4 6 8 10 12 14 16 18 20m

DRAWING No.	REFERENCE DRAWING TITLE	REVISION DESCRIPTION	REV.	BY	CHECKED	APPROVED	PROJ. ENG.	DATE
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		ISSUED FOR CONSTRUCTION	0	DM	SU	AY	BH	28/09/12

APPROVED	BY	DATE	CLIENT
CLIENT APPROVED			
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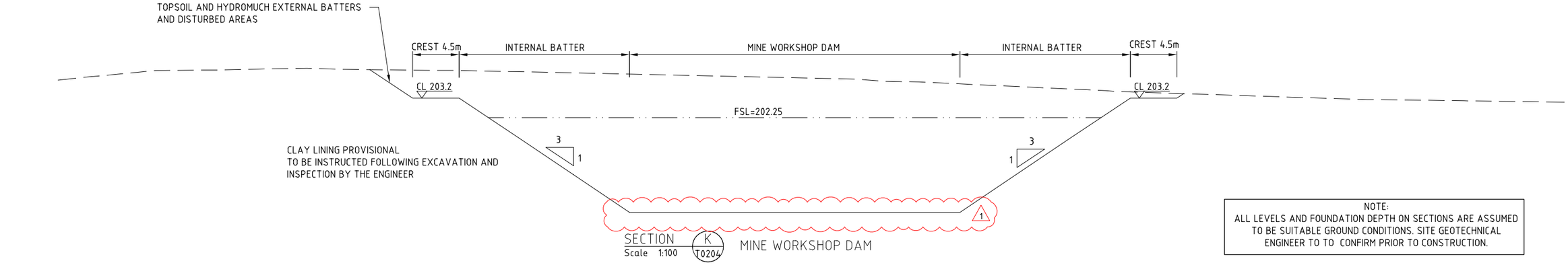
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DUGALD RIVER PROJECT
EARTHWORKS - PROCESS PLANT AREA
PROCESS DAM SECTIONS SHEET 3 OF 4

A1

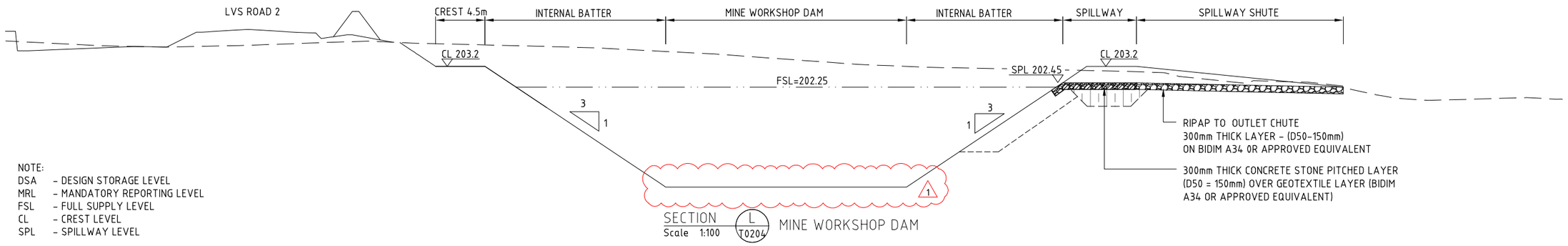
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SECTION K — MINE WORKSHOP DAM
Scale 1:100 (T0204)

NOTE:
ALL LEVELS AND FOUNDATION DEPTH ON SECTIONS ARE ASSUMED TO BE SUITABLE GROUND CONDITIONS. SITE GEOTECHNICAL ENGINEER TO TO CONFIRM PRIOR TO CONSTRUCTION.



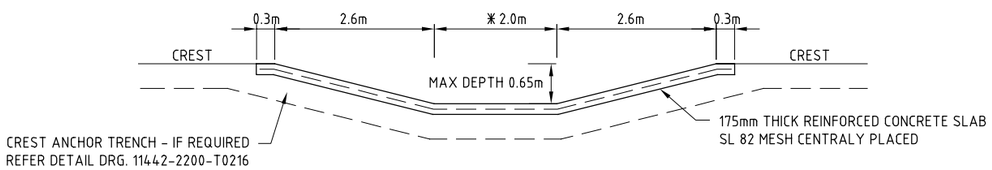
SECTION L — MINE WORKSHOP DAM
Scale 1:100 (T0204)

NOTE:
DSA – DESIGN STORAGE LEVEL
MRL – MANDATORY REPORTING LEVEL
FSL – FULL SUPPLY LEVEL
CL – CREST LEVEL
SPL – SPILLWAY LEVEL

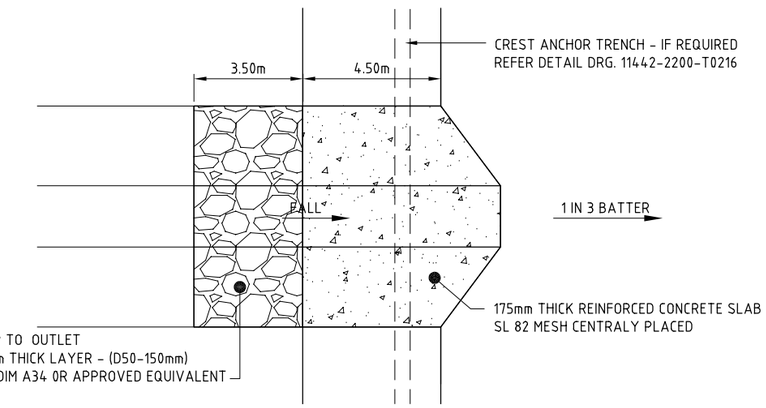
NOTE: MINE WORKSHOP RUNOFF DAM INVERT LEVEL
REVISED BY HYDER AS INSTRUCTED BY MMG (1)

NOTE
1. ADJOINING DRAINAGE CHANNELS BY OTHERS.
2. CHANNEL ENTERING DAMS MAY NEED TO BE TEMPORARY BLOCK-OFF OF DRAINAGE FLOWS MAY NEED TO BE DIVERTED DURING CONSTRUCTION.

* INLET CONCRETE SLAB PROCESS DAM 'A' = 3.5 m WIDE BASE
ALL OTHER INLET CONCRET SLABS TO BE 2.0m WIDE BASE



TYPICAL SECTION - CONCRETE INLET
Scale 1:25



LAYOUT - CONCRETE INLET
Scale 1:100

DETAIL - CONCRETE INLET SPILLWAY

ISSUED FOR CONSTRUCTION

1:100 — 1 0 1 2 3 4 5 6 7 8 9 10m
1:200 — 2 0 2 4 6 8 10 12 14 16 18 20m

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		RUN-OFF POND DEPTHS CHANGED - BY HYDER	1	GBM	FP	FP	FP	26/10/12
		ISSUED FOR CONSTRUCTION	0	DM	SU	AY	BH	28/09/12

APPROVED	BY	DATE	CLIENT: MMG
CLIENT APPROVED			
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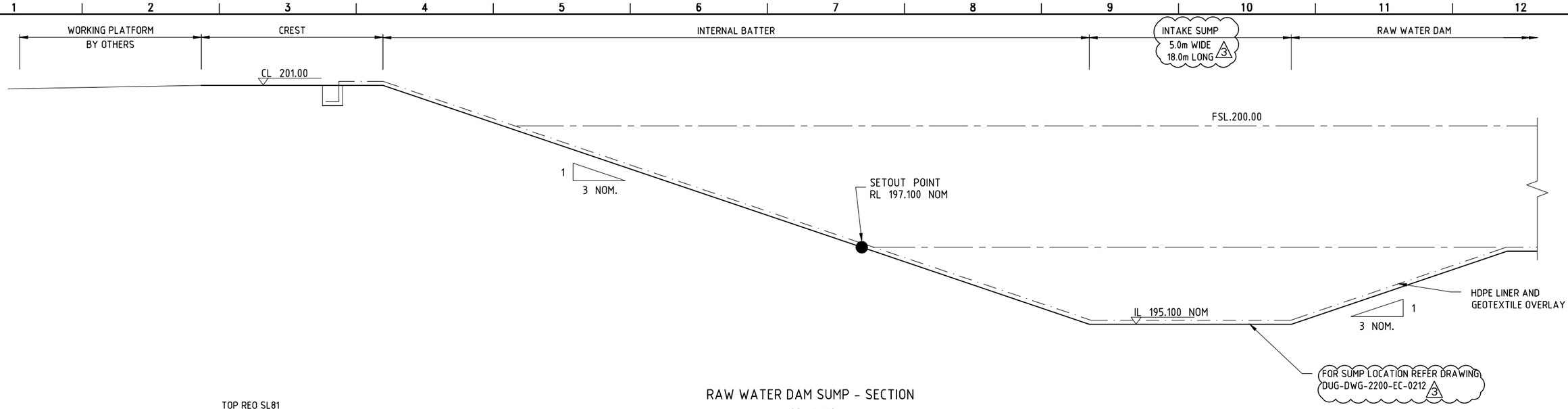
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DUGALD RIVER PROJECT
EARTHWORKS - PROCESS PLANT AREA
PROCESS DAM SECTIONS SHEET 4 OF 4

A1

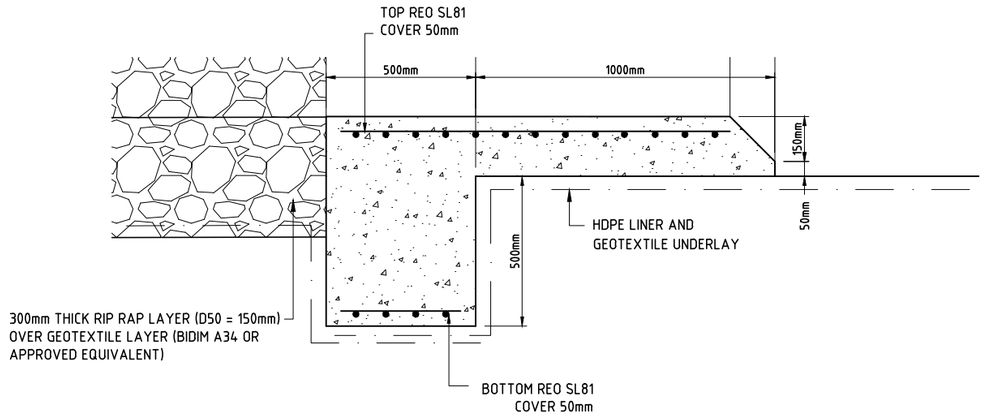
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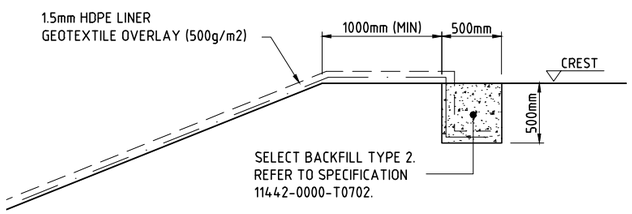
RAW WATER DAM SUMP - SECTION

SCALE 1:50



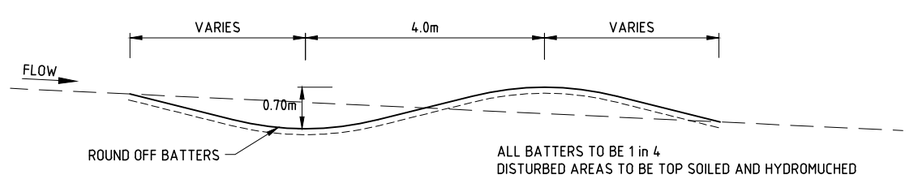
DETAIL A - CONCRETE ANCHOR TRENCH AT SPILLWAY

SCALE 1:10



RAW WATER DAM - CREST ANCHOR TRENCH DETAIL FOR HDPE LINER

SCALE 1:25



TEMPORARY CLEAN WATER DIVERSION CHANNEL -SECTION

SCALE 1:20

ISSUED FOR CONSTRUCTION

FORGE
Forge Group Minerals and Resources Pty Ltd
45 Stirling Hwy, Nedlands, Western Australia 6009
Ph 61 (8) 6222 6400 Fax 61 (8) 6222 6499 Info@forgegroup.com.au

Revised by Forge Group Minerals and Resources Rev-No. 1 on 12.02.2013

500 0 500 1000 1500 2000 2500mm
1:25
1 0 1 2 3 4 5 6 7 8 9 10m
1:100
500 0 1000 2000 3000 4000 5000mm
1:50

DRAWING No.	REFERENCE DRAWING TITLE	REVISION DESCRIPTION	REV.	BY	CHECKED	APPROVED	PROJ. ENG.	DATE
		ANNOTATION ADDED	3	DS	MK	AN	AN	29.05.13
		SUMP SECTION MODIFIED	2	MK	DS	AN	AN	02.04.13
		RAW WATER DAM SUMP UPDATED	1	MK	SRT	AN	AN	22.03.13
		ISSUED FOR CONSTRUCTION	0	DM	AB	AY	BH	28/09/12

	BY	DATE
APPROVED		
CLIENT APPROVED		
ISS'D FOR CONSTR.		

CLIENT MMG

SCALE AS SHOWN

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STATUS **ISSUED FOR CONSTRUCTION**

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CLIENT No. DUG-DWG-2200-EC-0231 REV. 3

DRG. No. 11442-2200-T0216 REV. 3

DUGALD RIVER PROJECT
EARTHWORKS - PROCESS PLANT AREA
PROCESS DAMS - TYPICAL DETAILS AND SECTIONS

A1

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File: T:\Transfer to Doc Control\39777 Dugald River\DUG Dwg\2200-EC-0231_R3.dwg

SURVEY NOTES:

1.- GRID COORDINATE SYSTEM IN USE GDA94.
2.- EXISTING SURVEY AND AS-BUILT LINES ARE BASED ON THE FOLLOWING FILES PROVIDED MY MMG: "Dam F_210415_group1_densified_point_cloud" AND "4SHEC_INFO-MGA94".

EXISTING CULVERTS (3 x 750mm DIAMETER RCP)

EXISTING SITE ROAD

INLET DRAIN

EXISTING RAMP

SED DAM F
(EXISTING CONFIGURATION)

EXISTING SITE ROAD

EXISTING SPILLWAY

EXISTING OUTLET PIPE AND KNIFE GATE VALVE (TO BE REMOVED). REFER TO SPECIFICATION FOR DETAILS

APPROX. 1 IN 100 AEP FLOOD LEVEL FROM SILVERMINE CREEK (ASSUMING NO SEDIMENT DAM INFRASTRUCTURE IN PLACE)

206
208
204

E 411550
E 411600
E 411650
E 411700
N 7760150
N 7760100

N
W
E
S

ISSUED FOR CONSTRUCTION

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0	ISSUED FOR CONSTRUCTION	27.08.21	HR	DMR	NB

SCALE:	1:500
JOB No.	108003.50
DATE	25.08.21
DESIGN	DMR
DRAWN	HR
CHECKED	DMR
APPROVED	NB

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TAILINGS . WATER . WASTE .
Melbourne T +61 3 8587 0900
melbourne@atcwilliams.com.au

MMG DUGALD RIVER
SEDIMENT DAM F UPGRADE

EXISTING CONDITIONS

DWG. No. 108003.50-001

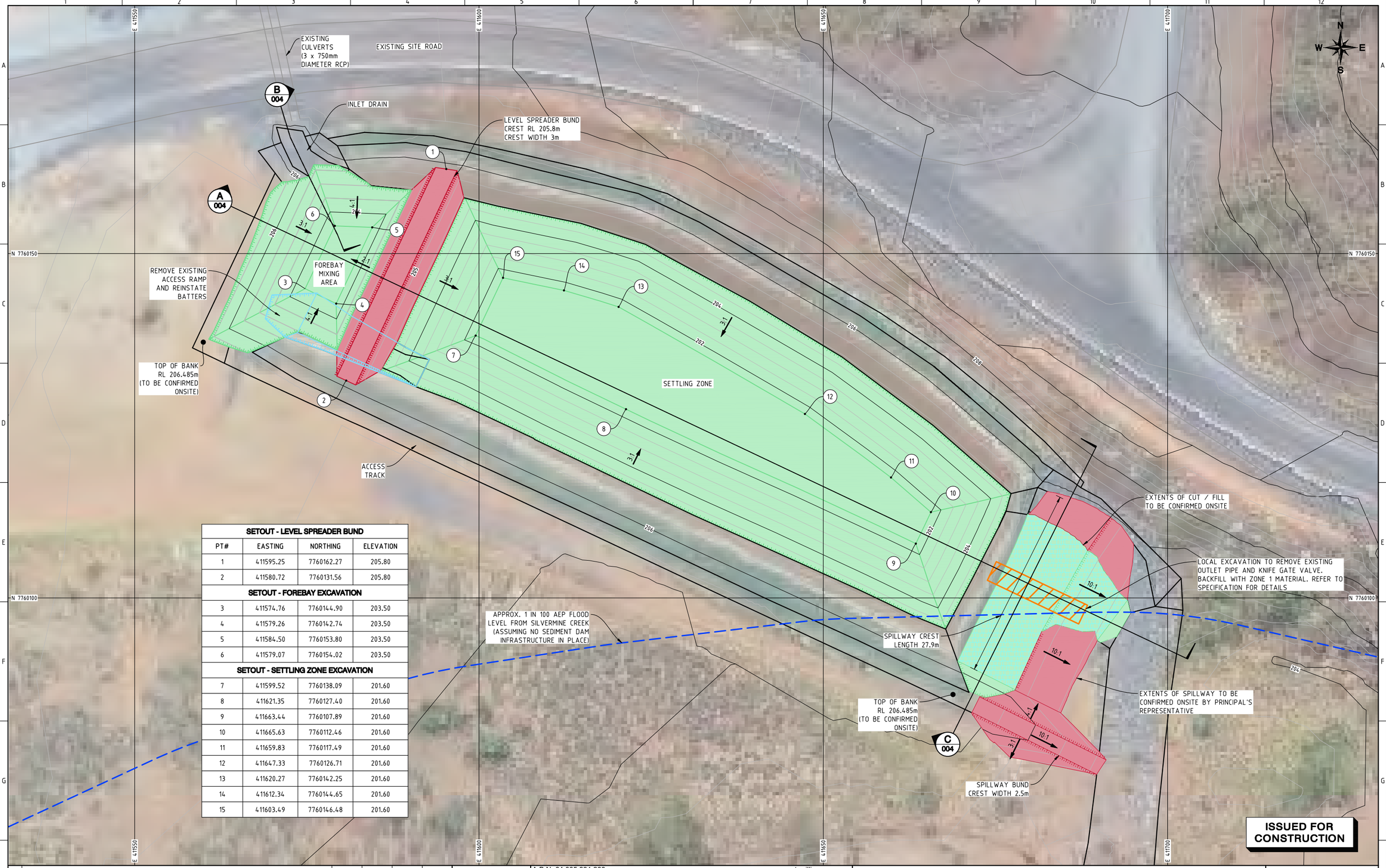
SHEET SIZE A3 Rev. 0

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SHEET 1 OF 1

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Printed on: Friday, 27 August 2021 10:07:03 AM



SETOUT - LEVEL SPREADER BUND			
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1	411595.25	7760162.27	205.80
2	411580.72	7760131.56	205.80
SETOUT - FOREBAY EXCAVATION			
3	411574.76	7760144.90	203.50
4	411579.26	7760142.74	203.50
5	411584.50	7760153.80	203.50
6	411579.07	7760154.02	203.50
SETOUT - SETTLING ZONE EXCAVATION			
7	411599.52	7760138.09	201.60
8	411621.35	7760127.40	201.60
9	411663.44	7760107.89	201.60
10	411665.63	7760112.46	201.60
11	411659.83	7760117.49	201.60
12	411647.33	7760126.71	201.60
13	411620.27	7760142.25	201.60
14	411612.34	7760144.65	201.60
15	411603.49	7760146.48	201.60

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No.	DESCRIPTION	DATE	DRAWN	CHECK'D	APPR'D
0	ISSUED FOR CONSTRUCTION	27.08.21	HR	DMR	NB

SCALE:	1:500
JOB No.	108003.50
DATE	25.08.21
DESIGN	DMR
DRAWN	HR
CHECKED	DMR
APPROVED	NB

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MMG DUGALD RIVER SEDIMENT DAM F UPGRADE

LAYOUT PLAN

DWG. No. 108003.50-002

SHEET SIZE A3 Rev. 0

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SHEET 1 OF 1

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Printed on: Friday, 27 August 2021 10:06:27 AM

EXISTING CULVERTS

EXISTING SITE ROAD

B 004

INLET DRAIN

OUTLET HEADWALL, APRON & SCOUR PROTECTION. EXTEND SCOUR PROTECTION (GEOTEXTILE & RIPRAP) TO BASE OF FOREBAY MIXING AREA. REFER NOTE 1.

INDICATIVE LOCATION OF RAIN ACTIVATED DOSING UNIT & SHED

A 004

REPAIR EXISTING EROSION PROTECTION AND PLACE ADDITIONAL EROSION PROTECTION AS DIRECTED BY PRINCIPAL'S REPRESENTATIVE. REFER NOTE 1.

FOREBAY MIXING AREA

5.0m

SETTLING ZONE

D 004

C 004

REPAIR EXISTING EROSION PROTECTION AND PLACE ADDITIONAL EROSION PROTECTION AS DIRECTED BY PRINCIPAL'S REPRESENTATIVE. REFER NOTE 1.

EXTENTS OF SPILLWAY TO BE CONFIRMED ONSITE BY PRINCIPAL'S REPRESENTATIVE

APPROX. 1 IN 100 AEP FLOOD LEVEL FROM SILVERMINE CREEK (ASSUMING NO SEDIMENT DAM INFRASTRUCTURE IN PLACE)

CONSTRUCT ACCESS RAMP TO SETTLING ZONE AREA BY EXCAVATING BATTER. MINIMUM WIDTH OF 6m, 6H TO 1V GRADE OR FLATTER.

RAMP SETOUT TO BE CONFIRMED ONSITE BY PRINCIPAL'S REPRESENTATIVE.

LOCAL EROSION PROTECTION ON SOUTH EAST CORNER OF BASIN AS DIRECTED BY PRINCIPAL'S REPRESENTATIVE. REFER NOTE 1.

N W E S

E 411550 E 411600 E 411650 E 411700

N 7760150 N 7760100

206 208 204

3:1 4:1 10:1

NOTE:

1.- EROSION PROTECTION TO CONSIST OF RIPRAP OVERLYING GEOTEXTILE. REFER TO SPECIFICATION FOR SOURCING, INSTALLATION AND PLACEMENT DETAILS.

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No.	DESCRIPTION	DATE	DRAWN	CHECK'D	APPR'D
0	ISSUED FOR CONSTRUCTION	27.08.21	CV	DMR	NB

SCALE:	1:500
JOB No.	108003.50
DATE	25.08.21
DESIGN	DMR
DRAWN	CV
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APPROVED	NB

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MMG DUGALD RIVER SEDIMENT DAM F UPGRADE

EROSION PROTECTION EXTENTS & ACCESS RAMPS

DWG. No. 108003.50-003

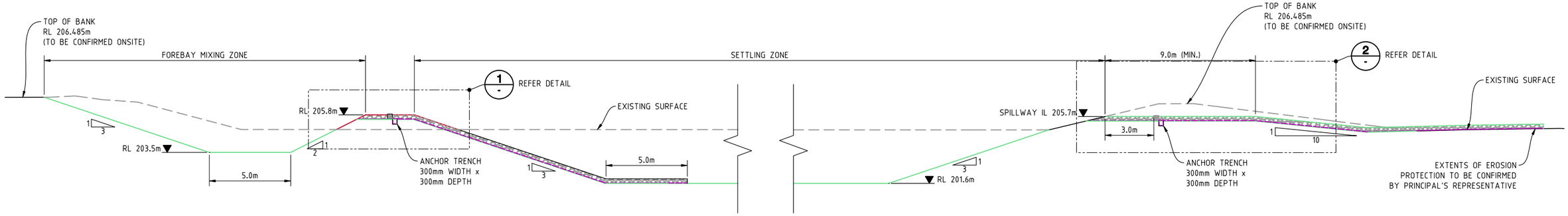
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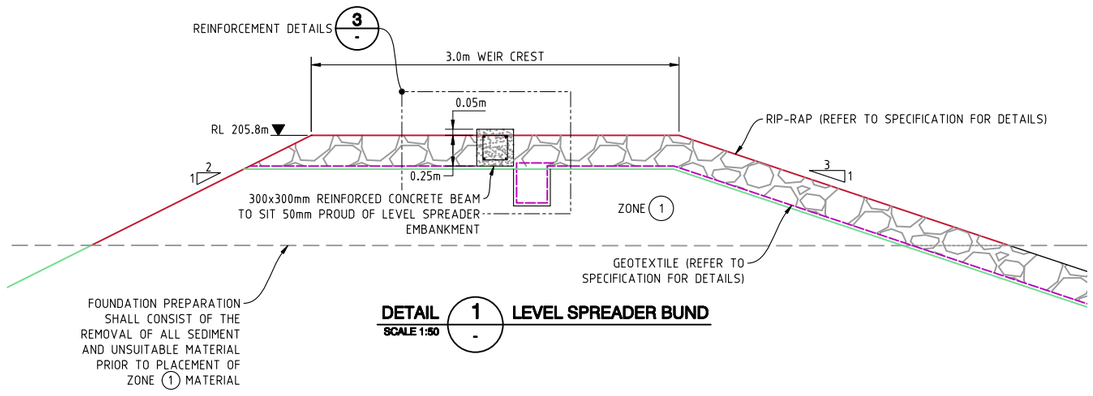
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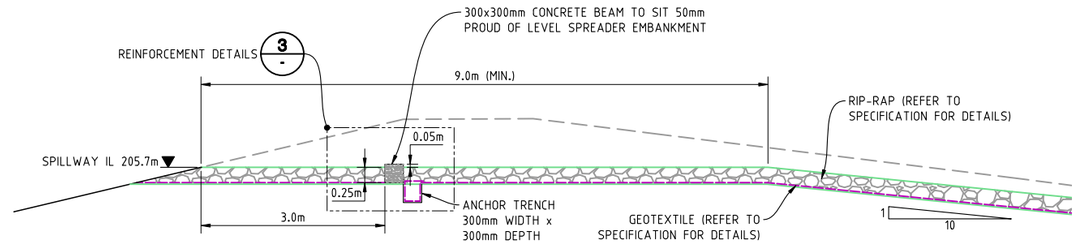
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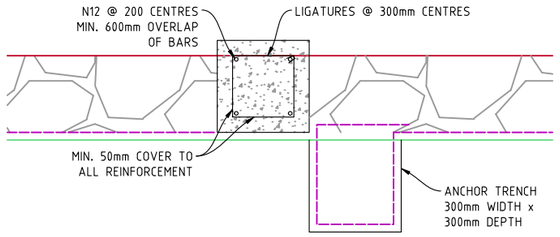
SECTION A 002 SEDIMENT BASIN
SCALE 1:250



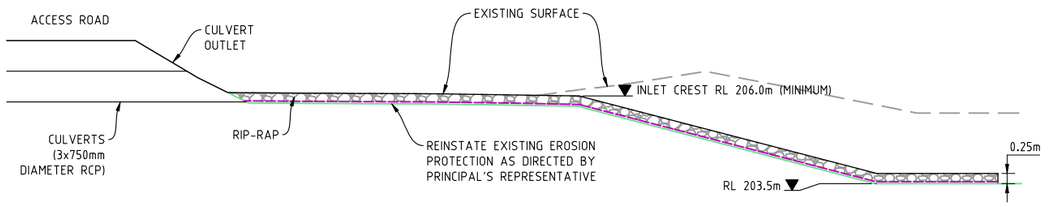
DETAIL 1 - LEVEL SPREADER BUND
SCALE 1:50



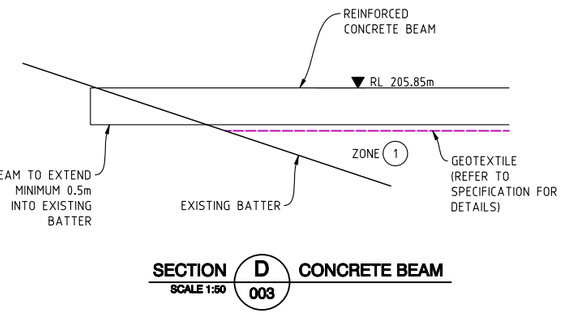
DETAIL 2 - SPILLWAY
SCALE 1:100



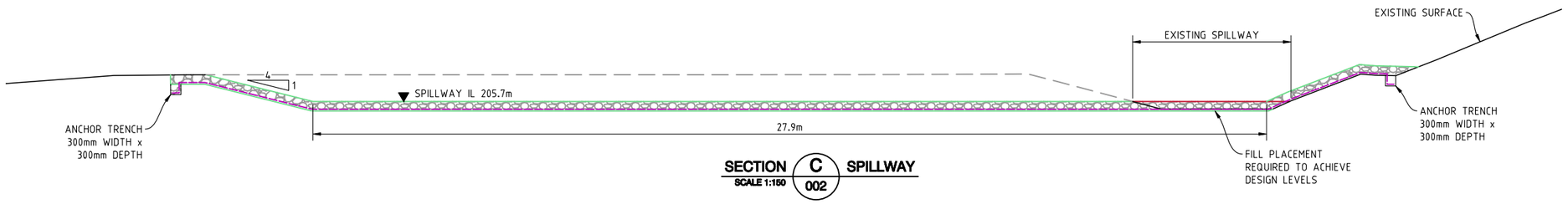
DETAIL 3 - REINFORCEMENT
SCALE 1:20



SECTION B 002 INLET DRAIN
SCALE 1:150



SECTION D 003 CONCRETE BEAM
SCALE 1:50



SECTION C 002 SPILLWAY
SCALE 1:150

ISSUED FOR CONSTRUCTION

No.	DESCRIPTION	DATE	DRAWN	CHECK'D	APPR'D
0	ISSUED FOR CONSTRUCTION	27.08.21	HR	DMR	NB

SCALE:	AS SHOWN
JOB No.	108003.50
DATE	25.08.21
DESIGN	DMR
DRAWN	HR
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APPROVED	NB

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Melbourne T +61 3 8587 0900
melbourne@atcwilliams.com.au

MMG DUGALD RIVER
SEDIMENT DAM F UPGRADE

SECTIONS & DETAILS

DWG. No. 108003.50-004

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SHEET 1 OF 1

Appendix B – ESCP Plan Reference

APPENDIX A REFERENCE DOCMENTS

Item	Title/Description	Author/Publisher	Version/Date
1	Bridge and Culvert Construction	IECA Book 4 – Design Fact Sheets	2010
2	Catch Drains Part-1 General	IECA Book 4 – Design Fact Sheets	2010
3	Catch Drains Part-2 Earth	IECA Book 4 – Design Fact Sheets	2010
4	Catch Drains Part-2 Grass	IECA Book 4 – Design Fact Sheets	2010
5	Check Dam Sediment Traps	IECA Book 4 – Design Fact Sheets	2010
6	Construction Access Roads	IECA Book 4 – Design Fact Sheets	2010
7	Construction Exits Part-3 – Vibration Grids	IECA Book 4 – Design Fact Sheets	2010
8	Construction Exits Part-4 – Wash Bays	IECA Book 4 – Design Fact Sheets	2010
9	Diversion Channels	IECA Book 4 – Design Fact Sheets	2010
10	Dust Control	IECA Book 4 – Design Fact Sheets	2010
11	Excavated Sediment Traps	IECA Book 4 – Design Fact Sheets	2010
12	Filter Fence	IECA Book 4 – Design Fact Sheets	2010
13	Flow Diversion Bank Part-1 General	IECA Book 4 – Design Fact Sheets	2010
14	Flow Diversion Bank Part-1 Grass	IECA Book 4 – Design Fact Sheets	2010
15	Flow Diversion Bank Part-2 Earth	IECA Book 4 – Design Fact Sheets	2010
16	Installation of Services	IECA Book 4 – Design Fact Sheets	2010
17	Level Spreaders	IECA Book 4 – Design Fact Sheets	2010
18	Mulch Filter Berms	IECA Book 4 – Design Fact Sheets	2010
19	Pipe & Culvert Inlet Sediment Traps	IECA Book 4 – Design Fact Sheets	2010
20	Sediment Basin Overview	IECA Book 4 – Design Fact Sheets	2010
21	Sediment Basin Spillways	IECA Book 4 – Design Fact Sheets	2010
22	Sediment Fence	IECA Book 4 – Design Fact Sheets	2010
23	Sediment Weirs	IECA Book 4 – Design Fact Sheets	2010
24	Site Management	IECA Book 4 – Design Fact Sheets	2010
25	Soil Management	IECA Book 4 – Design Fact Sheets	2010
26	Stockpile Management	IECA Book 4 – Design Fact Sheets	2010
27	Temporary Culvert Crossings	IECA Book 4 – Design Fact Sheets	2010
28	Vegetation Management	IECA Book 4 – Design Fact Sheets	2010

Appendix C – Non-Operational Area Soil Loss Calculations

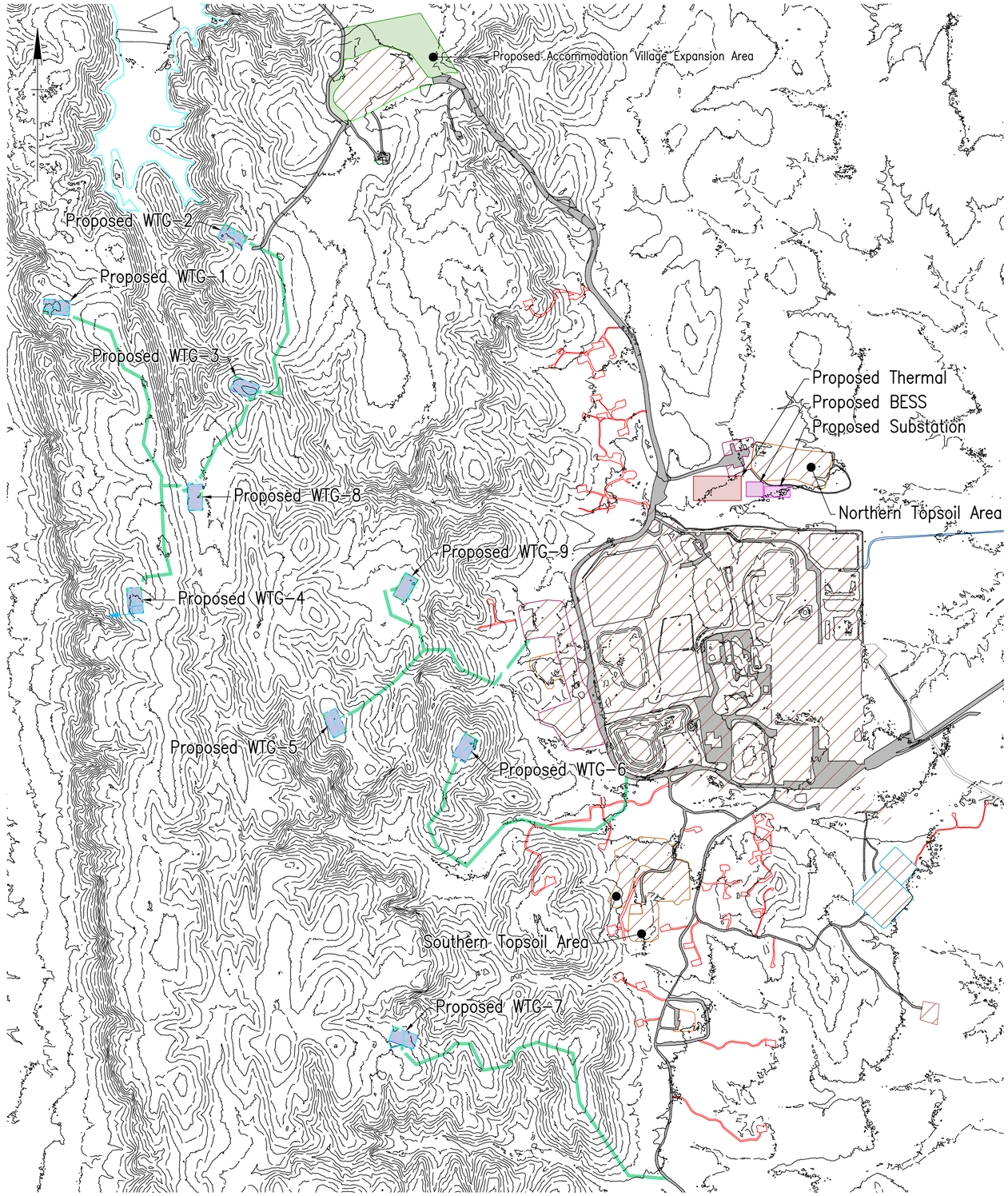
Sub-Catchment	Area (Ha)	Slope %)	Length (m)	K Factor	Ls	C Factor	Soil Loss Rate (t/ha/yr)	Soil Erosion Hazard	Soil Loss Class
WTG-1A	0.22	20	40.0	0.030	4.32	1.00	442	Moderate	3 to 4
WTG-1B	0.21	20	40.0	0.030	4.32	1.00	442	Moderate	3 to 4
WTG-1C	0.14	20	40.0	0.030	4.32	1.00	442	Moderate	3 to 4
WTG-2A	0.40	20	40.0	0.030	4.32	1.00	442	Moderate	3 to 4
WTG-2B	0.16	1	80.0	0.030	0.19	1.00	19	Very Low	1
WTG-3A	0.33	20	40.0	0.030	4.32	1.00	442	Moderate	3 to 4
WTG-3B	0.25	20	40.0	0.030	4.32	1.00	442	Moderate	3 to 4
WTG-4A	0.35	17	30.0	0.030	2.67	1.00	273	Moderate	3 to 4
WTG-4B	0.30	17	30.0	0.030	2.67	1.00	273	Moderate	3 to 4
WTG-5A	0.34	12	60.0	0.030	3.02	1.00	309	Moderate	3 to 4
WTG-5B	0.31	12	60.0	0.030	3.02	1.00	309	Moderate	3 to 4
WTG-6A	0.38	5	80.0	0.030	1.19	1.00	122	Very Low	1
WTG-6B	0.24	5	80.0	0.030	1.19	1.00	122	Very Low	1
WTG-7A	0.34	10	60.0	0.030	2.31	1.00	236	Moderate	3 to 4
WTG-7B	0.31	7	60.0	0.030	1.24	1.00	127	Very Low	1
WTG-8A	0.65	8	60.0	0.030	1.70	1.00	174	Low	2
WTG-9A	0.47	1	80.0	0.030	0.19	1.00	19	Very Low	1
VIL-W01	0.35	5	80.0	0.030	1.19	1.00	122	Very Low	1
VIL-W02	0.33	5	80.0	0.030	1.19	1.00	122	Very Low	1
VIL-N01	0.51	15	80.0	0.030	4.61	1.00	472	Moderate	3 to 4
VIL-N02	3.96	2.5	80.0	0.030	0.65	1.00	67	Very Low	1
VIL-N03	1.58	15	80.0	0.030	4.61	1.00	472	Moderate	3 to 4
THE-01	1.95	1	80.0	0.045	0.19	1.00	29	Very Low	1
BESS-01	0.42	1	80.0	0.045	0.19	1.00	29	Very Low	1
SS-01	0.47	1	80.0	0.045	0.19	1.00	29	Very Low	1

Sub-Catchment	Area (Ha)	Slope %)	Length (m)	K Factor	Ls	C Factor	Soil Loss Rate (t/ha/yr)	Soil Erosion Hazard	Soil Loss Class
STA-01	1.40	2.5	80.0	0.045	0.65	1.00	100	Very Low	1
STA-02	2.26	2.5	80.0	0.045	0.65	1.00	100	Very Low	1
STA-03	1.87	3.5	80.0	0.045	0.91	1.00	140	Very Low	1
STA-04	1.30	2.5	80.0	0.045	0.65	1.00	100	Very Low	1
STA-05	1.31	2.5	80.0	0.045	0.65	1.00	100	Very Low	1
NTA-01	1.08	1.5	80.0	0.045	0.41	1.00	63	Very Low	1
NTA-02	0.24	1.5	80.0	0.045	0.41	1.00	63	Very Low	1

Appendix D – Non-operational Sediment Basin Sizing

Sub-catchment ID	Disturbed Area (ha)	Design rainfall depth (as # day)	Design rainfall depth (percentile)	x-day, y-percentile rainfall event	Rainfall R-factor (if known)	IFD: 2-year, 6-hour storm (if known)	oil loss rate (t/ha/yr)	Length (m)	Width (m)	Ratio	Area (m²)	Depth of sediment zone	Depth of settling zone	Internal batter slope	Check basin storage (soil) volume (m3)	Check basin settling number	Check sediment basin total	Weir height (m)	Freeboard (m)	Check total depth (m)
WTG-2A	0.4	5	80	23.8	2624	11	261	15	5	3	75	0.4	0.9	2	33	65	98	0.3	0.3	1.9
WTG-3A	0.3	5	80	23.8	2624	11	261	15	5	3	75	0.4	0.7	2	27	54	80	0.3	0.3	1.7
WTG-4A	0.4	5	80	23.8	2624	11	273	15	5	3	75	0.4	0.8	2	29	58	87	0.3	0.3	1.8
WTG-4B	0.3	5	80	23.8	2624	11	273	15	5	3	75	0.3	0.7	2	25	49	74	0.3	0.3	1.6
WTG-5A	0.3	5	80	23.8	2624	11	309	15	5	3	75	0.4	0.7	2	28	56	84	0.3	0.3	1.7
WTG-5B	0.3	5	80	23.8	2624	11	309	15	5	3	75	0.3	0.7	2	25	51	76	0.3	0.3	1.6
WTG-7A	0.4	5	80	23.8	2624	11	236	15	5	3	75	0.5	0.9	2	34	68	102	0.3	0.3	2
WTG-8A	0.7	5	80	23.8	2624	11	174	20	7	3	133	0.4	0.8	2	54	107	161	0.9	0.3	2.4
VIL-N01	0.5	5	80	23.8	2624	11	472	18	6	3	108	0.4	0.8	2	42	84	126	0.3	0.3	1.8
VIL-N03	1.6	5	80	23.8	2624	11	472	30	10	3	300	0.4	0.9	2	130	259	389	0.3	0.3	1.9
STA-01	1.4	5	80	23.8	2624	11	100	27	9	3	243	0.5	0.9	2	115	230	345	0.3	0.3	2
STA-02	2.3	5	80	23.8	2624	11	100	35	12	3	408	0.5	0.9	2	186	371	557	0.3	0.3	2
STA-03	1.9	5	80	23.8	2624	11	140	35	12	3	408	0.4	0.8	2	154	307	461	0.3	0.3	1.7
STA-04	1.3	5	80	23.8	2624	11	100	30	10	3	300	0.4	0.7	2	107	213	320	0.3	0.3	1.7
STA-05	1.3	5	80	23.8	2624	11	100	30	10	3	300	0.4	0.7	2	107	213	320	0.3	0.3	1.7

Appendix E - Non-operational Area ESCP Plans



EXISTING FEATURES LEGEND:

- Existing Surface Contour
- Existing Roadways
- Existing Mine Infrastructure
- Existing Investigation Drill Pads and Tracks
- Existing Powerline Corridor

PROPOSED FEATURES LEGEND:

- Investigation Tracks
- Borrow Pits and Stockpiles
- Wind Turbine Hard Stand – WTG (107x61m)
- Thermal
- BESS
- Substation
- Accommodation Village Expansion Area

DRAWING INDEX

DRAWING NUMBER	DRAWING TITLE	DATE	REVISION
WTS-001-SKC000	PROPOSED AREAS OF INTEREST	01/12/22	A
WTS-001-SKC005	TYPICAL ROAD DETAILS SHEET 1 OF 2	01/12/22	A
WTS-001-SKC006	TYPICAL ROAD DETAILS SHEET 2 OF 2	01/12/22	A
WTS-001-SKC007	EROSION AND SEDIMENT CONTROL DETAILS SHEET 1 OF 2	01/12/22	A
WTS-001-SKC008	EROSION AND SEDIMENT CONTROL DETAILS SHEET 2 OF 2	01/12/22	A
WTS-001-SKC010	WIND TURBINE LOCATION KEY PLAN	01/12/22	A
WTS-001-SKC011	WTG-1 FOOTPRINT	01/12/22	A
WTS-001-SKC012	WTG-2 FOOTPRINT	01/12/22	A
WTS-001-SKC013	WTG-3 FOOTPRINT	01/12/22	A
WTS-001-SKC014	WTG-4 FOOTPRINT	01/12/22	A
WTS-001-SKC015	WTG-5 FOOTPRINT	01/12/22	A
WTS-001-SKC016	WTG-6 FOOTPRINT	01/12/22	A
WTS-001-SKC017	WTG-7 FOOTPRINT	01/12/22	A
WTS-001-SKC018	WTG-8 FOOTPRINT	01/12/22	A
WTS-001-SKC019	WTG-9 FOOTPRINT	01/12/22	A
WTS-001-SKC020	ACCOMMODATION VILLAGE EXPANSION OVERVIEW	01/12/22	A
WTS-001-SKC021	ACCOMMODATION VILLAGE EXPANSION DETAILS	01/12/22	A
WTS-001-SKC030	PROPOSED THERMAL, BESS AND SUBSTATION INFRASTRUCTURE	01/12/22	A
WTS-001-SKC031	PROPOSED THERMAL INFRASTRUCTURE	01/12/22	A
WTS-001-SKC032	PROSED BESS/SUBSTATION INFRASTRUCTURE	01/12/22	A
WTS-001-SKC040	DRILL PAD LOCATION KEY PLAN	01/12/22	A
WTS-001-SKC041	TYPICAL EXISTING DRILL PAD	01/12/22	A
WTS-001-SKC050	TOPSOIL AREAS KEY PLAN	01/12/22	A
WTS-001-SKC051	SOUTHERN TOPSOIL AREA SHEET 1 OF 2	01/12/22	A
WTS-001-SKC052	SOUTHERN TOPSOIL AREA SHEET 2 OF 2	01/12/22	A
WTS-001-SKC053	NORTHERN TOPSOIL AREA	01/12/22	A

Rev	Revision Description	Certification	Date
A	DRAFT FOR CLIENT REVIEW	M.HAUSFELD	01/12/22

Scales

0 100 200 300 400 500m

Scale 1:10000m

Dimensions shown in metres except where shown otherwise

civil IQ

Client

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Title

DUGALD RIVER MINE
EROSION AND SEDIMENT CONTROL
PROPOSED AREAS

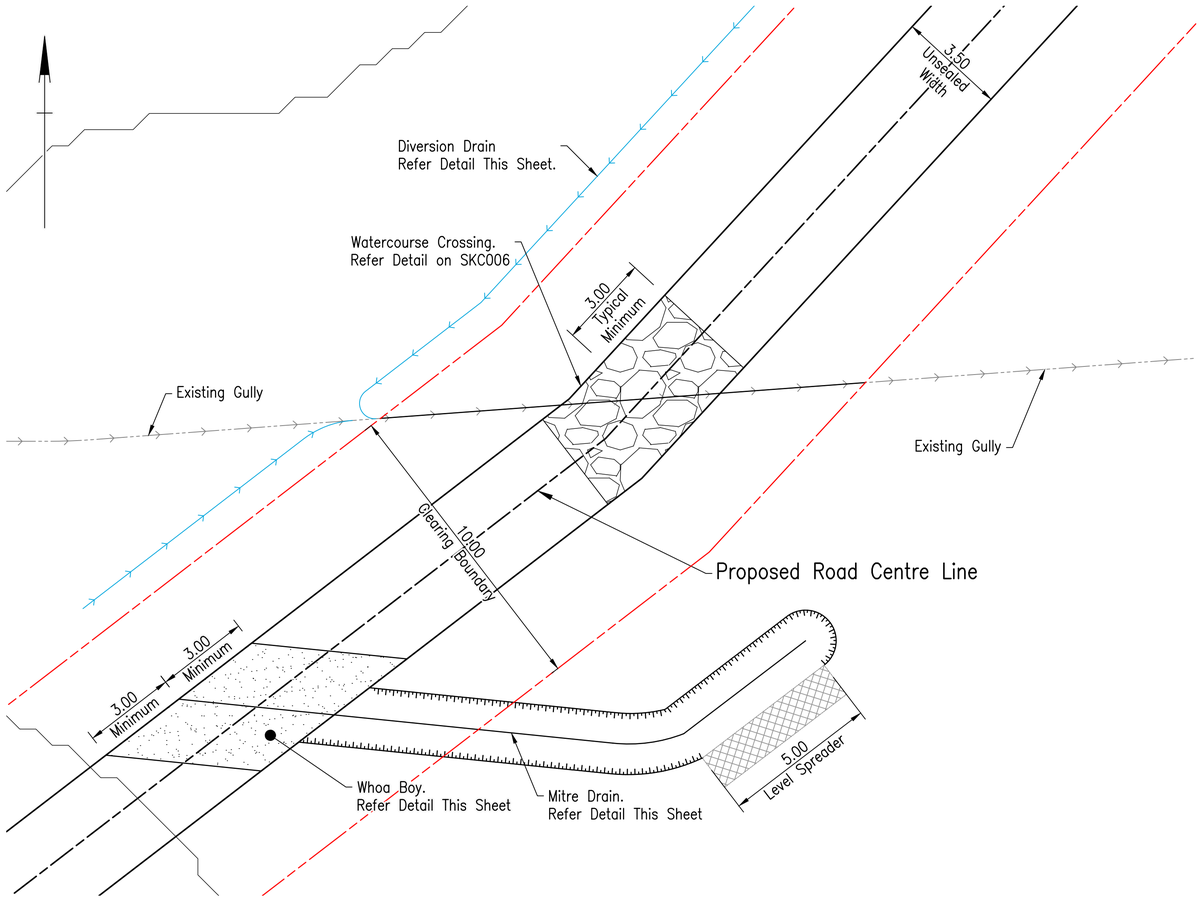
Drawn M.SMITH

Designed M.HAUSFELD

ENGINEERING CERTIFICATION (RPEQ)				
ENG. AREA	NAME	SIGNATURE	NO.	DATE

Job No.	WTS-002
Drawing No.	SKC000
Revision	A
Series Number	1 OF 1

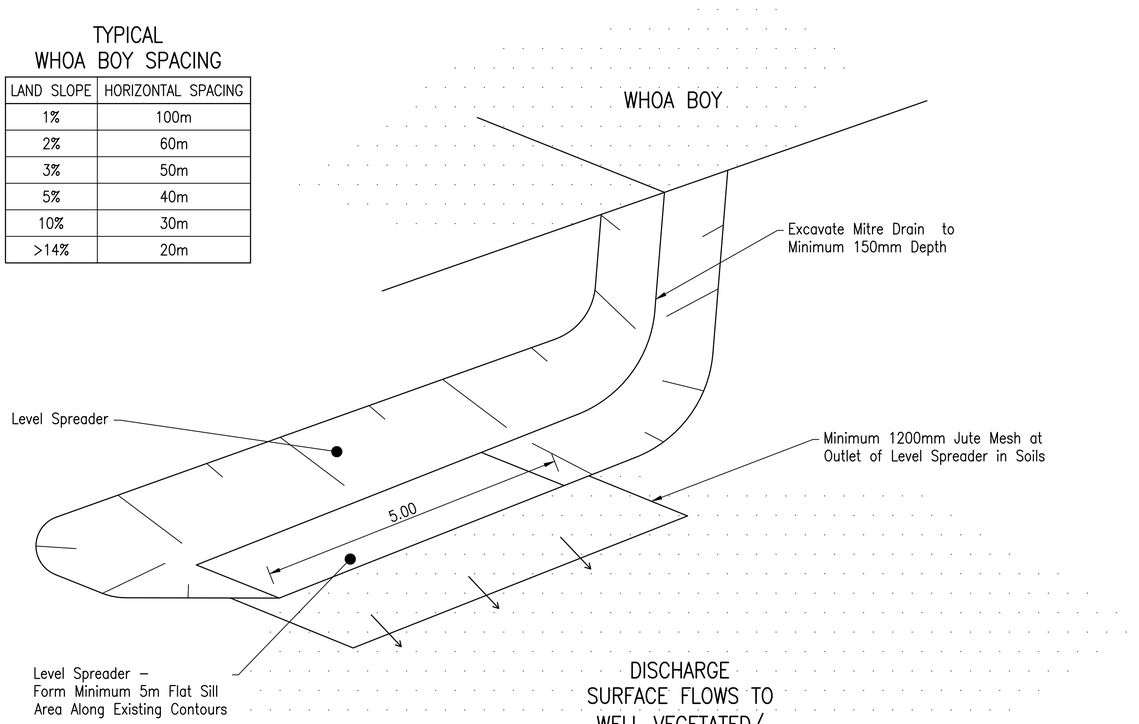
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WHOA BOY LAYOUT PLAN
Scale 1:100m

TYPICAL
WHOA BOY SPACING

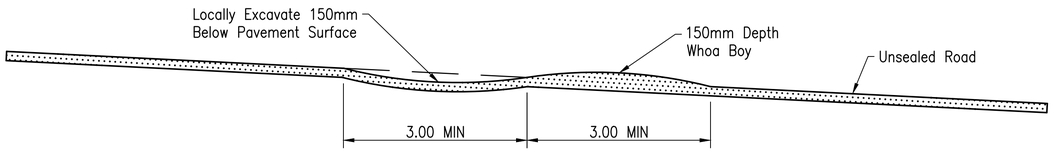
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3%	50m
5%	40m
10%	30m
>14%	20m



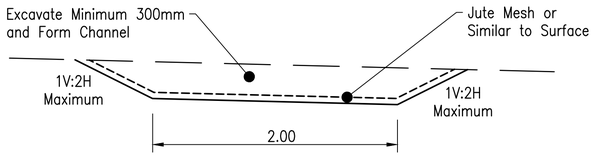
ROAD EROSION AND SEDIMENT CONTROL NOTES:

1. All Erosion and Sediment Control Measures to be in Accordance with the Best Practice Erosion and Sediment Control Guidelines, IECA, 2008.
2. Works for Access Roads shall be Undertaken in the Following Sequence:
   - 2.1. Install Stabilised Site Access
   - 2.2. Install Cut Off Channels to Divert External Catchment Flows to all Low Points, Gulllies and Watercourses
   - 2.3. Construct Rock Rip Rap Crossings at Low Points, Gullies and Watercourses
   - 2.4. Construct Woah Boys and Associated Mitre Drains and Level Spreaders at Required Spacings
3. Controls Affected by Works are to be Re–established Prior to the Completion of each days work.
4. The Contractor is to Stabilise all Disturbed Areas as soon as Final Levels are Reached.
5. Dust Control Measures shall be Implemented Continuously during Construction Works to the Satisfaction of the Superintendent and Council.
6. Topsoil Shall be Spread and Stabilised as Soon as Possible, Disturbed Areas shall be left with a Scarified Surface to Encourage Water Infiltration and Assist in Keying in Topsoil.
7. All Trees to be Retained Unless Approved for Removal by the Superintendent.
8. Topsoil Stockpiles shall not Exceed 2m in Height and Batter Slopes to be 1V:3H Maximum.
9. All Access to Site is to be Via the Stabilised Site Access. Site Shall be Fully Fenced to Prevent Access From Other Areas.
10. The Contractor Shall Maintain a Log Book Detailing:
    - 10.1.Records of All Rainfall
    - 10.2.Condition of Erosion and Sediment Control Measures
    - 10.3.Any Additional Remedial Works Required
11. The Contractor Shall at all times Restrict Construction Equipment Movement to the Essential Construction Areas. The Contractor shall not Extend Land Disturbance Beyond 2m from the Edge of any Essential Construction Activity.

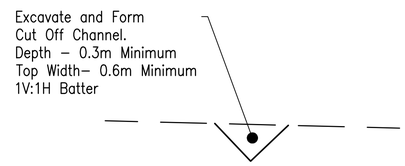
MITRE DRAIN/ LEVEL SPREADER TYPICAL PLAN
Scale 1:50m



WHOA BOYS/ CROSS BANKS
TYPICAL SECTION
Scale 1:50m



DIVERSION DRAIN
TYPICAL SECTION (SOILS)
Scale 1:25m



DIVERSION DRAIN
TYPICAL SECTION (ROCK)
Scale 1:25m

Rev	Revision Description	Certification	Date
A	DRAFT FOR CLIENT REVIEW	M.HAUSFELD	01/12/22

Scales
0 0.25 0.5 0.75 1.0 1.25m
Scale 1:25m
0 0.5 1.0 1.5 2.0 2.5m
Scale 1:50m
0 1 2 3 4 5.0m
Scale 1:100m
Dimensions shown in metres except where shown otherwise

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WULGURU TECHNICAL SERVICES

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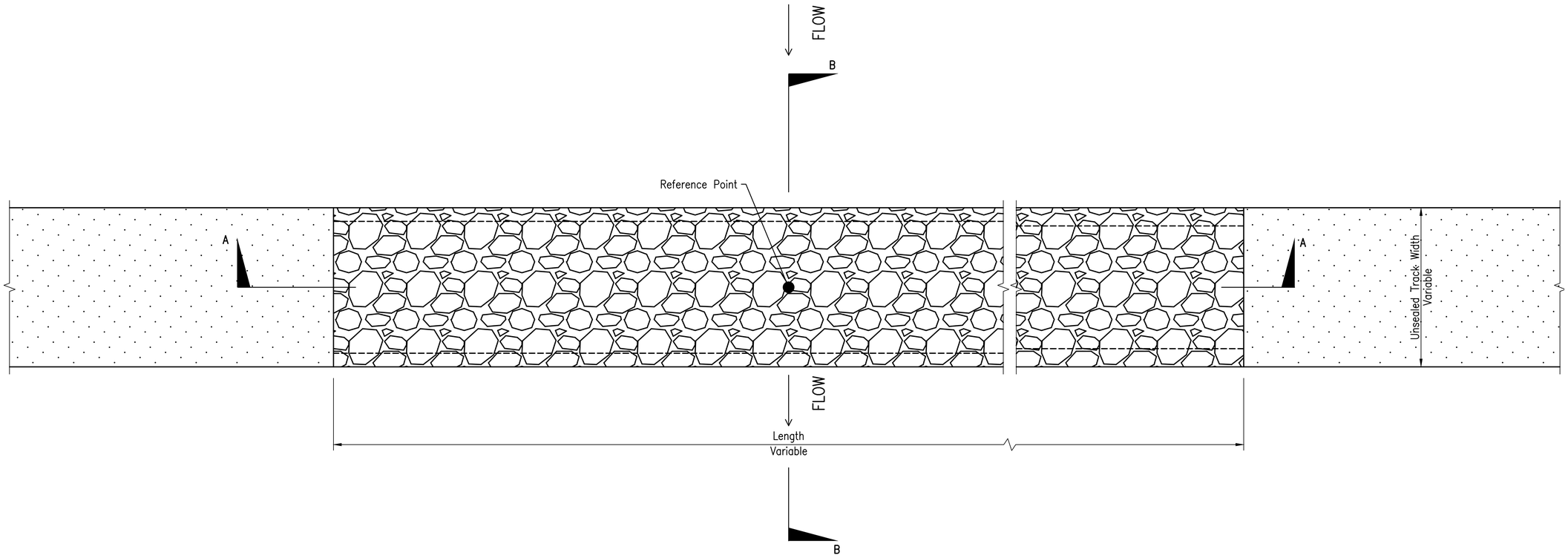
Title
DUGALD RIVER MINE
EROSION AND SEDIMENT CONTROL
TYPICAL ROAD DETAILS SHEET 1 OF 2

Drawn M.SMITH
Designed M.HAUSFELD

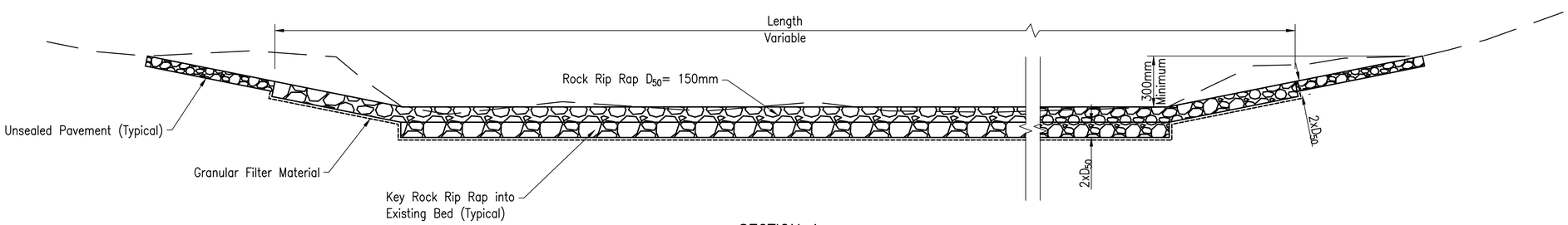
ENGINEERING CERTIFICATION (RPEQ)				
ENG. AREA	NAME	SIGNATURE	NO.	DATE

Job No.	WTS–002
Drawing No.	SKC005
Revision	A
Series Number	1 OF 2

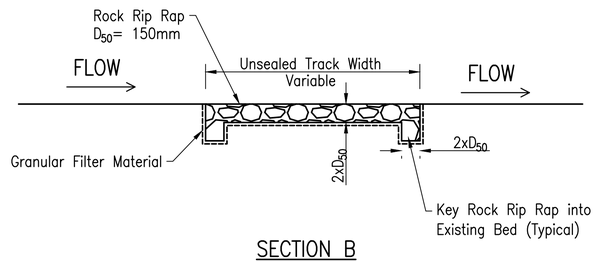
Last Modified :– Dec 01, 2022 – 2:31pm



PLAN
AT GRADE WATERCOURSE/ CREEK/ GULLY CROSSINGS
Scale 1:50m



SECTION A
Scale 1:50m



SECTION B
Scale 1:50m

Last Modified :- Dec 01, 2022 - 1:27pm

Rev	Revision Description	Certification	Date
A	DRAFT FOR CLIENT REVIEW	M.HAUSFELD	01/12/22

Scales
0 0.5 1.0 1.5 2.0 2.5m
Scale 1:50m

Dimensions shown in metres except where shown otherwise

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Title
DUGALD RIVER MINE
EROSION AND SEDIMENT CONTROL
TYPICAL ROAD DETAILS SHEET 2 OF 2

Drawn
M.SMITH

Designed
M.HAUSFELD

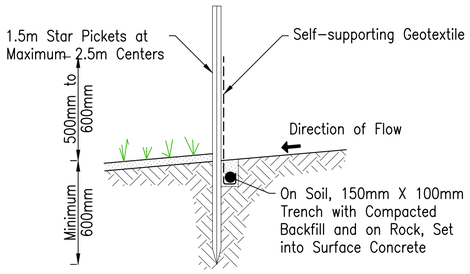
ENGINEERING CERTIFICATION (RPEQ)				
ENG. AREA	NAME	SIGNATURE	NO.	DATE

Job No.	WTS-002
Drawing No.	SKC006
Revision	A
Series Number	2 OF 2

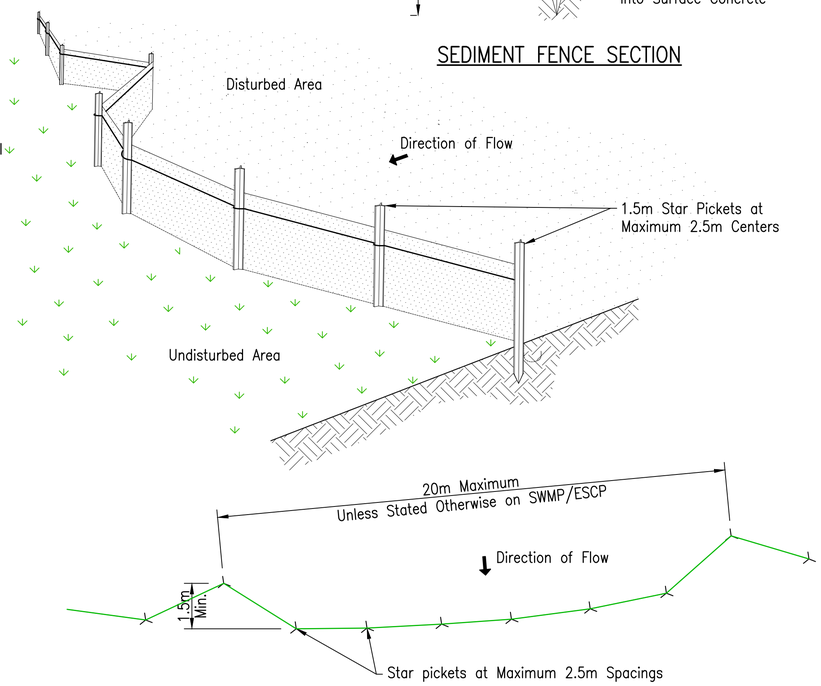
EROSION AND SEDIMENT CONTROL NOTES:

1. All Erosion and Sediment Control Measures to be in Accordance with the Best Practice Erosion and Sediment Control Guidelines, IECA, 2008.
2. Works for Infrastructure Expansion Footprints shall be Undertaken in the Following Sequence:
   - 2.1. Install Stabilised Site Access
   - 2.2. Construct Clean Water Diversion Channels and Level Spreaders where External Catchments Discharge to the Site
   - 2.3. Construct Dirty Water Channels/ Bunds
   - 2.4. Construct Sediment Basins and Sediment Weirs
   - 2.5. Install all Sediment Fencing
   - 2.6. Locate Stockpile Locations and Install Sediment Fences on Downstream sides
   - 2.7. Topsoil and Rehabilitate Bulk Earthwork Areas Immediately upon Completion
   - 2.8. Rehabilitate the Site
   - 2.9. Decommission Sediment Basins and Sediment Weirs and Remove Erosion and Sediment Control Measures once Surfaces are Stabilised to the Satisfaction of the Superintendent

   This Sequence is to be Reviewed in Context of Staging of Works, However, Must Achieve all Environmental Requirements.
3. Controls Affected by Works are to be Re-established Prior to the Completion of each days work.
4. The Contractor is to Stabilise all Disturbed Areas as soon as Final Levels are Reached.
5. Dust Control Measures shall be Implemented Continuously during Construction Works to the Satisfaction of the Superintendent and Council.
6. Topsoil Shall be Spread and Stabilised as Soon as Possible, Disturbed Areas shall be left with a Scarified Surface to Encourage Water Infiltration and Assist in Keying in Topsoil.
7. All Trees to be Retained Unless Approved for Removal by the Superintendent.
8. Topsoil Stockpiles shall not Exceed 2m in Height and Batter Slopes to be 1V:3H Maximum.
9. All Access to Site is to be Via the Stabilised Site Access. Site Shall be Fully Fenced to Prevent Access From Other Areas.
10. The Contractor Shall Maintain a Log Book Detailing:
    - 10.1. Records of All Rainfall
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    - 10.3. Any Additional Remedial Works Required
11. The Contractor Shall at all times Restrict Construction Equipment Movement to the Essential Construction Areas. The Contractor shall not Extend Land Disturbance Beyond 2m from the Edge of any Essential Construction Activity.



SEDIMENT FENCE SECTION

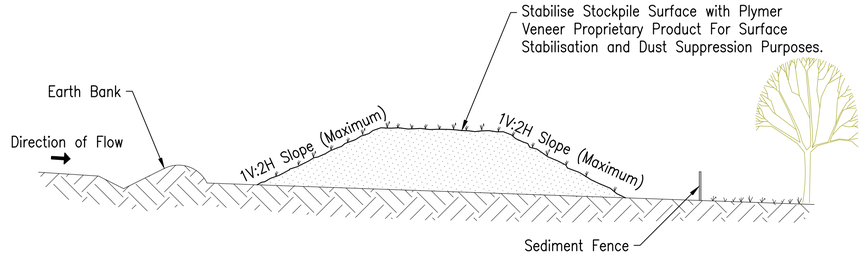


SEDIMENT FENCE PLAN

SEDIMENT FENCE CONSTRUCTION NOTES

1. Construct sediment fences as close as possible to being parallel to the contours of the site, but with small returns as shown in the drawing to limit the catchment area of any one section. The catchment area should be small enough to limit water flow if concentrated at one point to 50 litres per second in the design storm event, usually the 10-year event.
2. Cut a 150-mm deep trench along the upslope line of the fence for the bottom of the fabric to be entrenched.
3. Drive 1.5 metre long star pickets into ground at 2.5 metre intervals (max) at the downslope edge of the trench. Ensure any star pickets are fitted with safety caps.
4. Fix self-supporting geotextile to the upslope side of the posts ensuring it goes to the base of the trench. Fix the geotextile with wire ties or as recommended by the manufacturer. Only use geotextile specifically produced for sediment fencing. The use of shade cloth for this purpose is not satisfactory.
5. Join sections of fabric at a support post with a 150-mm overlap.
6. Backfill the trench over the base of the fabric and compact it thoroughly over the geotextile.

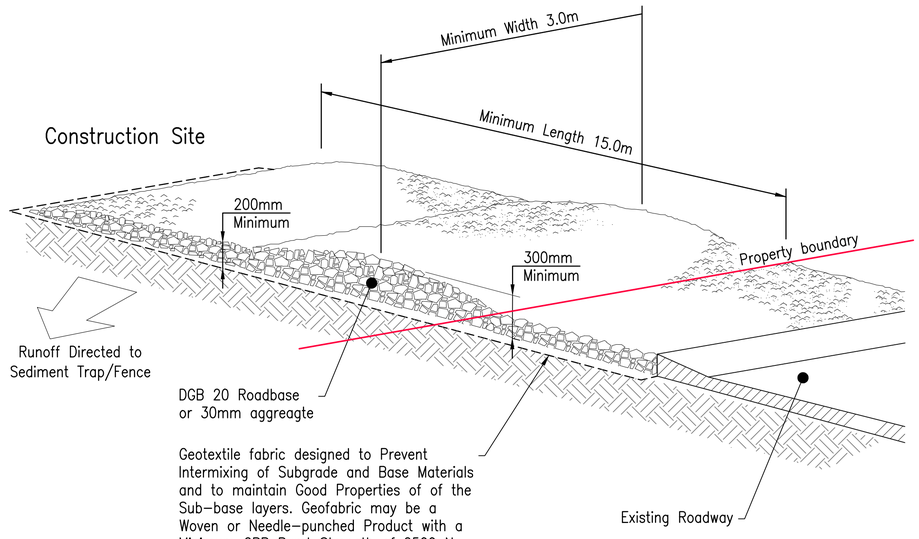
SEDIMENT FENCE DETAIL
N.T.S



STOCKPILES CONSTRUCTION NOTES

1. Place stockpiles more than 2 (preferably 5) metres from existing vegetation, concentrated water flow, roads and hazard areas.
2. Construct on the contour as low, flat, elongated mounds.
3. Where there is sufficient area, topsoil stockpiles shall be less than 2 metres in height.
4. Where they are to be in place for more than 10 days, stabilise following the approved ESCP or SWMP to reduce the C-factor to less than 0.10.
5. Construct earth banks (Standard Drawing 5-5) on the upslope side to divert water around stockpiles and sediment fences (Standard Drawing 6-8) 1 to 2 metres downslope.

STOCKPILES DETAIL
N.T.S



STABILISED SITE ACCESS CONSTRUCTION NOTES:

1. Strip the topsoil, Level the Site and Compact the Subgrade.
2. Cover the Area with Woven or Needle-punched Geotextile.
3. Construct at 200mm Thick Pad over the Geotextile using available Road base or 30mm Aggregate.
4. Ensure the Structure is a Minimum of 15.0m Long or to Building Alignment and at least 3.0m Wide.
5. Where a Sediment Fence Joins onto the Stabilised Access, Construct a hump in the Stabilised Access to Divert Water to the Sediment Fence.

STABILISED SITE ACCESS DETAIL
N.T.S

Rev	Revision Description	Certification	Date
A	DRAFT FOR CLIENT REVIEW	M.HAUSFELD	01/12/22

Scales

Dimensions shown in metres except where shown otherwise

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Client: WULGURU TECHNICAL SERVICES

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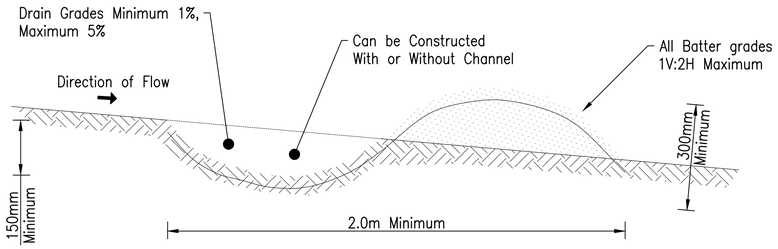
Title: DUGALD RIVER MINE
EROSION AND SEDIMENT CONTROL
EROSION AND SEDIMENT CONTROL DETAILS SHEET 1 OF 2

Drawn: M.SMITH
Designed: M.HAUSFELD

ENGINEERING CERTIFICATION (RPEQ)				
ENG. AREA	NAME	SIGNATURE	NO.	DATE

Job No.	WTS-002
Drawing No.	SKC007
Revision	A
Series Number	1 OF 2

Last Modified :- Dec 01, 2022 - 1:27pm

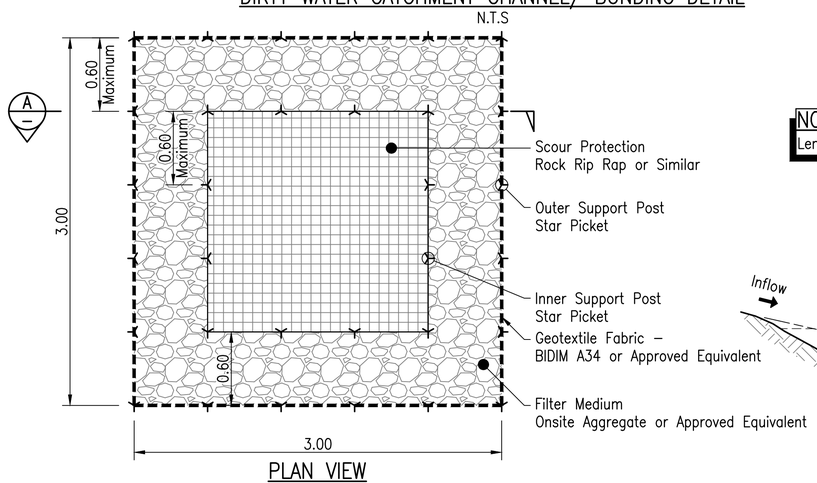


DIRTY WATER CATCHMENT CHANNEL/ BUNDING CONSTRUCTION NOTES:

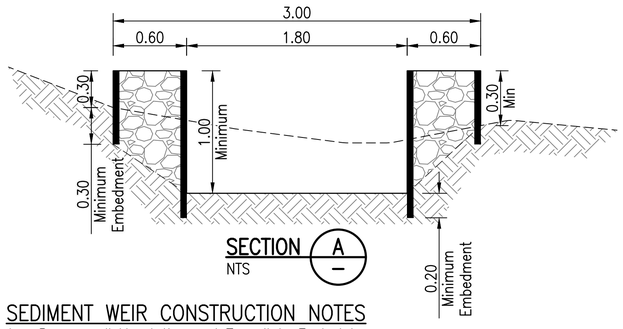
1. Build with Gradients Between 1% and 5%.
2. Avoid removing trees and Shrubs if Possible – Work around them.
3. Ensure the Structures are Free of Projections or other Irregularities that Could Impede Water Flow.
4. Build the Drains with Circular, Parabolic or Trapezoidal Cross Sections, not V Shaped.
5. Ensure Banks are Properly Compacted to Prevent Failure.
6. Complete Permanent or Temporary Stabilisation Within 10 Days of Construction.

DIRTY WATER CATCHMENT CHANNEL/ BUNDING DETAIL

N.T.S



PLAN VIEW

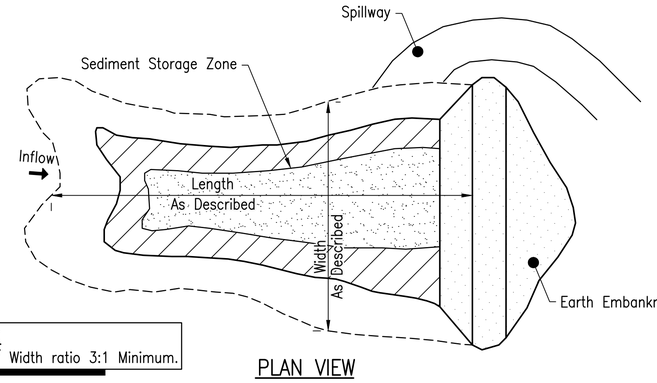


SEDIMENT WEIR CONSTRUCTION NOTES

1. Remove all Vegetation and Topsoil in Footprint.
2. Excavate to Depths and Widths Required.
3. Form Sediment Weir Utilising Star Pickets, Aggregate and Geotextile.
4. Rehabilitate Following Decommissioning.

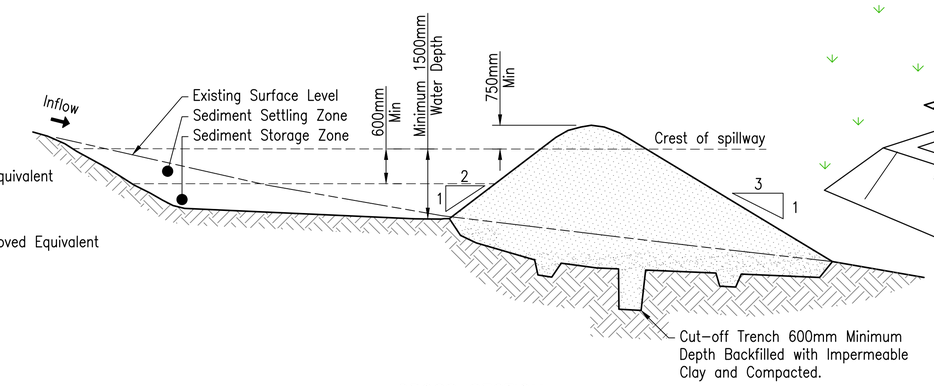
SEDIMENT WEIR DETAIL

N.T.S



NOTE:
Length/ Width ratio 3:1 Minimum.

PLAN VIEW



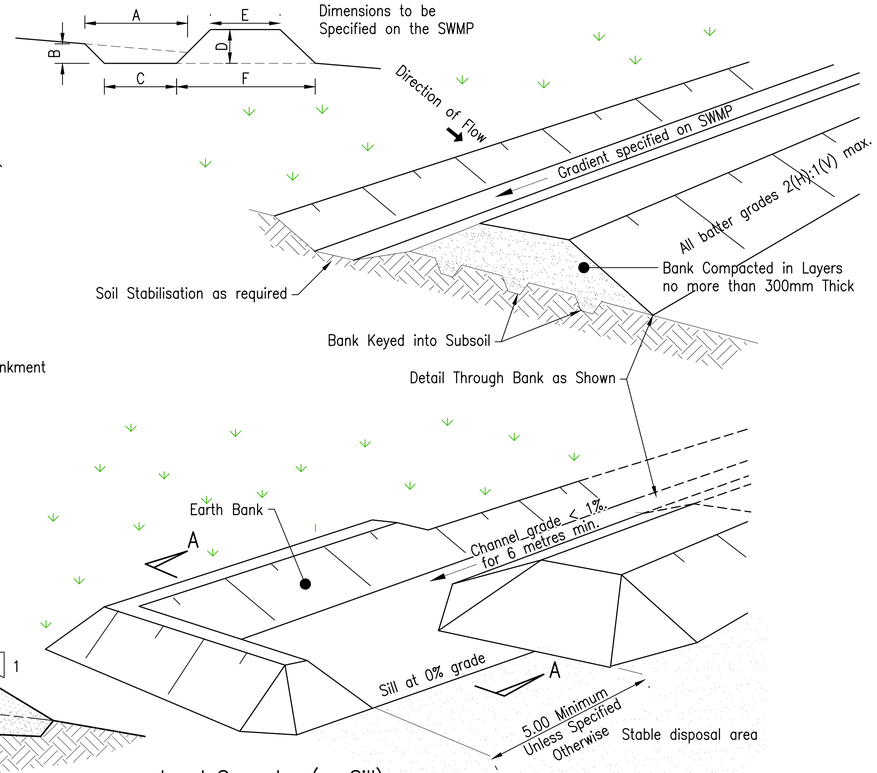
CROSS SECTION

EARTH SEDIMENT BASIN CONSTRUCTION NOTES

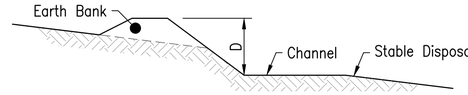
1. Remove all Vegetation and Topsoil from Under the Dam Wall and From Within the Storage Area.
2. Construct a Cut–off Trench 500mm Deep and 1,200mm Wide Along the Centreline of the Embankment Extending to a Point on the Gully Wall Level with the Riser Crest.
3. Maintain the Trench Free of Water and Recompact the Materials with Equipment as Specified in the SWMP to 95% Standard Proctor Density.
4. Select Fill Following the SWMP that is Free of Roots, Wood, Rock, Large Stone or Foreign Material.
5. Prepare the Site Under the Embankment by Ripping to at least 100mm to help bond Compacted Fill to the Existing Substrate.
6. Spread the Fill in 100mm to 150mm Layers and Compact it at Optimum Moisture Content Following the SWMP.
7. Construct the Emergency Spillway.
8. Rehabilitate the Structure Following the SWMP.

EARTH SEDIMENT BASIN DETAIL

N.T.S



Level Spreader (or Sill)



SECTION AA

CONSTRUCTION NOTES

1. Construct at the gradient specified on the ESCP or SWMP, normally between 1 and 5 percent
2. Avoid removing trees and shrubs if possible – work around them.
3. Ensure the structures are free of projections or other irregularities that could impede water flow.
4. Build the drains with circular, parabolic or trapezoidal cross sections, not V–shaped, at the dimensions shown on the SWMP.
5. Ensure the banks are properly compacted to prevent failure.
6. Complete permanent or temporary stabilisation within 10 days of construction following Table 5.2 in Landcom (2004).
7. Where discharging to erodible lands, ensure they outlet through a properly constructed level spreader.
8. Construct the level spreader at the gradient specified on the ESCP or SWMP, normally less than 1 percent or level.
9. Where possible, ensure they discharge waters onto either stabilised or undisturbed disposal sites within the same subcatchment area from which the water originated. Approval might be required to discharge into other subcatchments.

CHANNEL/ BUNDING DETAIL (LARGE)

N.T.S

Last Modified :- Dec 01, 2022 – 2:30pm

Rev	Revision Description	Certification	Date
A	DRAFT FOR CLIENT REVIEW	M.HAUSFELD	01/12/22

Scales

Dimensions shown in metres except where shown otherwise

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Client

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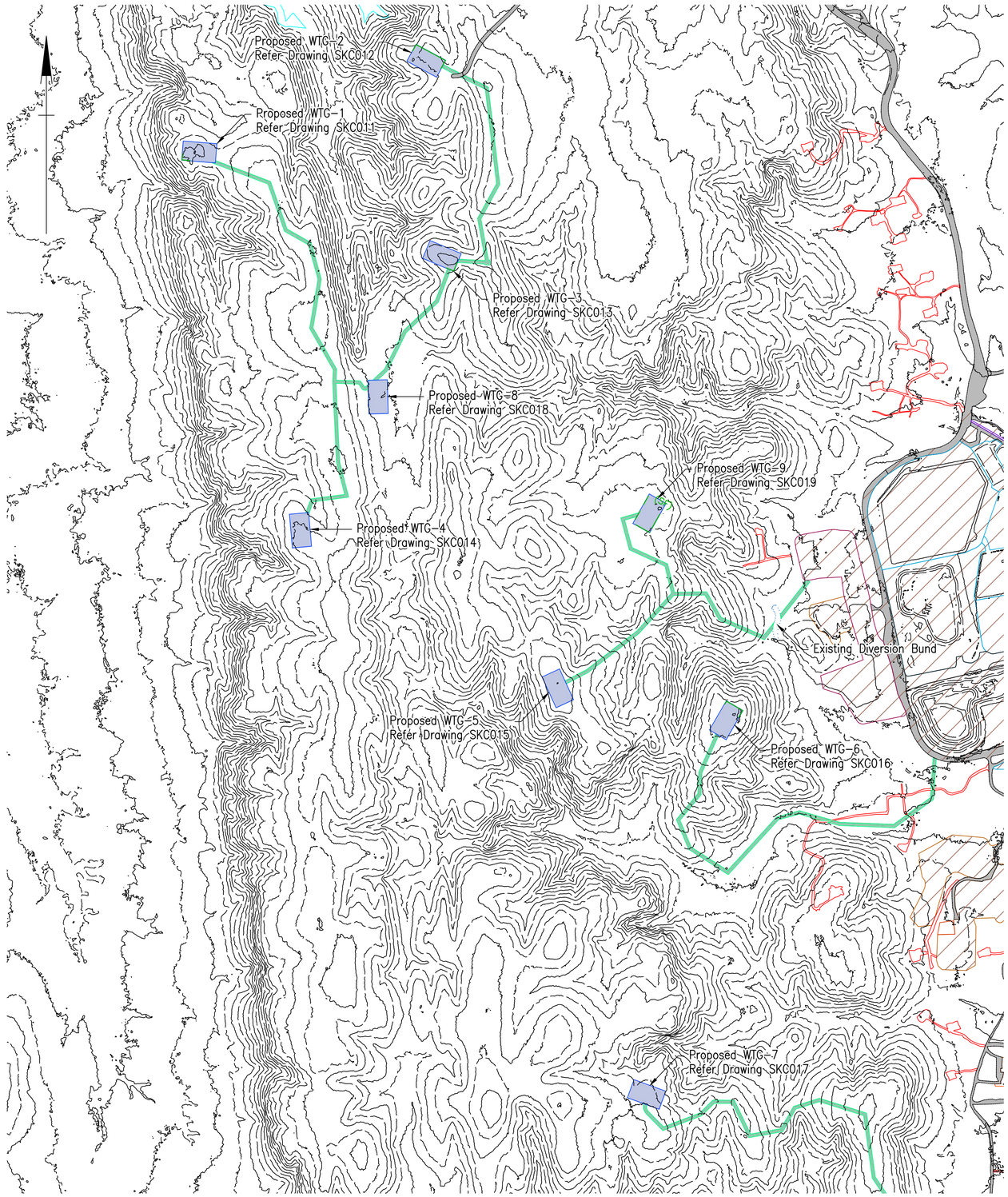
Title: DUGALD RIVER MINE
EROSION AND SEDIMENT CONTROL
EROSION AND SEDIMENT CONTROL DETAILS SHEET 2 OF 2

Drawn: M.SMITH
Designed: M.HAUSFELD

ENGINEERING CERTIFICATION (RPEQ)

ENG. AREA	NAME	SIGNATURE	NO.	DATE

Job No.	WTS–002
Drawing No.	SKC008
Revision	A
Series Number	2 OF 2



FEATURES LEGEND:

- 210m — Major Existing Surface Contour
- Minor Existing Surface Contour
- Existing Roadways
- Existing Mine Infrastructure
- Existing Drill Pads
- Existing Powerline Corridor
- Proposed Investigation Tracks
- Proposed Wind Turbine Hard Stand

EROSION CONTROL LEGEND:

- (SF) — Proposed Sediment Fence
- Proposed Clean Water Diversion Channels (Direction Shown)
- Proposed Dirty Water Catchment Channel/Bunding (Direction Shown)
- Proposed Dirty Water Catchment Area
- Proposed Whoa boys and Turnouts
- Proposed Rock Scour Protection
- Proposed Sediment Basin Extents
- S — Proposed Sediment Weir
- LS — Proposed Level Spreader
- Existing Overland Flow (Clean)
- Existing Overland Flow (Dirty)

EROSION AND SEDIMENT CONTROL NOTES:

1. All Erosion and Sediment Control Measures to be in Accordance with the Best Practice Erosion and Sediment Control Guidelines, IECA, 2008.
2. Works for Infrastructure Expansion Footprints shall be Undertaken in the Following Sequence:
   - 2.1. Install Stabilised Site Access
   - 2.2. Construct Clean Water Diversion Channels and Level Spreaders where External Catchments Discharge to the Site
   - 2.3. Construct Dirty Water Channels/ Bunds
   - 2.4. Construct Sediment Basins and Sediment Weirs
   - 2.5. Install all Sediment Fencing
   - 2.6. Locate Stockpile Locations and Install Sediment Fences on Downstream sides
   - 2.7. Topsoil and Rehabilitate Bulk Earthwork Areas Immediately upon Completion
   - 2.8. Rehabilitate the Site
   - 2.9. Decommission Sediment Basins and Sediment Weirs and Remove Erosion and Sediment Control Measures once Surfaces are Stabilised to the Satisfaction of the Superintendent

   This Sequence is to be Reviewed in Context of Staging of Works, However, Must Achieve all Environmental Requirements.
3. Works for Access Roads shall be Undertaken in the Following Sequence:
   - 3.1. Install Stabilised Site Access
   - 3.2. Install Cut Off Channels to Divert External Catchment Flows to all Low Points, Gulllies and Watercourses
   - 3.3. Construct Rock Rip Rap Crossings at Low Points, Gullies and Watercourses
   - 3.4. Construct Woah Boys and Associated Mitre Drains and Level Spreaders at Required Spacings
4. Controls Affected by Works are to be Re-established Prior to the Completion of each days work.
5. The Contractor is to Stabilise all Disturbed Areas as soon as Final Levels are Reached.
6. Dust Control Measures shall be Implemented Continuously during Construction Works to the Satisfaction of the Superintendent and Council.
7. Topsoil Shall be Spread and Stabilised as Soon as Possible, Disturbed Areas shall be left with a Scarified Surface to Encourage Water Infiltration and Assist in Keying in Topsoil.
8. All Trees to be Retained Unless Approved for Removal by the Superintendent.
9. Topsoil Stockpiles shall not Exceed 2m in Height and Batter Slopes to be 1V:3H Maximum.
10. All Access to Site is to be Via the Stabilised Site Access. Site Shall be Fully Fenced to Prevent Access From Other Areas.
11. The Contractor Shall Maintain a Log Book Detailing:
    - 11.1.Records of All Rainfall
    - 11.2.Condition of Erosion and Sediment Control Measures
    - 11.3.Any Additional Remedial Works Required
12. The Contractor Shall at all times Restrict Construction Equipment Movement to the Essential Construction Areas. The Contractor shall not Extend Land Disturbance Beyond 2m from the Edge of any Essential Construction Activity.

Rev	Revision Description	Certification	Date
A	DRAFT FOR CLIENT REVIEW	M.HAUSFELD	01/12/22

Scales: N.T.S

Dimensions shown in metres except where shown otherwise

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Title: DUGALD RIVER MINE
EROSION AND SEDIMENT CONTROL
WIND TURBINE LOCATION KEY PLAN

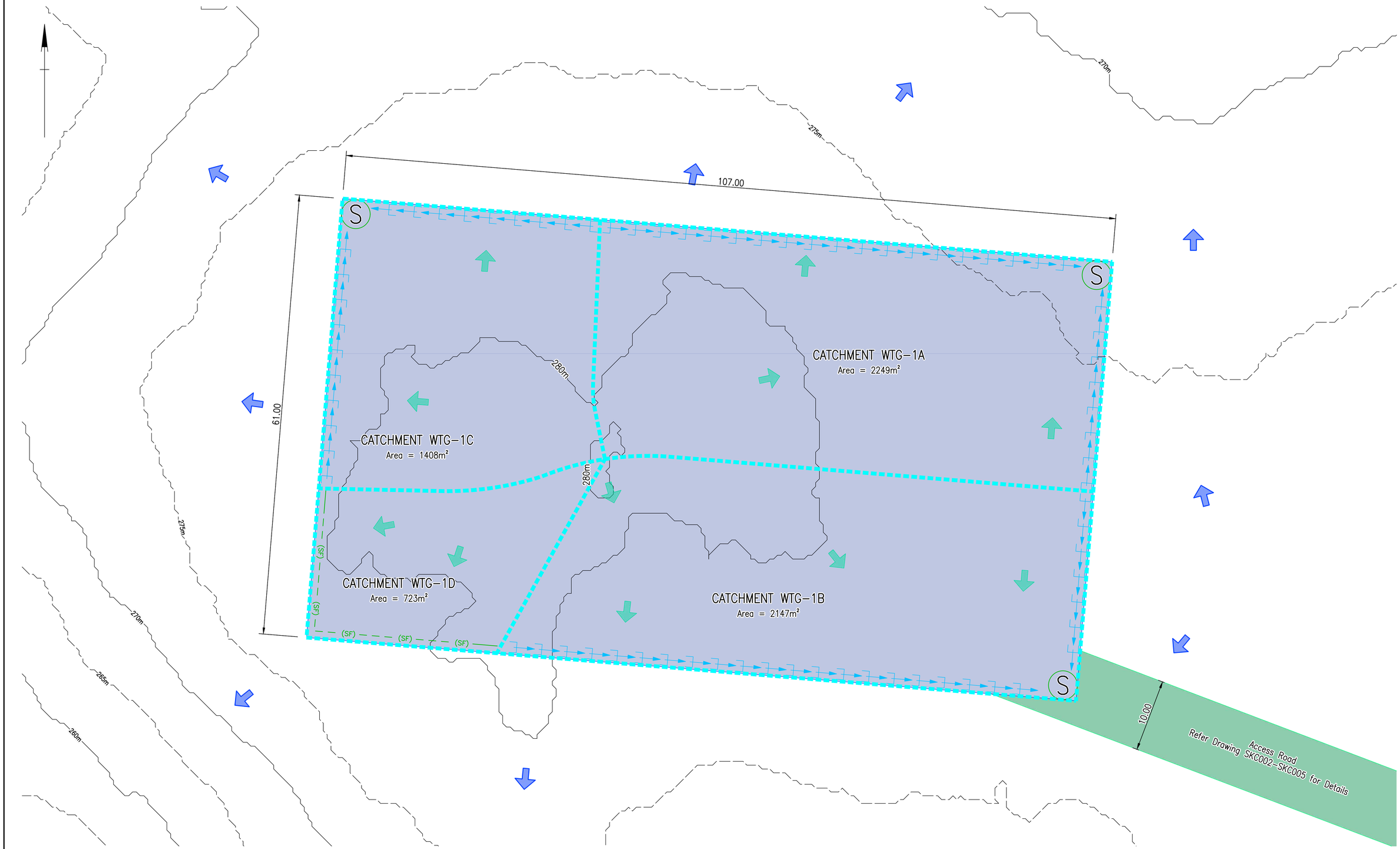
Drawn: M.SMITH

Designed: M.HAUSFELD

ENGINEERING CERTIFICATION (RPEQ)				
ENG. AREA	NAME	SIGNATURE	NO.	DATE

Job No.	WTS-002
Drawing No.	SKC010
Revision	A
Series Number	1 OF 10

Last Modified :- Dec 01, 2022 - 1:45pm



WTG-1 PLAN
Scale 1:250m

Last Modified :- Dec 01, 2022 - 1:28pm

Rev	Revision Description	Certification	Date
A	DRAFT FOR CLIENT REVIEW	M.HAUSFELD	01/12/22

Scales
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Scale 1:250m
Dimensions shown in metres except where shown otherwise

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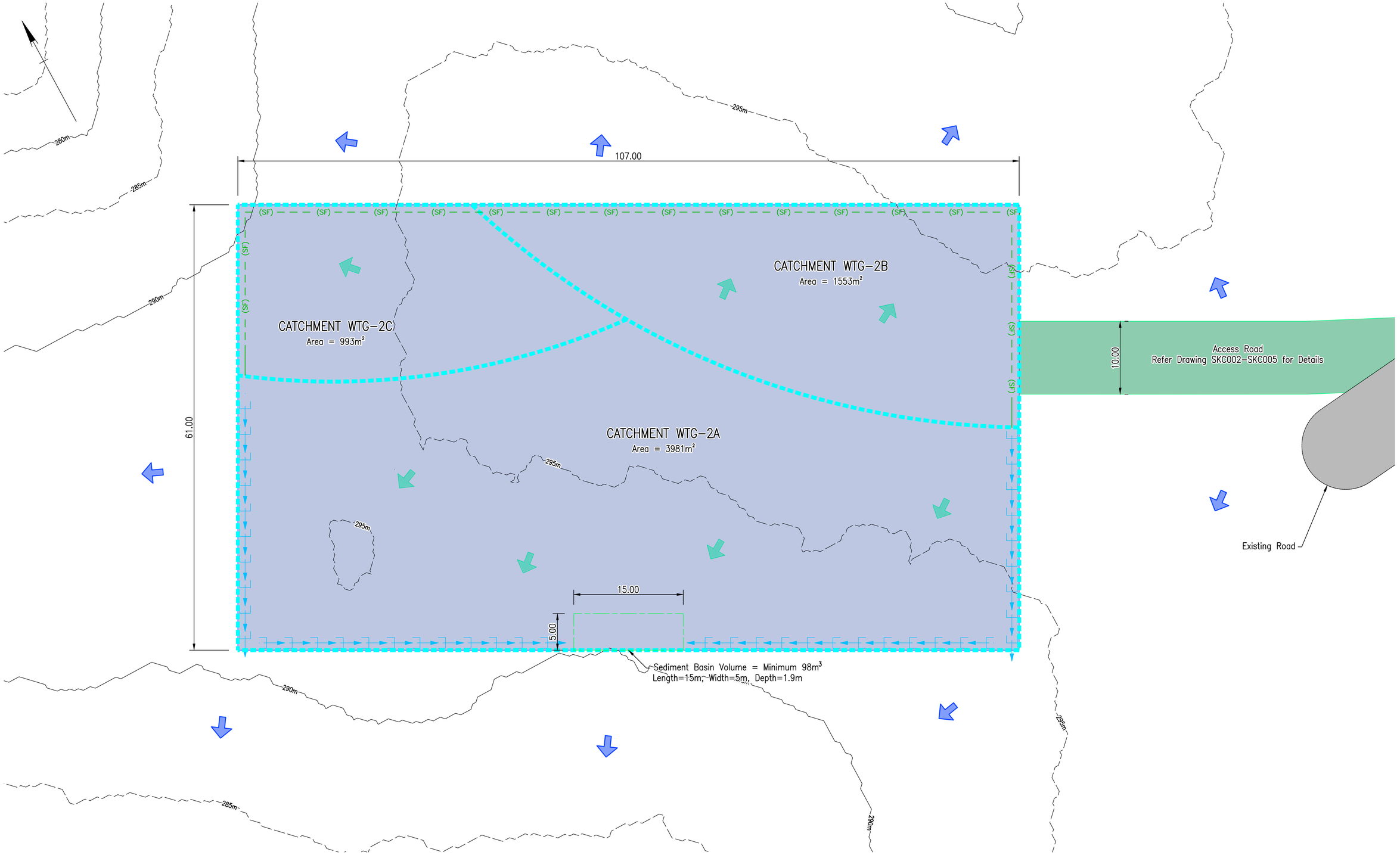
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Title
DUGALD RIVER MINE
EROSION AND SEDIMENT CONTROL
WTG-1 FOOTPRINT

Drawn M.SMITH
Designed M.HAUSFELD

ENGINEERING CERTIFICATION (RPEQ)				
ENG. AREA	NAME	SIGNATURE	NO.	DATE

Job No.	WTS-002
Drawing No.	SKC011
Revision	A
Series Number	2 OF 10



WTG-2 PLAN
Scale 1:250m

Last Modified :- Dec 01, 2022 - 1:29pm

Rev	Revision Description	Certification	Date
A	DRAFT FOR CLIENT REVIEW	M.HAUSFELD	01/12/22

Scales
0 2.5 5.0 7.5 10.0 12.5m
Scale 1:250m

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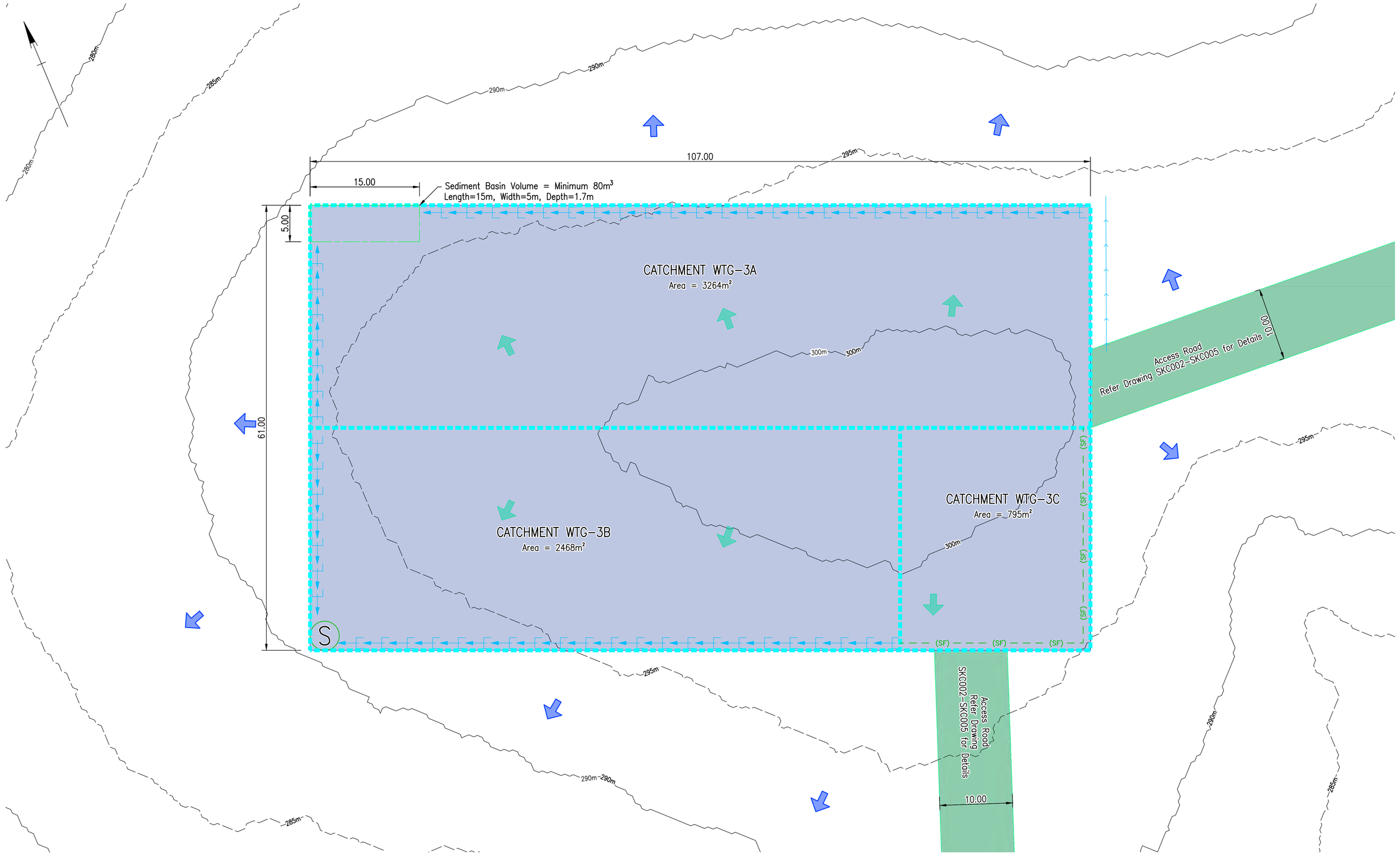
Title
DUGALD RIVER MINE
EROSION AND SEDIMENT CONTROL
WTG-2 FOOTPRINT

Drawn
M.SMITH

Designed
M.HAUSFELD

ENGINEERING CERTIFICATION (RPEQ)				
ENG. AREA	NAME	SIGNATURE	NO.	DATE

Job No.	WTS-002
Drawing No.	SKC012
Revision	A
Series Number	3 OF 10



WTG-3 PLAN
Scale 1:250m

Last Modified :- Dec 01, 2022 - 1:29pm

Rev	Revision Description	Certification	Date
A	DRAFT FOR CLIENT REVIEW	M.HAUSFELD	01/12/22

Scales
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Scale 1:250m
Dimensions shown in metres except where shown otherwise

civil IQ

Client
WULGURU TECHNICAL SERVICES

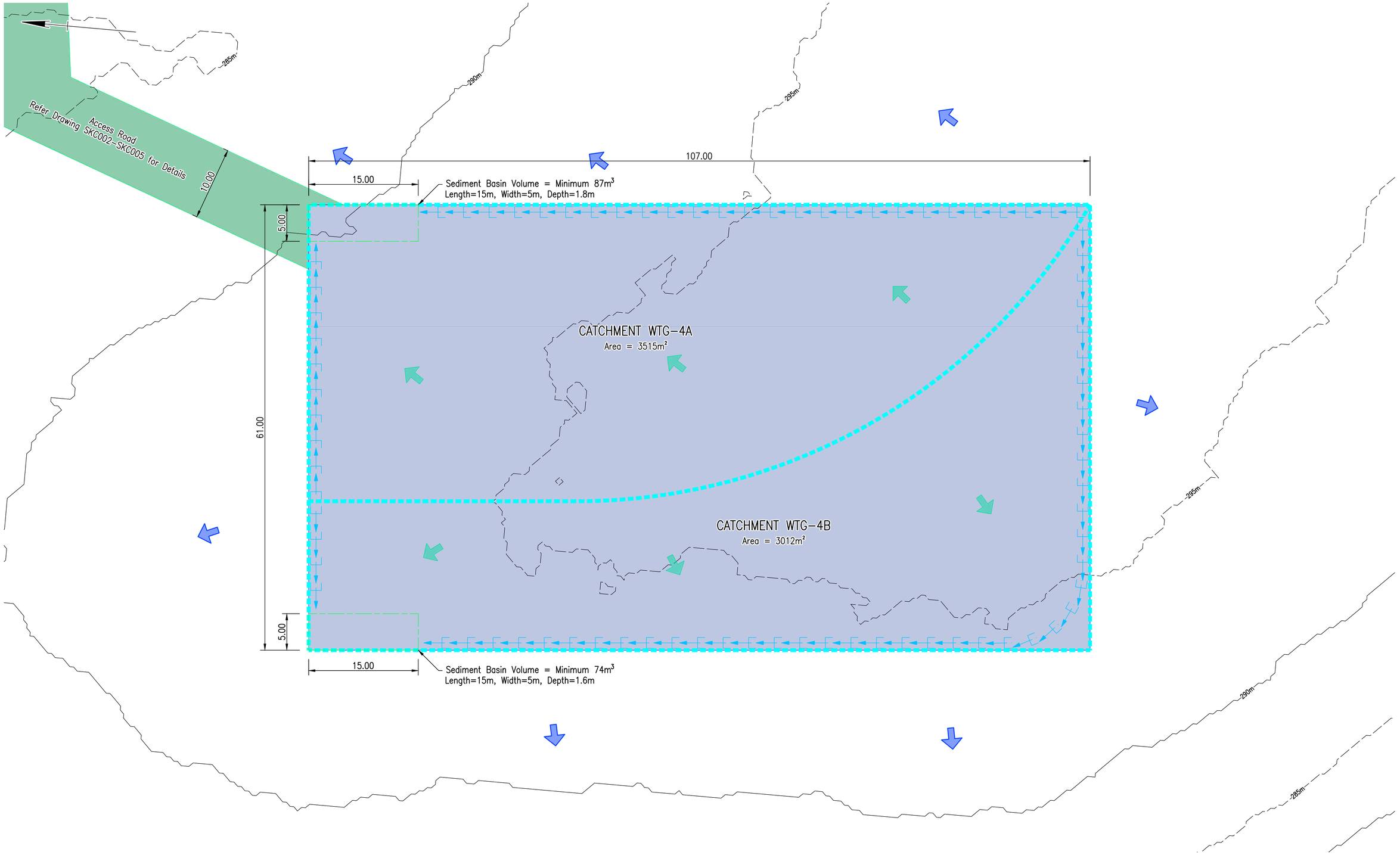
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Title
DUGALD RIVER MINE
EROSION AND SEDIMENT CONTROL
WTG-3 FOOTPRINT

Drawn M.SMITH
Designed M.HAUSFELD

ENGINEERING CERTIFICATION (RPEQ)				
ENG. AREA	NAME	SIGNATURE	NO.	DATE

Job No.	WTS-002
Drawing No.	SKC013
Revision	A
Series Number	4 OF 10



WTG-4 PLAN
Scale 1:250m

Last Modified :- Dec 01, 2022 - 1:30pm

Rev	Revision Description	Certification	Date
A	DRAFT FOR CLIENT REVIEW	M.HAUSFELD	01/12/22

Scales
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Scale 1:250m

Dimensions shown in metres except where shown otherwise

civil IQ

Client
WULGURU TECHNICAL SERVICES

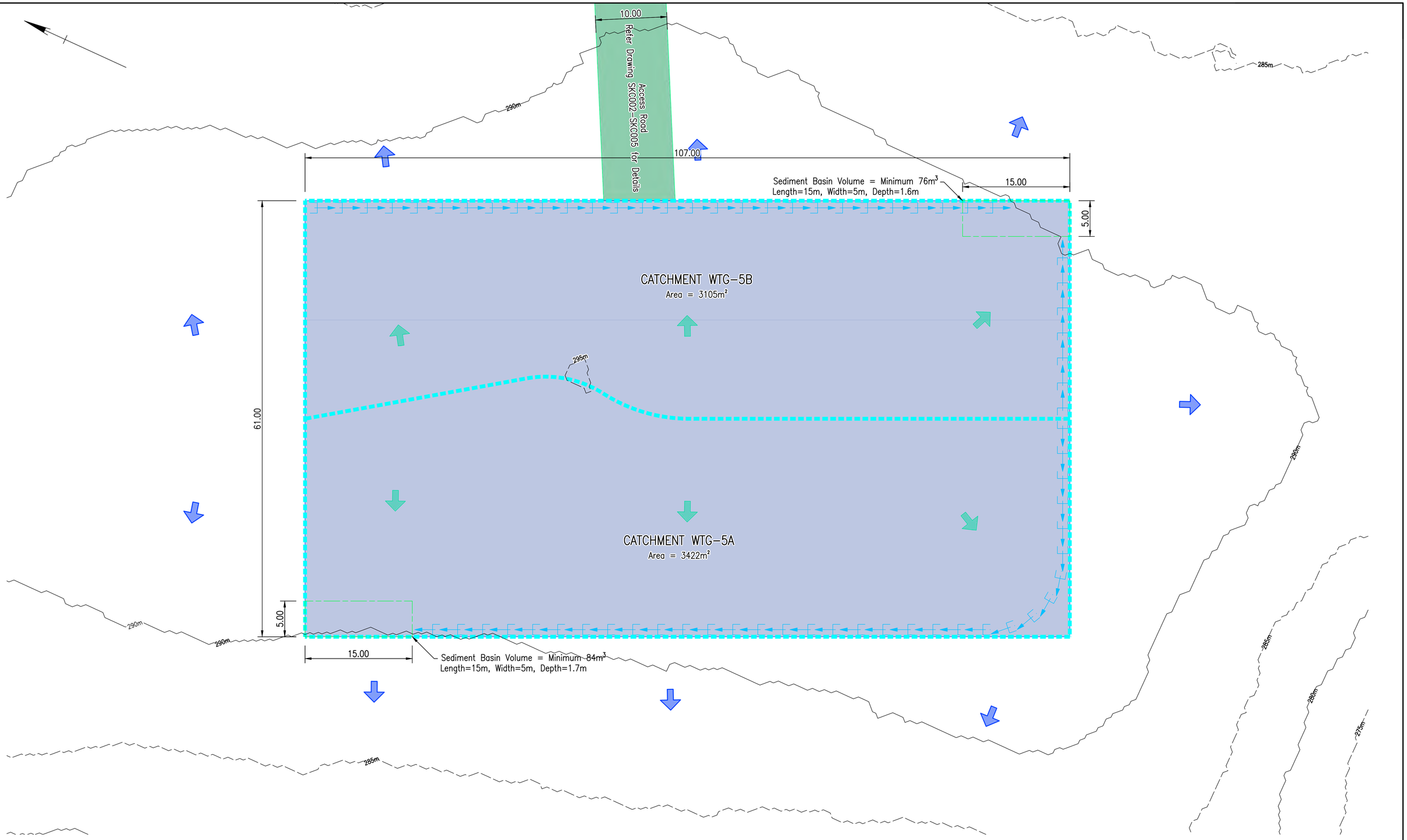
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Title
DUGALD RIVER MINE
EROSION AND SEDIMENT CONTROL
WTG-4 FOOTPRINT

Drawn M.SMITH
Designed M.HAUSFELD

ENGINEERING CERTIFICATION (RPEQ)				
ENG. AREA	NAME	SIGNATURE	NO.	DATE

Job No.	WTS-002
Drawing No.	SKC014
Revision	A
Series Number	5 OF 10



WTG–5 PLAN
Scale 1:250m

Last Modified :– Dec 01, 2022 – 1:30pm

Rev	Revision Description	Certification	Date
A	DRAFT FOR CLIENT REVIEW	M.HAUSFELD	01/12/22

Scales
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Scale 1:250m
Dimensions shown in metres except where shown otherwise

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Client
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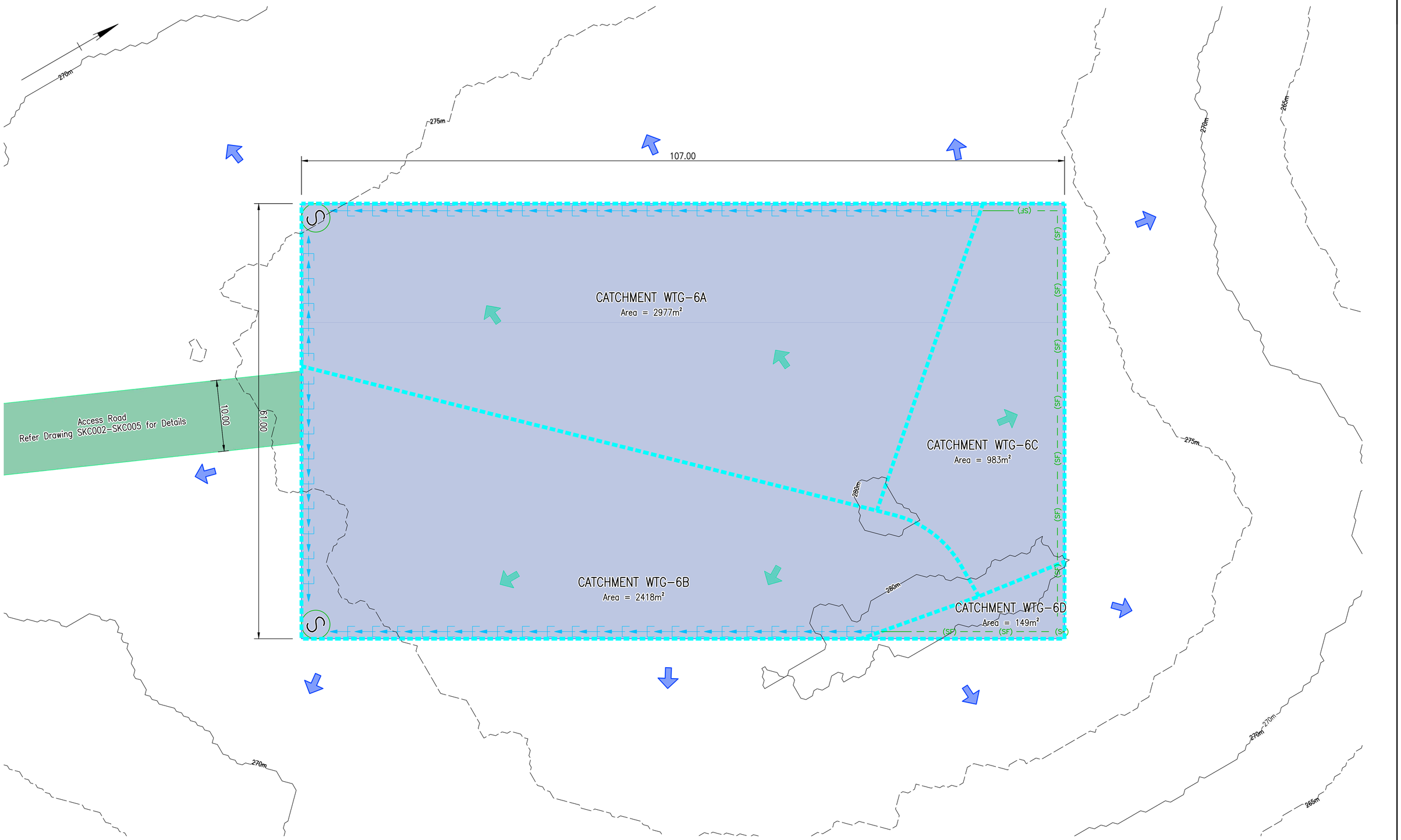
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Title
DUGALD RIVER MINE
EROSION AND SEDIMENT CONTROL
WTG–5 FOOTPRINT

Drawn M.SMITH
Designed M.HAUSFELD

ENGINEERING CERTIFICATION (RPEQ)				
ENG. AREA	NAME	SIGNATURE	NO.	DATE

Job No.	WTS–002
Drawing No.	SKC015
Revision	A
Series Number	6 OF 10



WTG-6 PLAN
Scale 1:250m

Last Modified :- Dec 01, 2022 - 1:31pm

Rev	Revision Description	Certification	Date
A	DRAFT FOR CLIENT REVIEW	M.HAUSFELD	01/12/22

Scales

0 2.5 5.0 7.5 10.0 12.5m
Scale 1:250m

Dimensions shown in metres except where shown otherwise

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Client

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Title

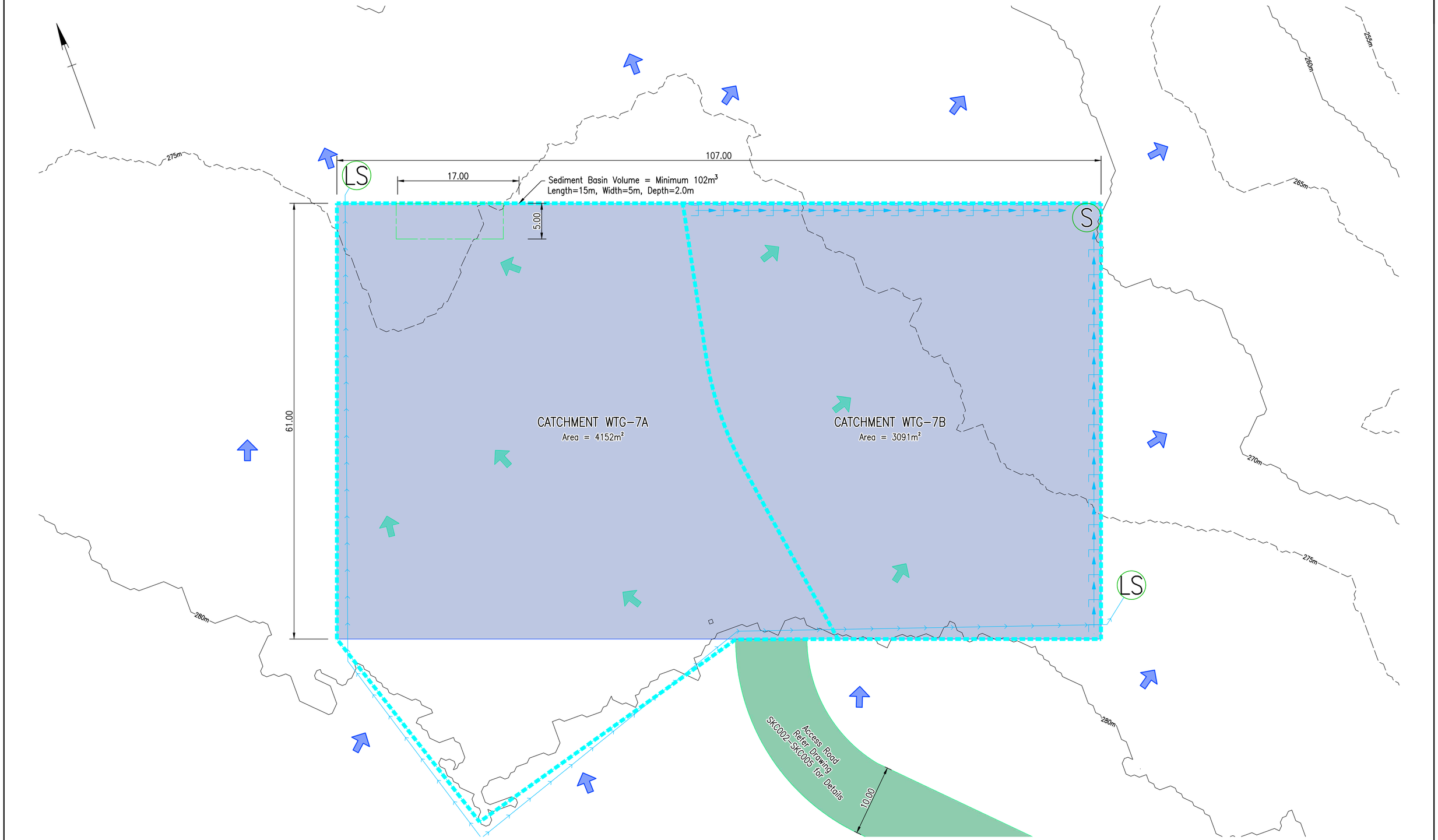
DUGALD RIVER MINE
EROSION AND SEDIMENT CONTROL
WTG-6 FOOTPRINT

Drawn M.SMITH

Designed M.HAUSFELD

ENGINEERING CERTIFICATION (RPEQ)				
ENG. AREA	NAME	SIGNATURE	NO.	DATE

Job No.	WTS-002
Drawing No.	SKC016
Revision	A
Series Number	7 OF 10



WTG-7 PLAN
Scale 1:250m

Last Modified :- Dec 01, 2022 - 2:32pm

Rev	Revision Description	Certification	Date
A	DRAFT FOR CLIENT REVIEW	M.HAUSFELD	01/12/22

Scales
0 2.5 5.0 7.5 10.0 12.5m
Scale 1:250m

Dimensions shown in metres except where shown otherwise

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Title
DUGALD RIVER MINE
EROSION AND SEDIMENT CONTROL
WTG-7 FOOTPRINT

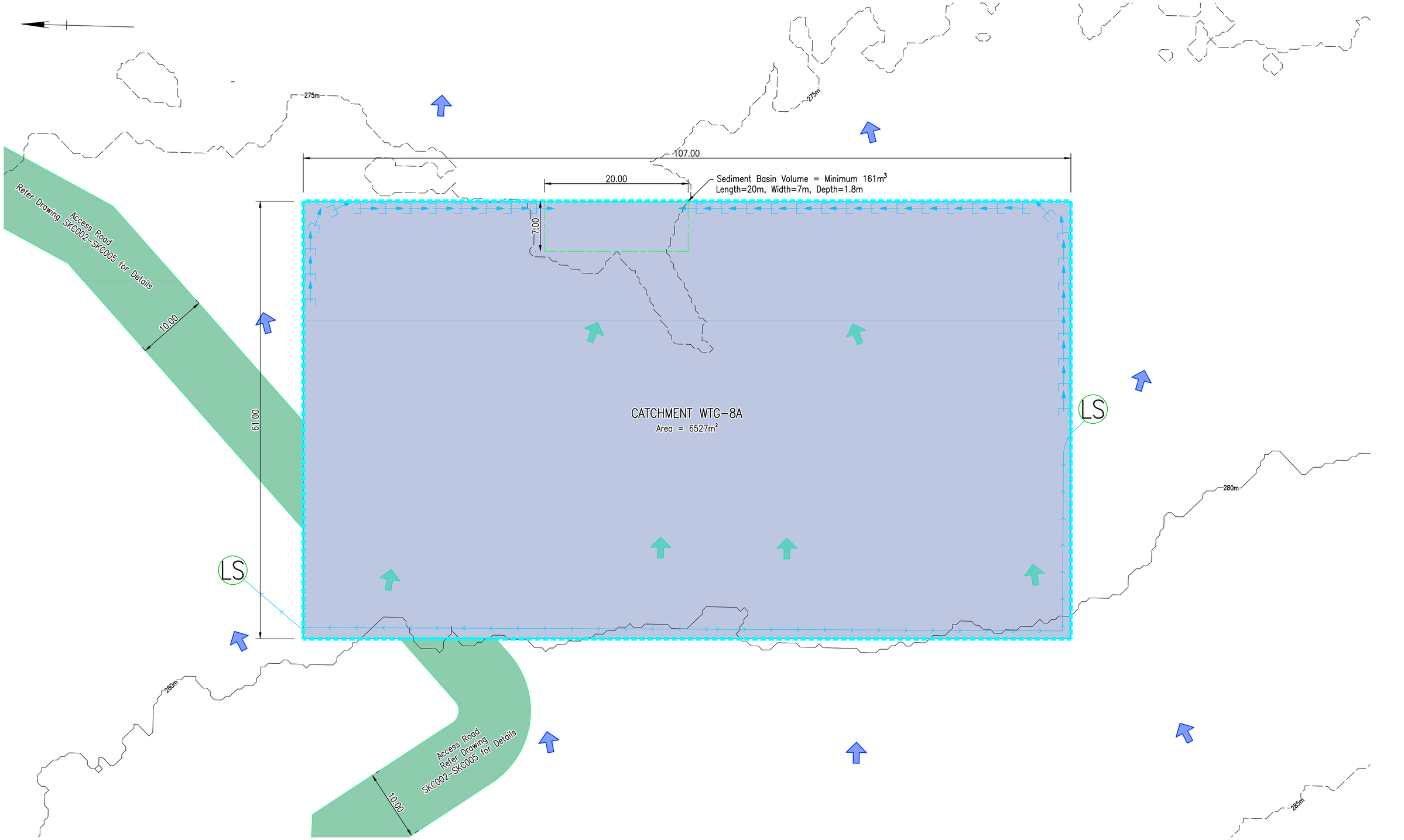
Drawn
M.SMITH

Designed
M.HAUSFELD

ENGINEERING CERTIFICATION (RPEQ)

ENG. AREA	NAME	SIGNATURE	NO.	DATE

Job No.	WTS-002
Drawing No.	SKC017
Revision	A
Series Number	8 OF 10



WTG-8 PLAN
Scale 1:250m

Last Modified :- Dec 01, 2022 - 1:32pm

Rev	Revision Description	Certification	Date
A	DRAFT FOR CLIENT REVIEW	M.HAUSFELD	01/12/22

Scales
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Scale 1:250m
Dimensions shown in metres except where shown otherwise

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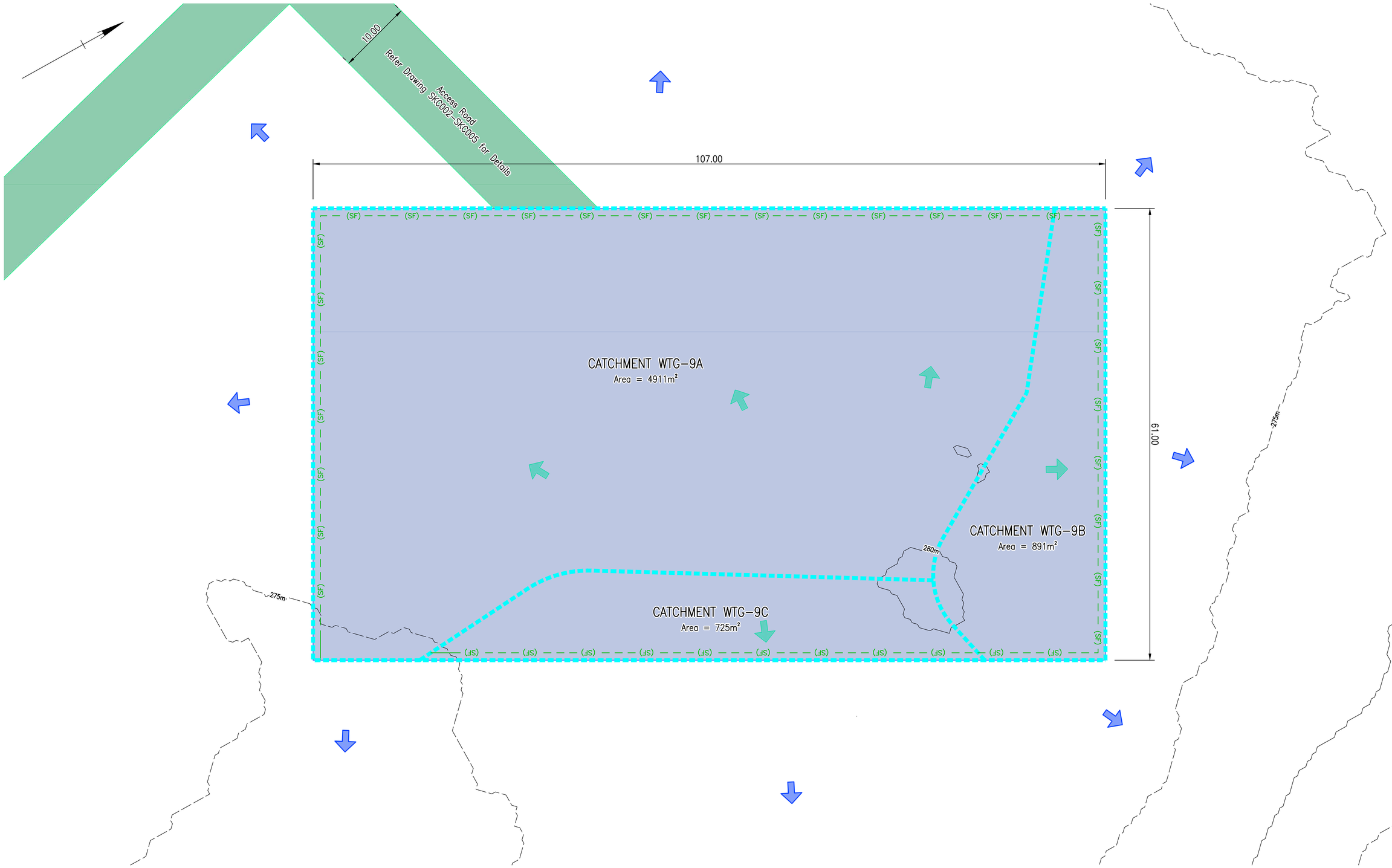
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Title
DUGALD RIVER MINE
EROSION AND SEDIMENT CONTROL
WTG-8 FOOTPRINT

Drawn M.SMITH
Designed M.HAUSFELD

ENGINEERING CERTIFICATION (RPEQ)				
ENG. AREA	NAME	SIGNATURE	NO.	DATE

Job No.	WTS-002
Drawing No.	SKC018
Revision	A
Series Number	9 OF 10



WTG-9 PLAN
Scale 1:250m

Last Modified :- Dec 01, 2022 - 1:32pm

Rev	Revision Description	Certification	Date
A	DRAFT FOR CLIENT REVIEW	M.HAUSFELD	01/12/22

Scales
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Scale 1:250m

Dimensions shown in metres except where shown otherwise

civil IQ

Client
WULGURU TECHNICAL SERVICES

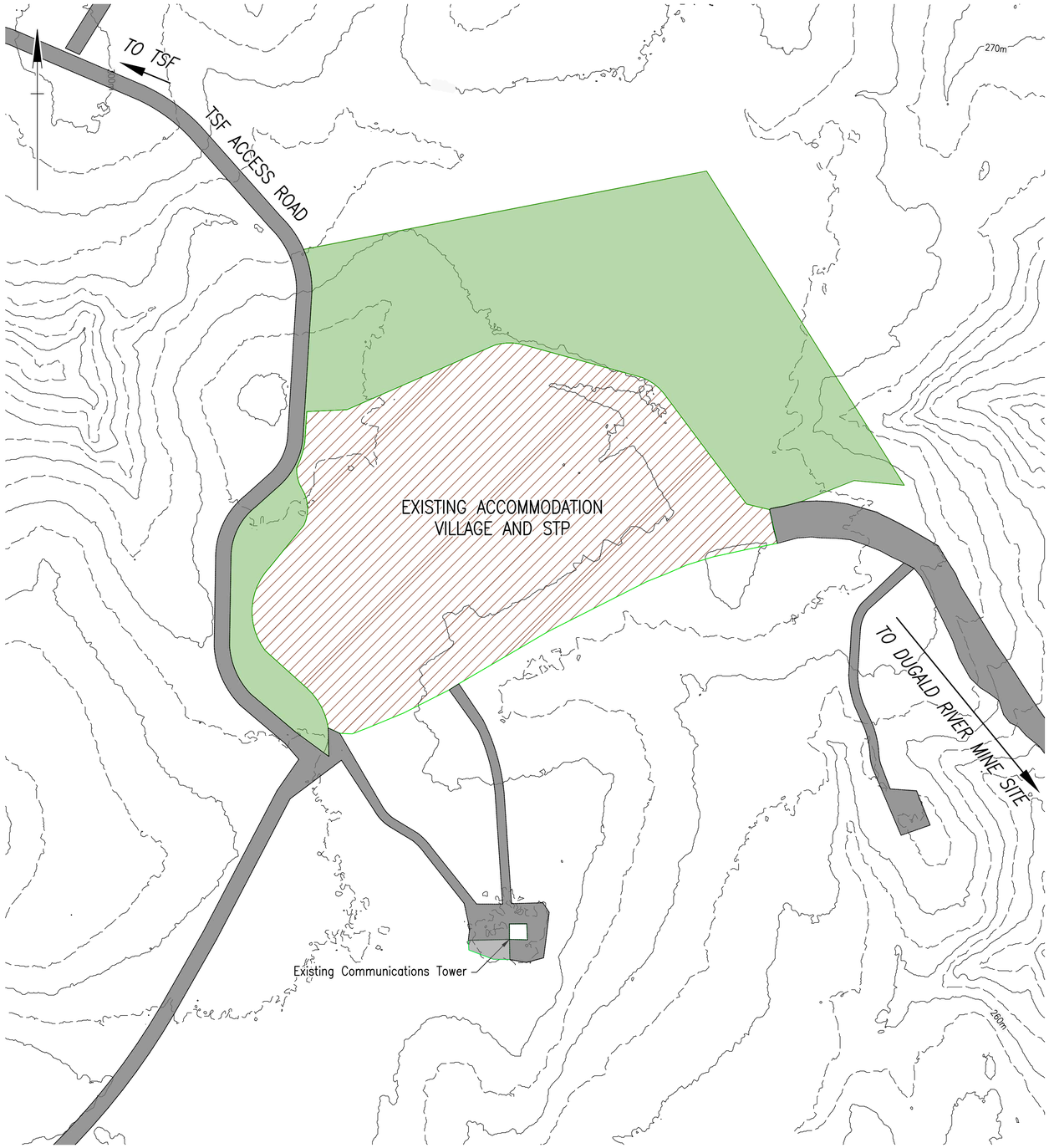
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Title
DUGALD RIVER MINE
EROSION AND SEDIMENT CONTROL
WTG-9 FOOTPRINT

Drawn M.SMITH
Designed M.HAUSFELD

ENGINEERING CERTIFICATION (RPEQ)				
ENG. AREA	NAME	SIGNATURE	NO.	DATE

Job No.	WTS-002
Drawing No.	SKC019
Revision	A
Series Number	10 OF 10



PROPOSED ACCOMMODATION VILLAGE EXPANSION PLAN

Scale 1:2000m

FEATURES LEGEND:

- 210m — Existing Surface Contour
- Existing Roadways
- Existing Village Accommodation Area
- Proposed Village Expansion Area

EROSION CONTROL LEGEND:

- (SF) — Proposed Sediment Fence
- Proposed Clean Water Diversion Channels (Direction Shown)
- Proposed Dirty Water Catchment Area
- Proposed Dirty Water Catchment Channel/Bunding (Direction Shown)
- Proposed Whoa boys and Turnouts
- Proposed Sediment Basin Extents
- S — Proposed Sediment Weir
- LS — Proposed Level Spreader
- Existing Overland Flow (Clean)
- Existing Overland Flow (Dirty)

EROSION AND SEDIMENT CONTROL NOTES:

1. All Erosion and Sediment Control Measures to be in Accordance with the Best Practice Erosion and Sediment Control Guidelines, IECA, 2008.
2. Works for Infrastructure Expansion Footprints shall be Undertaken in the Following Sequence:
   - 2.1. Install Stabilised Site Access
   - 2.2. Construct Clean Water Diversion Channels and Level Spreaders where External Catchments Discharge to the Site
   - 2.3. Construct Dirty Water Channels/ Bunds
   - 2.4. Construct Sediment Basins and Sediment Weirs
   - 2.5. Install all Sediment Fencing
   - 2.6. Locate Stockpile Locations and Install Sediment Fences on Downstream sides
   - 2.7. Topsoil and Rehabilitate Bulk Earthwork Areas Immediately upon Completion
   - 2.8. Rehabilitate the Site
   - 2.9. Decommission Sediment Basins and Sediment Weirs and Remove Erosion and Sediment Control Measures once Surfaces are Stabilised to the Satisfaction of the Superintendent

   This Sequence is to be Reviewed in Context of Staging of Works, However, Must Achieve all Environmental Requirements.
3. Works for Access Roads shall be Undertaken in the Following Sequence:
   - 3.1. Install Stabilised Site Access
   - 3.2. Install Cut Off Channels to Divert External Catchment Flows to all Low Points, Gulllies and Watercourses
   - 3.3. Construct Rock Rip Rap Crossings at Low Points, Gullies and Watercourses
   - 3.4. Construct Woah Boys and Associated Mitre Drains and Level Spreaders at Required Spacings
4. Controls Affected by Works are to be Re-established Prior to the Completion of each days work.
5. The Contractor is to Stabilise all Disturbed Areas as soon as Final Levels are Reached.
6. Dust Control Measures shall be Implemented Continuously during Construction Works to the Satisfaction of the Superintendent and Council.
7. Topsoil Shall be Spread and Stabilised as Soon as Possible, Disturbed Areas shall be left with a Scarified Surface to Encourage Water Infiltration and Assist in Keying in Topsoil.
8. All Trees to be Retained Unless Approved for Removal by the Superintendent.
9. Topsoil Stockpiles shall not Exceed 2m in Height and Batter Slopes to be 1V:3H Maximum.
10. All Access to Site is to be Via the Stabilised Site Access. Site Shall be Fully Fenced to Prevent Access From Other Areas.
11. The Contractor Shall Maintain a Log Book Detailing:
    - 11.1.Records of All Rainfall
    - 11.2.Condition of Erosion and Sediment Control Measures
    - 11.3.Any Additional Remedial Works Required
12. The Contractor Shall at all times Restrict Construction Equipment Movement to the Essential Construction Areas. The Contractor shall not Extend Land Disturbance Beyond 2m from the Edge of any Essential Construction Activity.

Rev	Revision Description	Certification	Date
A	DRAFT FOR CLIENT REVIEW	M.HAUSFELD	01/12/22

Scales

0 20 40 60 80 100m

Scale 1:2000m

Dimensions shown in metres except where shown otherwise

civil IQ

Client: WULGURU TECHNICAL SERVICES

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Title: DUGALD RIVER MINE
EROSION AND SEDIMENT CONTROL
ACCOMMODATION VILLAGE EXPANSION OVERVIEW

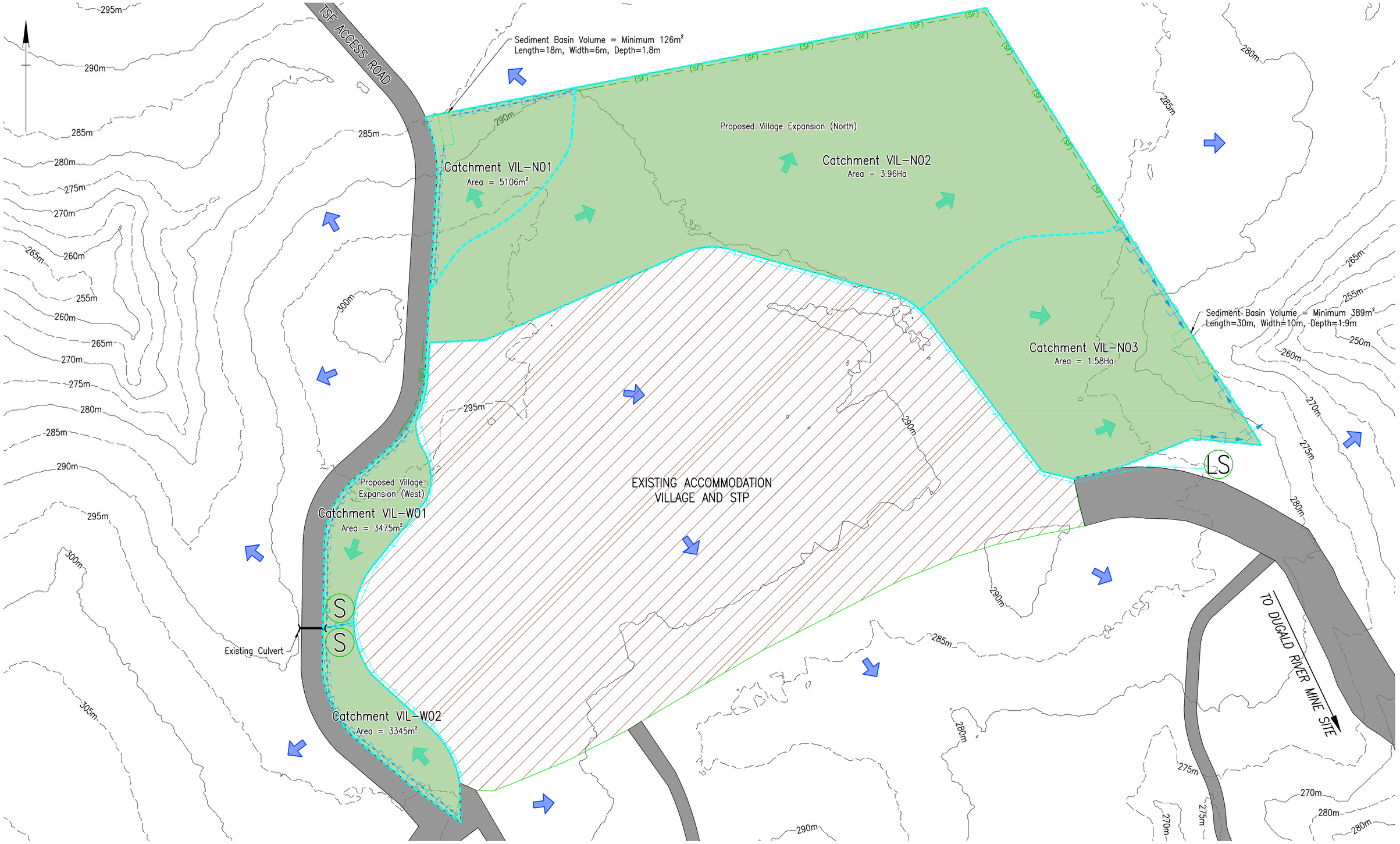
Drawn: M.HAUSFELD

Designed: M.SMITH

ENGINEERING CERTIFICATION (RPEQ)				
ENG. AREA	NAME	SIGNATURE	NO.	DATE

Job No.	WTS-002
Drawing No.	SKC020
Revision	A
Series Number	1 OF 2

Last Modified :- Dec 01, 2022 - 1:45pm



PROPOSED ACCOMMODATION VILLAGE EXPANSION PLAN

Scale 1:1000m

Rev	Revision Description	Certification	Date
A	DRAFT FOR CLIENT REVIEW	M.HAUSFELD	01/12/22

Scales

0 10 20 30 40 50m

Scale 1:1000m

Dimensions shown in metres except where shown otherwise

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Title: DUGALD RIVER MINE
EROSION AND SEDIMENT CONTROL
ACCOMMODATION VILLAGE EXPANSION DETAILS

Drawn: M.SMITH

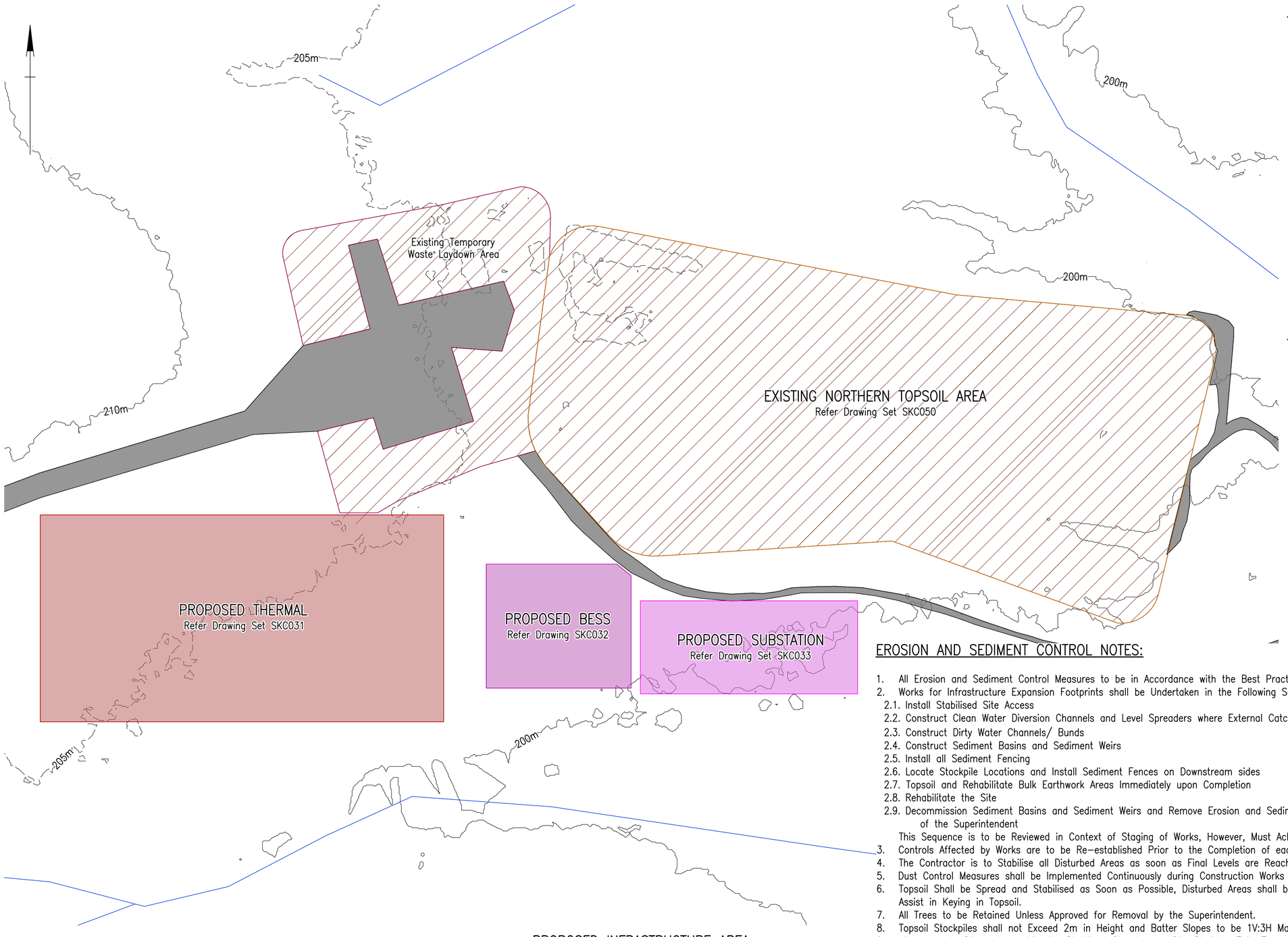
Designed: M.HAUSFELD

ENGINEERING CERTIFICATION (RPEQ)

ENG. AREA	NAME	SIGNATURE	NO.	DATE

Job No.	WTS–002
Drawing No.	SKC021
Revision	A
Series Number	2 OF 2

Last Modified :- Dec 01, 2022 - 2:30pm



PROPOSED INFRASTRUCTURE AREA
Scale 1:1000m

FEATURES LEGEND:

- 210m — Major Existing Surface Contour
- Minor Existing Surface Contour
- Existing Watercourse
- Existing Temporary Waste Laydown Area
- Existing Roadways
- Existing Borrow Pits and Stockpiles
- Proposed Thermal
- Proposed BESS
- Proposed Substation

EROSION CONTROL LEGEND:

- (SF) — Proposed Sediment Fence
- Proposed Clean Water Diversion Channels (Direction Shown)
- Proposed Dirty Water Catchment Channel/Bunding (Direction Shown)
- Proposed Dirty Water Catchment Area
- Proposed Whoa boys and Turnouts
- Proposed Sediment Basin Extents
- S — Proposed Sediment Weir
- LS — Proposed Level Spreader
- Existing Overland Flow (Clean)
- Existing Overland Flow (Dirty)

EROSION AND SEDIMENT CONTROL NOTES:

1. All Erosion and Sediment Control Measures to be in Accordance with the Best Practice Erosion and Sediment Control Guidelines, IECA, 2008.
2. Works for Infrastructure Expansion Footprints shall be Undertaken in the Following Sequence:
   - 2.1. Install Stabilised Site Access
   - 2.2. Construct Clean Water Diversion Channels and Level Spreaders where External Catchments Discharge to the Site
   - 2.3. Construct Dirty Water Channels/ Bunds
   - 2.4. Construct Sediment Basins and Sediment Weirs
   - 2.5. Install all Sediment Fencing
   - 2.6. Locate Stockpile Locations and Install Sediment Fences on Downstream sides
   - 2.7. Topsoil and Rehabilitate Bulk Earthwork Areas Immediately upon Completion
   - 2.8. Rehabilitate the Site
   - 2.9. Decommission Sediment Basins and Sediment Weirs and Remove Erosion and Sediment Control Measures once Surfaces are Stabilised to the Satisfaction of the Superintendent

   This Sequence is to be Reviewed in Context of Staging of Works, However, Must Achieve all Environmental Requirements.
3. Controls Affected by Works are to be Re-established Prior to the Completion of each days work.
4. The Contractor is to Stabilise all Disturbed Areas as soon as Final Levels are Reached.
5. Dust Control Measures shall be Implemented Continuously during Construction Works to the Satisfaction of the Superintendent and Council.
6. Topsoil Shall be Spread and Stabilised as Soon as Possible, Disturbed Areas shall be left with a Scarified Surface to Encourage Water Infiltration and Assist in Keying in Topsoil.
7. All Trees to be Retained Unless Approved for Removal by the Superintendent.
8. Topsoil Stockpiles shall not Exceed 2m in Height and Batter Slopes to be 1V:3H Maximum.
9. All Access to Site is to be Via the Stabilised Site Access. Site Shall be Fully Fenced to Prevent Access From Other Areas.
10. The Contractor Shall Maintain a Log Book Detailing:
    - 10.1. Records of All Rainfall
    - 10.2. Condition of Erosion and Sediment Control Measures
    - 10.3. Any Additional Remedial Works Required
11. The Contractor Shall at all times Restrict Construction Equipment Movement to the Essential Construction Areas. The Contractor shall not Extend Land Disturbance Beyond 2m from the Edge of any Essential Construction Activity.

Last Modified :- Dec 01, 2022 - 1:46pm

Rev	Revision Description	Certification	Date
A	DRAFT FOR CLIENT REVIEW	M.HAUSFELD	01/12/22

Scales

0 10 20 30 40 50m
Scale 1:1000m

Dimensions shown in metres except where shown otherwise

civil IQ

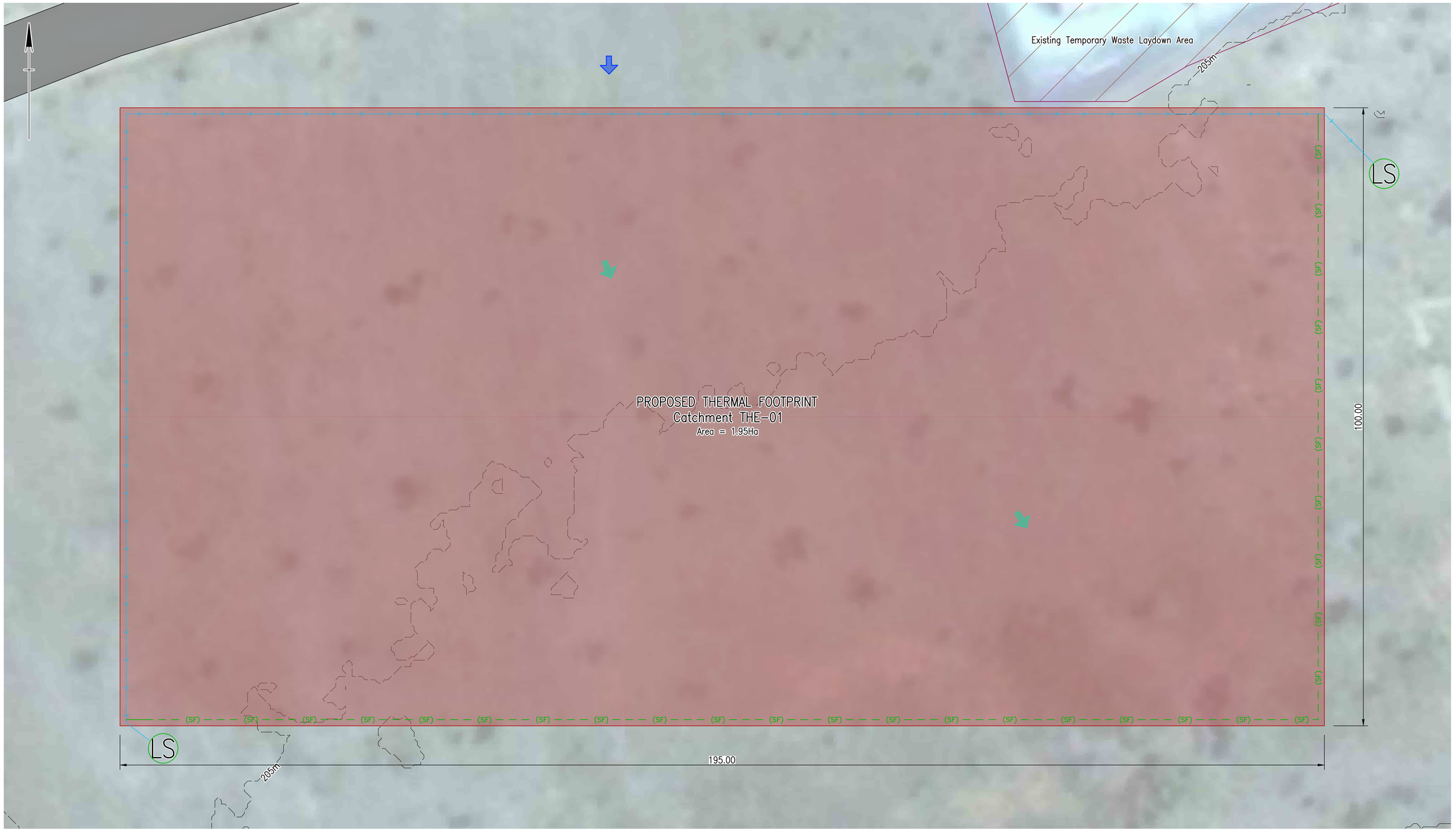
Client: WULGURU TECHNICAL SERVICES

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Title: DUGALD RIVER MINE
EROSION AND SEDIMENT CONTROL
PROPOSED THERMAL, BESS AND SUBSTATION INFRASTRUCTURE

Drawn	ENGINEERING CERTIFICATION (RPEQ)				
M.SMITH	ENG. AREA	NAME	SIGNATURE	NO.	DATE
Designed					
M.HAUSFELD					

Job No.	WTS-002
Drawing No.	SKC030
Revision	A
Series Number	1 OF 3



PROPOSED WINDFARM THERMAL FOOTPRINT

Scale 1::300m

Last Modified :- Dec 01, 2022 - 1:34pm

Rev	Revision Description	Certification	Date
A	DRAFT FOR CLIENT REVIEW	M.HAUSFELD	01/12/22

Scales

0 3 6 9 12 15m

Scale 1:300m

Dimensions shown in metres except where shown otherwise

civil IQ

Client

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Title

DUGALD RIVER MINE
EROSION AND SEDIMENT CONTROL
PROPOSED THERMAL INFRASTRUCTURE

Drawn M.SMITH

Designed M.HAUSFELD

ENGINEERING CERTIFICATION (RPEQ)				
ENG. AREA	NAME	SIGNATURE	NO.	DATE

Job No.	WTS-002
Drawing No.	SKC031
Revision	A
Series Number	2 OF 3



PROPOSED BESS AND SUBSTATION FOOTPRINT

Scale 1:300m

Rev	Revision Description	Certification	Date
A	DRAFT FOR CLIENT REVIEW	M.HAUSFELD	01/12/22

Scales

0 3 6 9 12 15m

Scale 1:300m

Dimensions shown in metres except where shown otherwise

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Client

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Title

DUGALD RIVER MINE
EROSION AND SEDIMENT CONTROL
PROPOSED BESS/SUBSTATION INFRASTRUCTURE

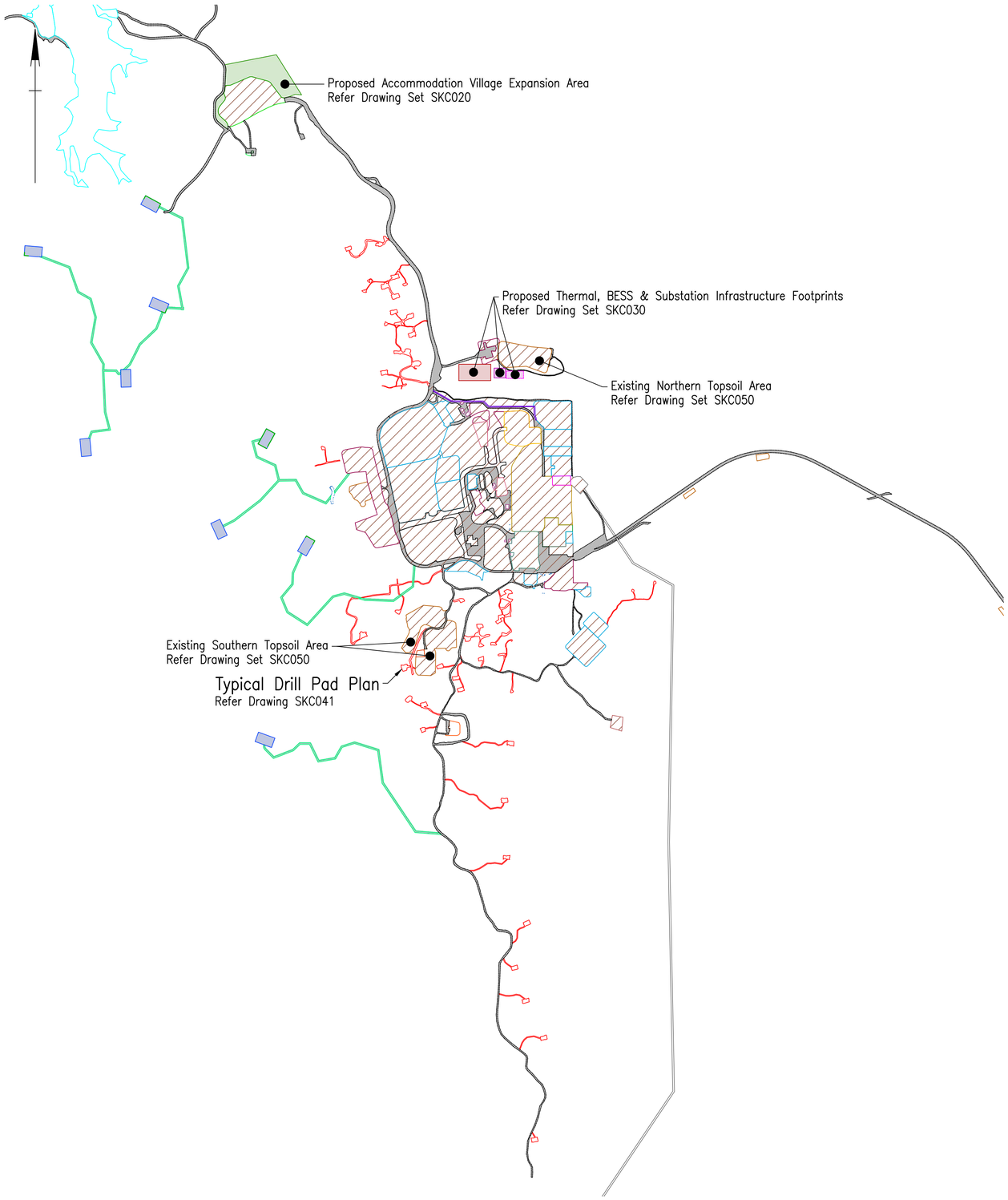
Drawn M.SMITH

Designed M.HAUSFELD

ENGINEERING CERTIFICATION (RPEQ)				
ENG. AREA	NAME	SIGNATURE	NO.	DATE

Job No.	WTS-002
Drawing No.	SKC032
Revision	A
Series Number	3 OF 3

Last Modified :- Dec 01, 2022 - 1:35pm



FEATURES LEGEND:

- 210m — Major Existing Surface Contour
- Minor Existing Surface Contour
- Existing Mine Infrastructure
- Haulroads
- Existing Investigation Drill Pads and Tracks
- Existing Powerline Corridor
- Proposed Investigation Tracks
- Proposed Wind Turbine Hard Stand

EROSION CONTROL LEGEND:

- (SF) — Proposed Sediment Fence
- Proposed Clean Water Diversion Channels (Direction Shown)
- Proposed Dirty Water Catchment Channel/Bunding (Direction Shown)
- Proposed Dirty Water Catchment Area
- Proposed Whoa boys and Turnouts
- Proposed Sediment Basin Extents
- S — Proposed Sediment Weir
- LS — Proposed Level Spreader
- Existing Overland Flow (Clean)
- Existing Overland Flow (Dirty)

EROSION AND SEDIMENT CONTROL NOTES:

1. All Erosion and Sediment Control Measures to be in Accordance with the Best Practice Erosion and Sediment Control Guidelines, IECA, 2008.
2. Works for Infrastructure Expansion Footprints shall be Undertaken in the Following Sequence:
   - 2.1. Install Stabilised Site Access
   - 2.2. Construct Clean Water Diversion Channels and Level Spreaders where External Catchments Discharge to the Site
   - 2.3. Construct Dirty Water Channels/ Bunds
   - 2.4. Construct Sediment Basins and Sediment Weirs
   - 2.5. Install all Sediment Fencing
   - 2.6. Locate Stockpile Locations and Install Sediment Fences on Downstream sides
   - 2.7. Topsoil and Rehabilitate Bulk Earthwork Areas Immediately upon Completion
   - 2.8. Rehabilitate the Site
   - 2.9. Decommission Sediment Basins and Sediment Weirs and Remove Erosion and Sediment Control Measures once Surfaces are Stabilised to the Satisfaction of the Superintendent

   This Sequence is to be Reviewed in Context of Staging of Works, However, Must Achieve all Environmental Requirements.
3. Works for Access Roads shall be Undertaken in the Following Sequence:
   - 3.1. Install Stabilised Site Access
   - 3.2. Install Cut Off Channels to Divert External Catchment Flows to all Low Points, Gulllies and Watercourses
   - 3.3. Construct Rock Rip Rap Crossings at Low Points, Gullies and Watercourses
   - 3.4. Construct Woah Boys and Associated Mitre Drains and Level Spreaders at Required Spacings
4. Controls Affected by Works are to be Re-established Prior to the Completion of each days work.
5. The Contractor is to Stabilise all Disturbed Areas as soon as Final Levels are Reached.
6. Dust Control Measures shall be Implemented Continuously during Construction Works to the Satisfaction of the Superintendent and Council.
7. Topsoil Shall be Spread and Stabilised as Soon as Possible, Disturbed Areas shall be left with a Scarified Surface to Encourage Water Infiltration and Assist in Keying in Topsoil.
8. All Trees to be Retained Unless Approved for Removal by the Superintendent.
9. Topsoil Stockpiles shall not Exceed 2m in Height and Batter Slopes to be 1V:3H Maximum.
10. All Access to Site is to be Via the Stabilised Site Access. Site Shall be Fully Fenced to Prevent Access From Other Areas.
11. The Contractor Shall Maintain a Log Book Detailing:
    - 11.1.Records of All Rainfall
    - 11.2.Condition of Erosion and Sediment Control Measures
    - 11.3.Any Additional Remedial Works Required
12. The Contractor Shall at all times Restrict Construction Equipment Movement to the Essential Construction Areas. The Contractor shall not Extend Land Disturbance Beyond 2m from the Edge of any Essential Construction Activity.

Last Modified :- Dec 01, 2022 - 1:46pm

Rev	Revision Description	Certification	Date
A	DRAFT FOR CLIENT REVIEW	M.HAUSFELD	01/12/22

Scales

0 150 300 450 600 750m

Scale 1:15000m

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Title: DUGALD RIVER MINE
EROSION AND SEDIMENT CONTROL
INVESTIGATION DRILL PAD AND TRACKS LOCATION KEY PLAN

Drawn: M.SMITH

Designed: M.HAUSFELD

ENGINEERING CERTIFICATION (RPEQ)				
ENG. AREA	NAME	SIGNATURE	NO.	DATE

Job No.	WTS-002
Drawing No.	SKC040
Revision	A
Series Number	1 OF 3



EXISTING INVESTIGATION DRILL PAD AND TRACKS FOOTPRINT

Scale 1:250m

Last Modified :- Dec 01, 2022 - 1:35pm

Rev	Revision Description	Certification	Date
A	DRAFT FOR CLIENT REVIEW	M.HAUSFELD	01/12/22

Scales

0 2.5 5.0 7.5 10.0 12.5m

Scale 1:250m

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Title

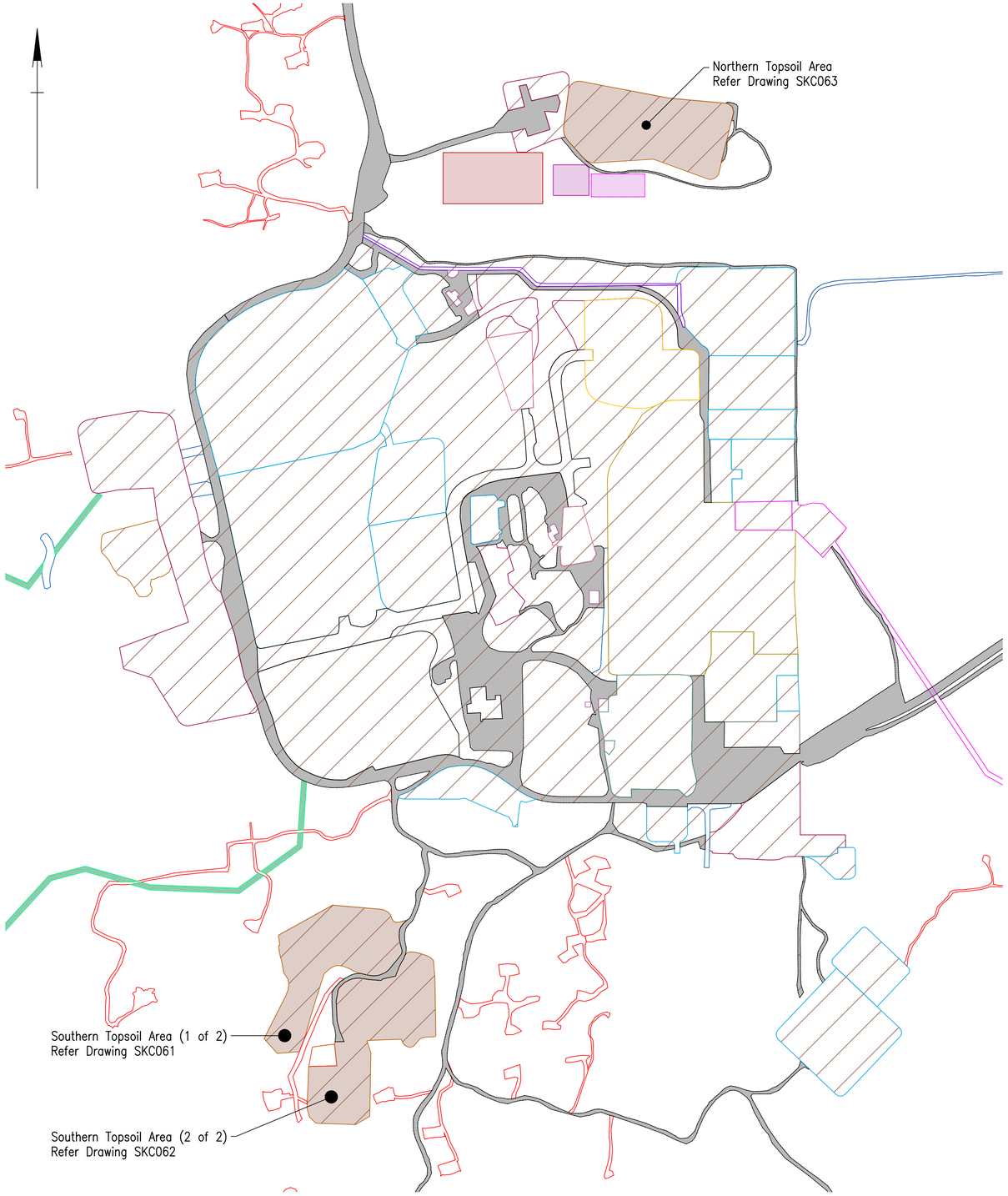
DUGALD RIVER MINE
EROSION AND SEDIMENT CONTROL
TYPICAL EXISTING INVESTIGATION DRILL PAD AND TRACKS

Drawn M.SMITH

Designed M.HAUSFELD

ENGINEERING CERTIFICATION (RPEQ)				
ENG. AREA	NAME	SIGNATURE	NO.	DATE

Job No.	WTS-002
Drawing No.	SKC041
Revision	A
Series Number	2 OF 3



FEATURES LEGEND:

- Existing Roadways
- Existing Mine Infrastructure
- Existing Topsoil Area
- Existing Drill Pads
- Existing Powerline Corridor
- Proposed Investigation Tracks (Drawing Set SKC000)
- Thermal Location (Drawing Set SKC040)
- Bess Location (Drawing Set SKC040)
- Substation Location (Drawing Set SKC040)

EROSION CONTROL DEVICES LEGEND:

- Proposed Sediment Fence
- Proposed Clean Water Diversion Channels (Direction Shown)
- Proposed Dirty Water Catchment Channel/Bunding (Direction Shown)
- Proposed Dirty Water Catchment Area
- Proposed Whoa boys and Turnouts
- Proposed Sediment Basin Extents
- Proposed Sediment Weir
- Proposed Level Spreader
- Existing Overland Flow (Clean)
- Existing Overland Flow (Dirty)

EROSION AND SEDIMENT CONTROL NOTES:

1. All Erosion and Sediment Control Measures to be in Accordance with the Best Practice Erosion and Sediment Control Guidelines, IECA, 2008.
2. Works for Infrastructure Expansion Footprints shall be Undertaken in the Following Sequence:
   - 2.1. Install Stabilised Site Access
   - 2.2. Construct Clean Water Diversion Channels and Level Spreaders where External Catchments Discharge to the Site
   - 2.3. Construct Dirty Water Channels/ Bunds
   - 2.4. Construct Sediment Basins and Sediment Weirs
   - 2.5. Install all Sediment Fencing
   - 2.6. Locate Stockpile Locations and Install Sediment Fences on Downstream sides
   - 2.7. Topsoil and Rehabilitate Bulk Earthwork Areas Immediately upon Completion
   - 2.8. Rehabilitate the Site
   - 2.9. Decommission Sediment Basins and Sediment Weirs and Remove Erosion and Sediment Control Measures once Surfaces are Stabilised to the Satisfaction of the Superintendent

   This Sequence is to be Reviewed in Context of Staging of Works, However, Must Achieve all Environmental Requirements.
3. Works for Access Roads shall be Undertaken in the Following Sequence:
   - 3.1. Install Stabilised Site Access
   - 3.2. Install Cut Off Channels to Divert External Catchment Flows to all Low Points, Gulllies and Watercourses
   - 3.3. Construct Rock Rip Rap Crossings at Low Points, Gullies and Watercourses
   - 3.4. Construct Woah Boys and Associated Mitre Drains and Level Spreaders at Required Spacings
4. Controls Affected by Works are to be Re-established Prior to the Completion of each days work.
5. The Contractor is to Stabilise all Disturbed Areas as soon as Final Levels are Reached.
6. Dust Control Measures shall be Implemented Continuously during Construction Works to the Satisfaction of the Superintendent and Council.
7. Topsoil Shall be Spread and Stabilised as Soon as Possible, Disturbed Areas shall be left with a Scarified Surface to Encourage Water Infiltration and Assist in Keying in Topsoil.
8. All Trees to be Retained Unless Approved for Removal by the Superintendent.
9. Topsoil Stockpiles shall not Exceed 2m in Height and Batter Slopes to be 1V:3H Maximum.
10. All Access to Site is to be Via the Stabilised Site Access. Site Shall be Fully Fenced to Prevent Access From Other Areas.
11. The Contractor Shall Maintain a Log Book Detailing:
    - 11.1.Records of All Rainfall
    - 11.2.Condition of Erosion and Sediment Control Measures
    - 11.3.Any Additional Remedial Works Required
12. The Contractor Shall at all times Restrict Construction Equipment Movement to the Essential Construction Areas. The Contractor shall not Extend Land Disturbance Beyond 2m from the Edge of any Essential Construction Activity.

Last Modified :- Dec 01, 2022 - 1:46pm

Rev	Revision Description	Certification	Date
A	DRAFT FOR CLIENT REVIEW	M.HAUSFELD	01/12/22

Scales

0 50 100 150 200 250m
Scale 1:5000m

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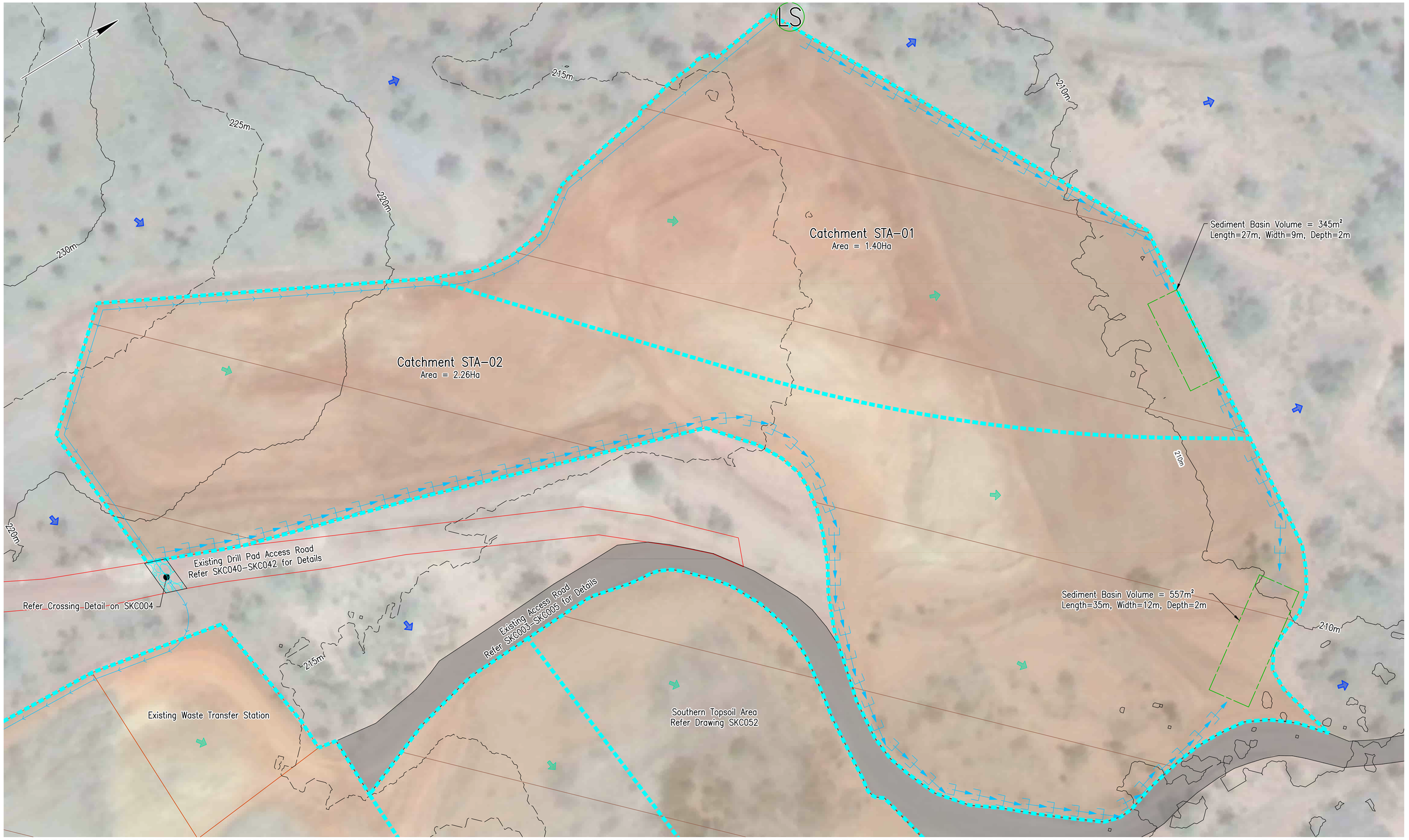
Title: DUGALD RIVER MINE
EROSION AND SEDIMENT CONTROL
TOPSOIL AREAS KEY PLAN

Drawn: M.SMITH
Designed: M.HAUSFELD

ENGINEERING CERTIFICATION (RPEQ)

ENG. AREA	NAME	SIGNATURE	NO.	DATE

Job No.	WTS-002
Drawing No.	SKC050
Revision	A
Series Number	1 OF 4



Joins SKC052

SOUTHERN TOPSOIL AREA PLAN

Scale 1:500m

Rev	Revision Description	Certification	Date
A	DRAFT FOR CLIENT REVIEW	M.HAUSFELD	01/12/22

Scales

0 5 10 15 20 25.0m

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Title: DUGALD RIVER MINE
EROSION AND SEDIMENT CONTROL
SOUTHERN TOPSOIL AREA SHEET 1 OF 2

Drawn: M.SMITH

Designed: M.HAUSFELD

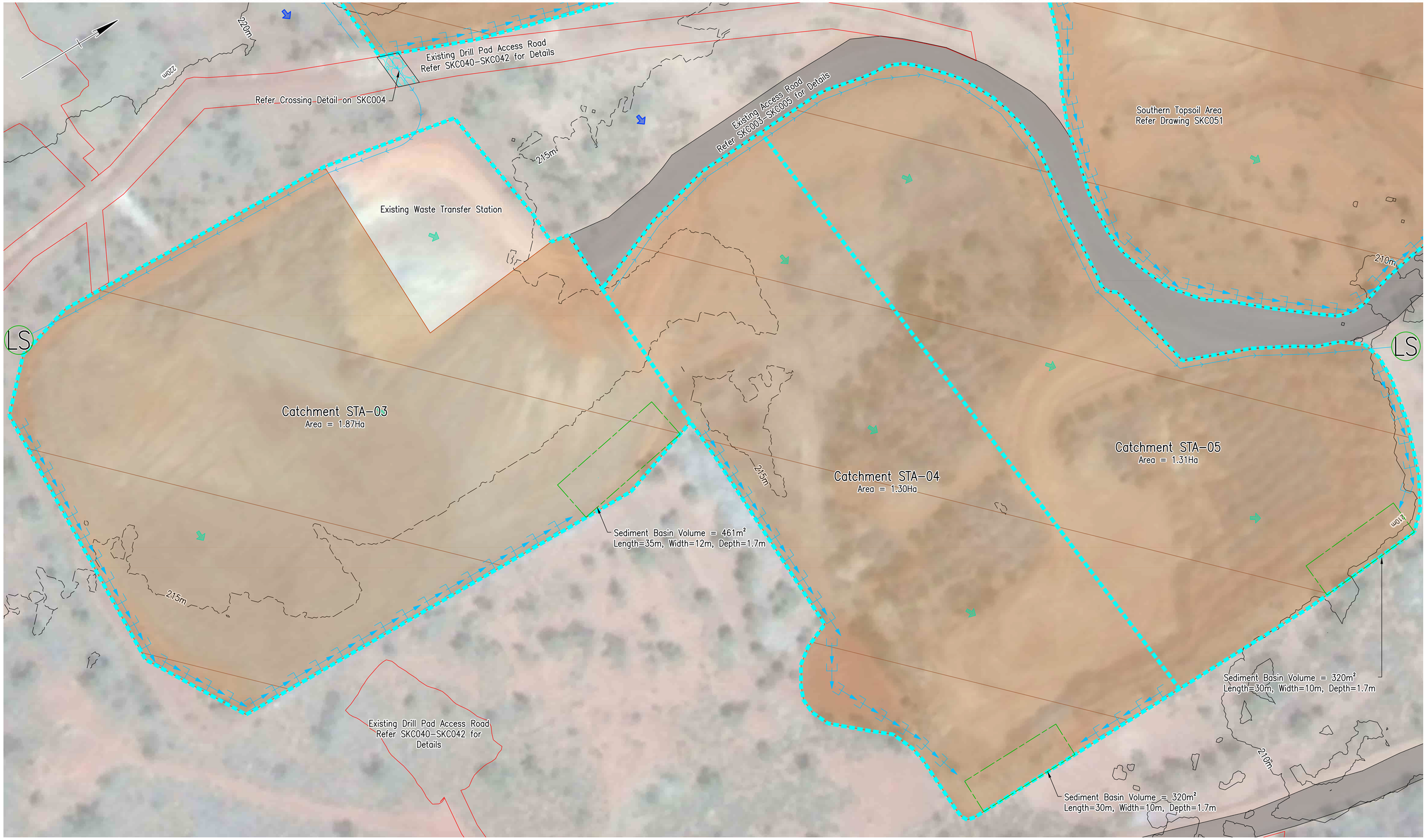
ENGINEERING CERTIFICATION (RPEQ)

ENG. AREA	NAME	SIGNATURE	NO.	DATE

Job No.	WTS-002
Drawing No.	SKC051
Revision	A
Series Number	2 OF 4

Last Modified :- Dec 01, 2022 - 1:37pm

Joins SKC051



SOUTHERN TOPSOIL AREA PLAN

Scale 1:500m

Last Modified :- Dec 01, 2022 - 1:38pm

Rev	Revision Description	Certification	Date
A	DRAFT FOR CLIENT REVIEW	M.HAUSFELD	01/12/22

Scales

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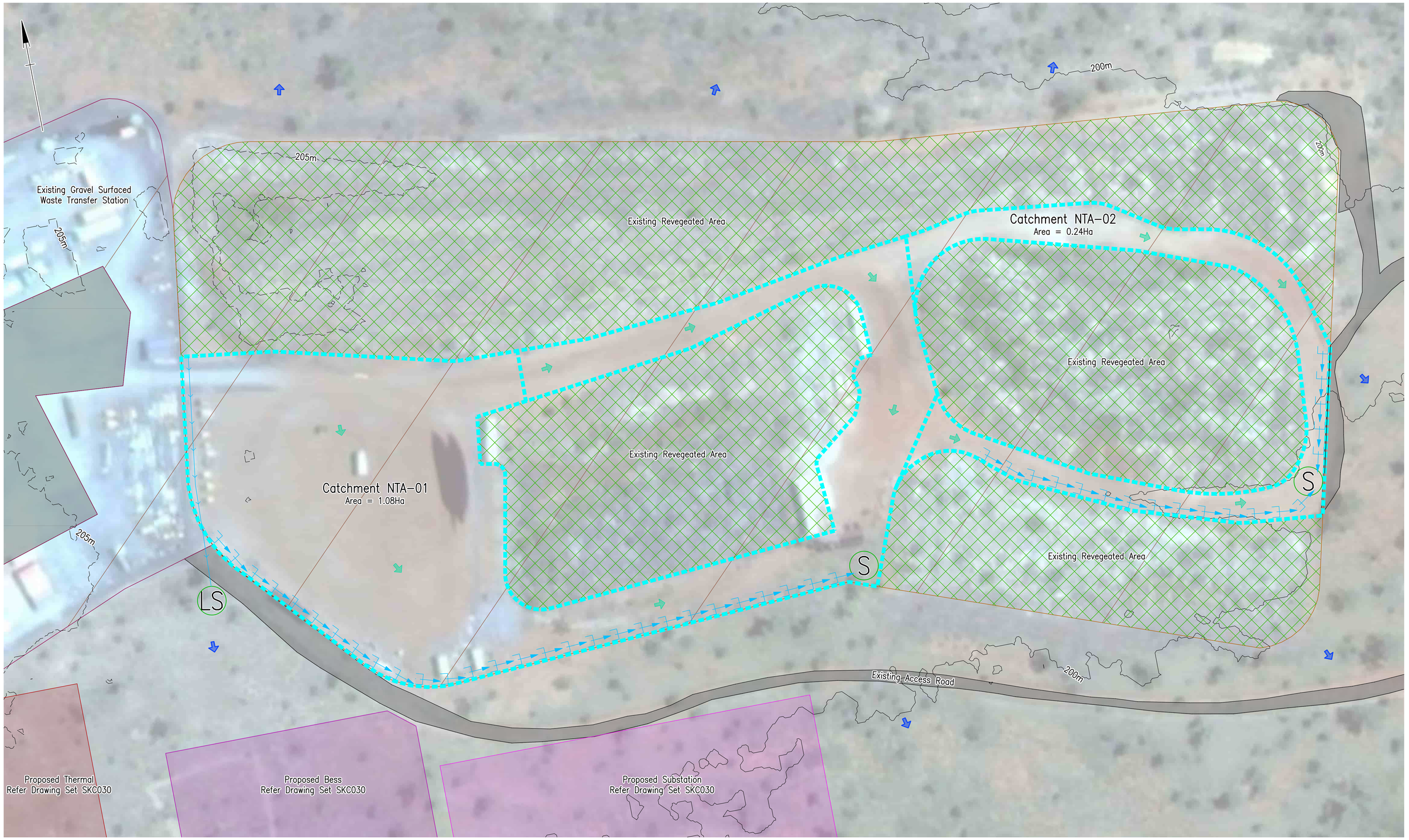
Title: DUGALD RIVER MINE
EROSION AND SEDIMENT CONTROL
SOUTHERN TOPSOIL AREA SHEET 2 OF 2

Drawn: M.SMITH

Designed: M.HAUSFELD

ENGINEERING CERTIFICATION (RPEQ)				
ENG. AREA	NAME	SIGNATURE	NO.	DATE

Job No.	WTS-002
Drawing No.	SKC052
Revision	A
Series Number	3 OF 4



BORROW PIT AND STOCKPILE B PLAN

Scale 1:500m

Last Modified :- Dec 01, 2022 - 1:38pm

Rev	Revision Description	Certification	Date
A	DRAFT FOR CLIENT REVIEW	M.HAUSFELD	01/12/22

Scales

0 5 10 15 20 25.0m

Scale 1:500m

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Title

DUGALD RIVER MINE
EROSION AND SEDIMENT CONTROL
NORTHERN TOPSOIL AREA

Drawn
M.SMITH

Designed
M.HAUSFELD

ENGINEERING CERTIFICATION (RPEQ)				
ENG. AREA	NAME	SIGNATURE	NO.	DATE

Job No.	WTS-002
Drawing No.	SKC053
Revision	A
Series Number	4 OF 4

Appendix F– ESCP Calculations

Rainfall Factor

Determined from E3.2 in IECA guidelines

$R = 164.74 \times 1.1177^{S} \times S^{0.6444}$

S= 2 year 6 hour storm

S=	11
R=	2624.422

R	2624.42	**RUSLE = K x R x P x C x LS**
P (default)	1.3	
C (default)	1.00	

From Table 3.1 - Soil Loss Classes (IECA 2008)

Soil Loss Class	Soil Loss Rate (t/ha/yr)	Erosion Risk
1	0 to 150	Very Low
2	151 to 225	Low
3 to 4	226 to 500	Moderate
5 to 6	501 to 1500	High
7	above 1500	Extremely High

Catchment ID	Catchment Size Area (ha)	Slope %	Length m	K Factor	Ls	C Factor	Soil Loss Rate (t/ha/yr)	Soil Erosion Hazard	Soil Loss Class
WTG-1A	0.22	20	40.0	0.030	4.32	1.00	442	Moderate	3 to 4
WTG-1B	0.21	20	40.0	0.030	4.32	1.00	442	Moderate	3 to 4
WTG-1C	0.14	20	40.0	0.030	4.32	1.00	442	Moderate	3 to 4
WTG-2A	0.40	20	40.0	0.030	4.32	1.00	442	Moderate	3 to 4
WTG-2B	0.16	1	80.0	0.030	0.19	1.00	19	Very Low	1
WTG-3A	0.33	20	40.0	0.030	4.32	1.00	442	Moderate	3 to 4
WTG-3B	0.25	20	40.0	0.030	4.32	1.00	442	Moderate	3 to 4
WTG-4A	0.35	17	30.0	0.030	2.67	1.00	273	Moderate	3 to 4
WTG-4B	0.30	17	30.0	0.030	2.67	1.00	273	Moderate	3 to 4
WTG-5A	0.34	12	60.0	0.030	3.02	1.00	309	Moderate	3 to 4
WTG-5B	0.31	12	60.0	0.030	3.02	1.00	309	Moderate	3 to 4
WTG-6A	0.30	5	80.0	0.030	1.19	1.00	122	Very Low	1
WTG-6B	0.24	5	80.0	0.030	1.19	1.00	122	Very Low	1
WTG-7A	0.42	10	60.0	0.030	2.31	1.00	236	Moderate	3 to 4
WTG-7B	0.31	7	60.0	0.030	1.24	1.00	127	Very Low	1
WTG-8A	0.65	8	60.0	0.030	1.70	1.00	174	Low	2
WTG-9A	0.49	1	80.0	0.030	0.19	1.00	19	Very Low	1
VIL-W01	0.35	5	80.0	0.030	1.19	1.00	122	Very Low	1
VIL-W02	0.33	5	80.0	0.030	1.19	1.00	122	Very Low	1
VIL-N01	0.51	15	80.0	0.030	4.61	1.00	472	Moderate	3 to 4
VIL-N02	3.96	2.5	80.0	0.030	0.65	1.00	67	Very Low	1
VIL-N03	1.58	15	80.0	0.030	4.61	1.00	472	Moderate	3 to 4
THE-01	1.95	1	80.0	0.045	0.19	1.00	29	Very Low	1
BESS-01	0.42	1	80.0	0.045	0.19	1.00	29	Very Low	1
SS-01	0.47	1	80.0	0.045	0.19	1.00	29	Very Low	1
STA-01	1.40	2.5	80.0	0.045	0.65	1.00	100	Very Low	1
STA-02	2.26	2.5	80.0	0.045	0.65	1.00	100	Very Low	1
STA-03	1.87	3.5	80.0	0.045	0.91	1.00	140	Very Low	1
STA-04	1.30	2.5	80.0	0.045	0.65	1.00	100	Very Low	1
STA-05	1.31	2.5	80.0	0.045	0.65	1.00	100	Very Low	1
NTA-01	1.08	1.5	80.0	0.045	0.41	1.00	63	Very Low	1
NTA-02	0.24	1.5	80.0	0.045	0.41	1.00	63	Very Low	1

From Table 4.4.7 (IECA 2008) - Best practice land clearing and rehabilitation requirements

Erosion Risk Rating	Soil Loss Rate (t/ha/yr)	Advanced land clearing allowed (wks work)	Max No. Of Days for stablisation	Minimum Cover (%)	Stage constructoin of Batters > 6H to 1V	Stablisation of stockpiles
Very Low	0 to 150	8	30	60		
Low	151 to 225	8	30	70		
Moderate	226 to 500	6	20	70	Yes	
High	501 to 1500	4	10	75	Yes	Yes
Very High	above 1500	2	5	80	Yes	Yes

All cases - All practical steps must be taken to apply Erosion and Sedimentation Controls and stablise works prior to anticipated rainfall

From Table B1 Appendix B (IECA 2018) - Sediment control standard (default) based on soil loss rate

Area Limit (m^2)	Soil Loss Rate (t/ha/yr)			Soil Loss Rate (t/ha/month)		
	Type 1	Type 2	Type 3	Type 1	Type 2	Type 3
250	N/A	N/A	All	N/A	N/A	All
1000	N/A	N/A	All	N/A	N/A	All
2500	N/A	>75	75	N/A	>6.25	6.25
>2500	>150	150	75	>12.5	12.5	6.25
>10000	>75	N/A	75	>6.25	N/A	6.25

From Table 4.5.2 (IECA 2008) - Sediment control based on erosivity and rainfall

Area Limit (m^2)	Soil Loss Rate (t/ha/yr)			Soil Loss Rate (t/ha/month)		
	Type 1	Type 2	Type 3	Type 1	Type 2	Type 3
250	N/A	N/A	All	N/A	N/A	All
1000	N/A	N/A	All	N/A	N/A	All
2500	N/A	>60	60	N/A	>30	30
>2500	>100	100	60	>45	45	30

1. Sediment Basins

Site Name: Dugald Mine Site Expansion
Site Location: Cloncurry, QLD
Precinct/Stage: WTG Areas
Date: 29/11/2022
Other Details: SHEET 1

Site area	Sub-catchment or Name of Structure						
	WTG-2A	WTG-3A	WTG-4A	WTG-4B	WTG-5A	WTG-5B	WTG-7A
Total catchment area (ha)	0.40	0.33	0.35	0.30	0.34	0.31	0.42
Disturbed catchment area (ha)	0.4	0.3	0.4	0.3	0.3	0.3	0.4

Soil analysis (enter sediment type if known, or laboratory particle size data)

Sediment Type (C, F or D) if known:	D	D	D	D	D	D	D
% sand (fraction 0.02 to 2.00 mm)							
% silt (fraction 0.002 to 0.02 mm)							
% clay (fraction finer than 0.002 mm)							
Dispersion percentage							
% of whole soil dispersible	0	0	0	0	0	0	0
Soil Texture Group	D	D	D	D	D	D	D

Rainfall data

Design rainfall depth (no of days)	5	5	5	5	5	5	5
Design rainfall depth (percentile)	80	80	80	80	80	80	80
x-day, y-percentile rainfall event (mm)	23.8	23.8	23.8	23.8	23.8	23.8	23.8
Rainfall R-factor (if known)	2624	2624	2624	2624	2624	2624	2624
IFD: 2-year, 6-hour storm (if known)	11	11	11	11	11	11	11

RUSLE Factors

Rainfall erosivity (*R*-factor)	2624	2624	2624	2624	2624	2624	2624
Soil erodibility (*K*-factor)	0.03	0.03	0.03	0.03	0.03	0.03	0.03
Slope length (m)	20	20	30	30	60	60	60
Slope gradient (%)	20.0	20.0	17.0	17.0	12.0	12.0	10.0
Length/gradient (*LS*-factor)	2.6	2.6	2.7	2.7	3.0	3.0	2.3
Erosion control practice (*P*-factor)	1.3	1.3	1.3	1.3	1.3	1.3	1.3
Ground cover (*C*-factor)	1	1	1	1	1	1	1

Sediment Basin Design Criteria (for Type D/F basins only. Leave blank for Type C basins)

Put an X here to use 50% of water zone							
Storage (soil) zone design (months)	2	2	2	2	2	2	2
Cv (Volumetric runoff coefficient)	0.69	0.69	0.69	0.69	0.69	0.69	0.69

Calculations and Type D/F Sediment Basin Volumes

Soil loss rate (t/ha/yr)	261	261	273	273	309	309	236
Soil loss class	3	3	3	3	3	3	3
Soil loss (m^3/ha/yr)	201	201	210	210	238	238	182
Basin storage (soil) volume (m^3)	33	27	29	25	28	25	34
Basin settling (water) volume (m^3)	65	54	58	49	56	51	68
Sediment basin total volume (m^3)	98	80	87	74	84	76	102

Typical Sizing

Length	15	15	15	15	15	15	15
Width	5	5	5	5	5	5	5
Ratio	3	3	3	3	3	3	3
Area	75	75	75	75	75	75	75
Depth of sediment zone	0.4	0.4	0.4	0.3	0.4	0.3	0.5
Depth of settling zone	0.9	0.7	0.8	0.7	0.7	0.7	0.9
Internal batter slope	2	2	2	2	2	2	2
Check basin storage (soil) volume (m^3)	33	27	29	25	28	25	34
Check basin settling (water) volume (m^3)	65	54	58	49	56	51	68
Check sediment basin total volume (m^3)	98	80	87	74	84	76	102
Weir height (m)	0.3	0.3	0.3	0.3	0.3	0.3	0.3
Freeboard (m)	0.3	0.3	0.3	0.3	0.3	0.3	0.3
Check total depth (m)	1.9	1.7	1.8	1.6	1.7	1.6	2.0

1. Sediment Basins

Site Name: Dugald Mine Site Expansion
Site Location: Cloncurry, QLD
Precinct/Stage: WTG Areas
Date: 29/11/2022
Other Details: SHEET 2

Site area	Sub-catchment or Name of Structure							
	WTG-8A	VIL-N01	VIL-N03	STA-01	STA-02	STA-03	STA-04	STA-05
Total catchment area (ha)	0.65	0.51	1.58	1.40	2.26	1.87	1.30	1.30
Disturbed catchment area (ha)	0.7	0.5	1.6	1.4	2.3	1.9	1.3	1.3

Soil analysis (enter sediment type if known, or laboratory particle size data)

Sediment Type (C, F or D) if known:	D	D	D	D	D	D	D	D
% sand (fraction 0.02 to 2.00 mm)								
% silt (fraction 0.002 to 0.02 mm)								
% clay (fraction finer than 0.002 mm)								
Dispersion percentage								
% of whole soil dispersible	0	0	0	0	0	0	0	0
Soil Texture Group	D	D	D	D	D	D	D	D

Rainfall data

Design rainfall depth (no of days)	5	5	5	5	5	5	5	5
Design rainfall depth (percentile)	80	80	80	80	80	80	80	80
x-day, y-percentile rainfall event (mm)	23.8	23.8	23.8	23.8	23.8	23.8	23.8	23.8
Rainfall R-factor (if known)	2624	2624	2624	2624	2624	2624	2624	2624
IFD: 2-year, 6-hour storm (if known)	11	11	11	11	11	11	11	11

RUSLE Factors

Rainfall erosivity (*R*-factor)	2624	2624	2624	2624	2624	2624	2624	2624
Soil erodibility (*K*-factor)	0.03	0.03	0.03	0.045	0.045	0.045	0.045	0.045
Slope length (m)	60	80	80	80	80	80	80	80
Slope gradient (%)	8.0	15.0	15.0	2.5	2.5	3.5	2.5	2.5
Length/gradient (*LS*-factor)	1.7	4.6	4.6	0.7	0.7	0.9	0.7	0.7
Erosion control practice (*P*-factor)	1.3	1.3	1.3	1.3	1.3	1.3	1.3	1.3
Ground cover (*C*-factor)	1	1	1	1	1	1	1	1

Sediment Basin Design Criteria (for Type D/F basins only. Leave blank for Type C basins)

Put an X here to use 50% of water zone								
Storage (soil) zone design (months)	2	2	2	2	2	2	2	2
Cv (Volumetric runoff coefficient)	0.69	0.69	0.69	0.69	0.69	0.69	0.69	0.69

Calculations and Type D/F Sediment Basin Volumes

Soil loss rate (t/ha/yr)	174	472	472	100	100	140	100	100
Soil loss class	2	3	3	1	1	1	1	1
Soil loss (m^3/ha/yr)	134	363	363	77	77	107	77	77
Basin storage (soil) volume (m^3)	54	42	130	115	186	154	107	107
Basin settling (water) volume (m^3)	107	84	259	230	371	307	213	213
Sediment basin total volume (m^3)	161	126	389	345	557	461	320	320

Typical Sizing

Length	20	18	30	27	35	35	30	30
Width	7	6	10	9	12	12	10	10
Ratio	3	3	3	3	3	3	3	3
Area	133	108	300	243	408	408	300	300
Depth of sediment zone	0.4	0.4	0.4	0.5	0.5	0.4	0.4	0.4
Depth of settling zone	0.8	0.8	0.9	0.9	0.9	0.8	0.7	0.7
Internal batter slope	2	2	2	2	2	2	2	2
Check basin storage (soil) volume (m^3)	54	42	130	115	186	154	107	107
Check basin settling (water) volume (m^3)	107	84	259	230	371	307	213	213
Check sediment basin total volume (m^3)	161	126	389	345	557	461	320	320
Weir height (m)	0.9	0.3	0.3	0.3	0.3	0.3	0.3	0.3
Freeboard (m)	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
Check total depth (m)	2.4	1.8	1.9	2.0	2.0	1.7	1.7	1.7

APPENDIX P: Noise Impact Assessment (AECOM, 2023)

AECOM Australia Pty Ltd
Gadigal Country
Level 21, 420 George Street
Sydney NSW 2000
PO Box Q410
QVB Post Office NSW 1230
Australia
www.aecom.com

+61 2 8008 1700 tel

ABN 20 093 846 925

21 November 2023

Commercial-in-Confidence

Daniel Bales
MMG Dugald River Pty Ltd

Dear Daniel,

Dugald River Mine Wind Farm
Construction, Operational and Decommissioning Predicted Noise Levels

1.0 Introduction

AECOM Australia Pty Ltd (AECOM) has been engaged by MMG Dugald River Pty Ltd (MMG) to provide preliminary noise levels associated with the Construction, Operational and Decommissioning phase of the Dugald River Wind Farm (the Project).

The predicted noise levels presented in this letter are preliminary and were prepared to provide general information to MMG to inform next steps for engagement with the Department of Environment & Science.

2.0 Predicted Noise Levels

Predicted noise levels associated with the Construction, Operational and Decommissioning phase of the Project are presented in this letter.

Only one noise sensitive land use receptor has been identified in this study, Receptor R03, residential property.

Predicted noise levels are presented in this letter using the L_{Aeq} descriptor. The L_{Aeq} represent the time averaged A-weighted equivalent continuous sound pressure level. As sound levels usually vary over time, this measure converts the varying levels to an equivalent constant level of sound.

The applicable noise limits stated in the Environmental Authority (EA) for Dugald River Mine use the $L_{Aeq,adj,15min}$ descriptor. This descriptor means an A-weighted sound pressure level of a continuous steady sound, adjusted for tonal character, that within a 15 minute period has the same mean square sound pressure of a sound that varies with time.

2.1 Construction Phase

Construction noise contours were calculated for two typical construction scenarios, as described below:

- Construction Scenario 1 – Earthworks
- Construction Scenario 2 – Turbine Installation

Typical construction equipment and sound power levels (SWL) have been applied as follows:

Table 1 Construction noise modelling scenarios and equipment

Scenario	Equipment	Number of	Overall SWL L_{Aeq}, dB(A)[1]
Scenario 1 (Earthworks)	Cat D9 Dozer	2	108
	Soil Compactor	1	106
	12t Pad foot rollers	2	101
	30t Excavator	3	103
	45t Excavator	1	107
	30t Dump trucks	4	109
	15kL Watercarts	3	93
	Cat 14m Grader	1	112

Scenario	Equipment	Number of	Overall SWL L_{Aeq}, dB(A)[1]
Scenario 2 (Turbine Installation)	600t Crawler crane	1	103
	220t All terrain crane	1	105
	25t Franna crane	1	105
	4t Telehandler	1	104
	85ft EWP	1	85
	Flatbed truck (delivery)	2	106
	4wd utes	3	90
	Pressure washer	1	90
	Diesel generator (for lighting)	1	100
	Electrical torque tool	2	104
	Lighting towers	2	93

Location of wind turbines and sensitive receiver were extracted from document titled "*Dougald River IPP Reference Design General Arrangement"*, drawing No. 0016-EGA-3120-E-0001-0, revision 0, dated 19 September 2023.

2.1.1 Assumptions

- Construction scenarios assumes worst case where all construction equipment would be operating simultaneously.
- Construction would be undertaken sequentially one wind turbine at a time, i.e. not concurrently.
- Construction equipment noise sources modelled at 2.0 metres above ground level.
- Noise contours calculated at 1.5 metres above ground level.

The Construction Phase predicted noise contours, A-weighted L_{Aeq} sound pressure levels (SPL), are presented in Appendix A.

2.2 Operational Phase

AECOM was engaged by MMG to undertake a noise impact assessment for the Project in July 2023. The noise impact assessment was prepared in accordance with the State Code 23 Wind Farm Development Planning Guidelines (Planning Guideline), dated February 2022.

AECOM report titled "*Dugald River Mine Wind Farm Noise Impact Assessment*", reference report 60698169-ACRP-0001, revision 1, dated 21 July 2023 (AECOM Wind Farm Noise Impact Assessment Report), presents the Project's operational noise contours in Appendix C.

The operational noise contours presented in the AECOM Wind Farm Noise Impact Assessment Report represent highest noise levels from the Project.

The AECOM Wind Farm Noise Impact Assessment Report is appended to this letter in Appendix B.

2.3 Decommissioning Phase

Noise levels associated with Decommissioning Phase of the Project are assumed to be equivalent to the noise levels associated with Construction Scenario 2 (Turbine Installation). Refer to Appendix A for predicted noise contours.

Yours faithfully

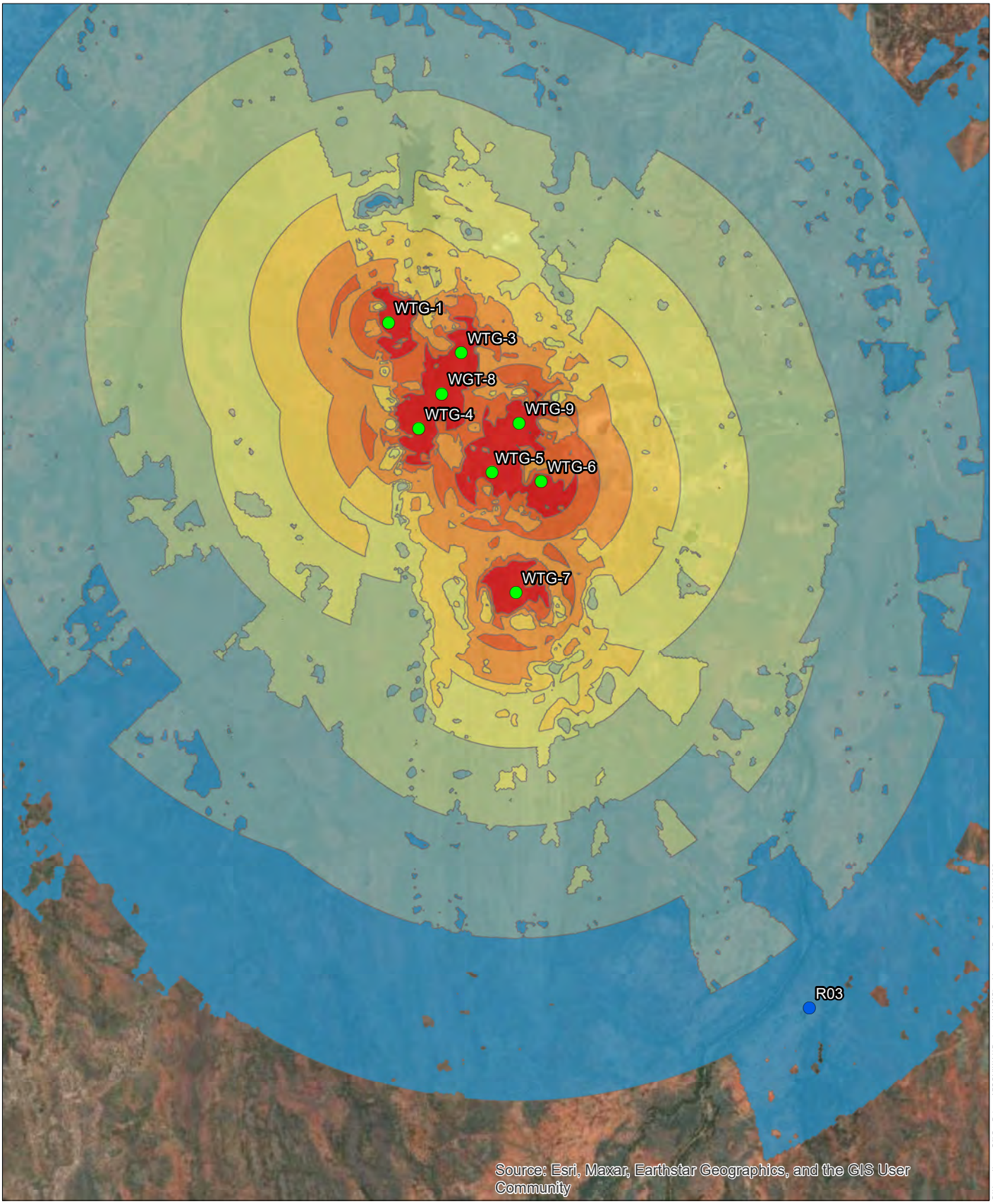


Patrick Martinez
Technical Director - Acoustics
patrick.martinez@aecom.com
Mobile: +61 431 257 229

cc: Dane Nobel (AECOM)

Appendix A

Construction Phase Noise Contours



Dugald River Wind Farm - Construction Scenario 1 - L_{Aeq}

N 0 1 2 km

AECOM

- Noise Sensitive Receptor
- Turbine Locations

Sound Pressure Level, L_{Aeq} dB(A)

20 25 30 35 40 45 50 55

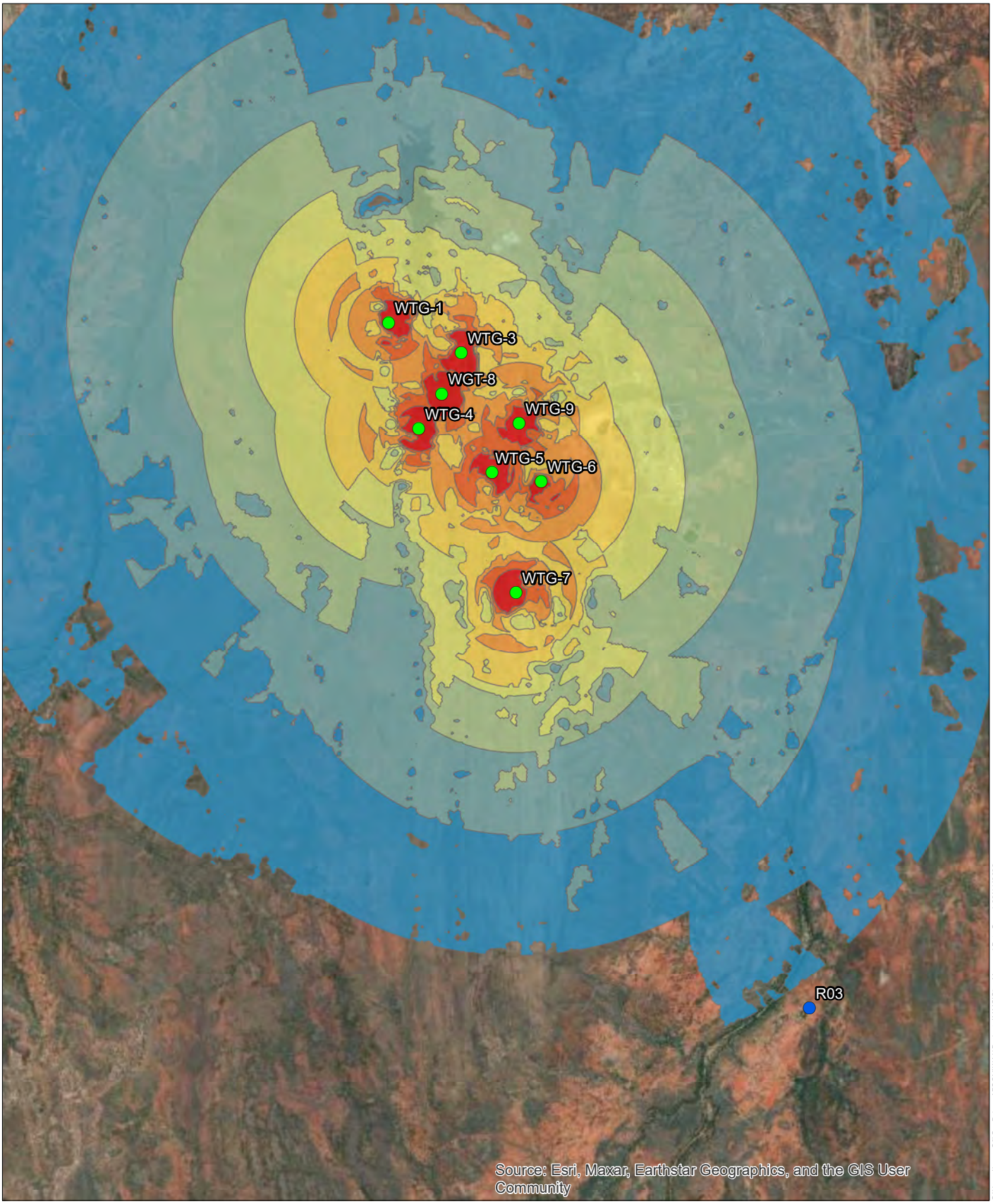
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Dugald River Wind Farm - Construction Scenario 2 - L_{Aeq}

N 0 1 2 km

AECOM

- Noise Sensitive Receptor
- Turbine Locations

Sound Pressure Level, L_{Aeq} dB(A)

20 25 30 35 40 45 50 55

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Appendix B

AECOM Wind Farm Noise Impact Assessment Report

Prepared for
MMG Dugald River Pty Ltd
ABN: 19 083 405 556

Dugald River Mine Wind Farm

Noise Impact Assessment

21-Jul-2023
Dugald River Mine Wind Farm

aecom.com

Delivering a better world

Dugald River Mine Wind Farm

Noise Impact Assessment

Client: MMG Dugald River Pty Ltd

ABN: 19 083 405 556

Prepared by

AECOM Australia Pty Ltd
Turrbal and Jagera Country, Level 8, 540 Wickham Street, PO Box 1307, Fortitude Valley QLD 4006, Australia
T +61 7 3056 4800 www.aecom.com
ABN 20 093 846 925

21-Jul-2023

Job No.: 60698169

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Quality Information

Document	Dugald River Mine Wind Farm
Ref	60698169
Date	21-Jul-2023
Originator	Omar Al-Busaidi
Reviewer	Tim Osborne

Revision History

Rev	Revision Date	Details	Approved	
			Name/Position	Signature
A	05-Jul-2023	Draft	Tim Osborne Team Leader - Acoustics	
1	21-Jul-2023	Final	Tim Osborne Team Leader - Acoustics	

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Executive Summary

AECOM has been engaged by MMG Dugald River Pty Ltd (MMG) to undertake a noise impact assessment for the development of a wind farm located at MMG Australia's Dugald River mine located approximately 65 km to the north-west of Cloncurry in North West Queensland.

This report presents a noise impact assessment for the Dugald River Mine Wind Farm (the Project) in support of a development application. The project involves the construction and operation of eight wind turbines.

The assessment was conducted in accordance with the State Code 23: Wind farm development (State Code 23) of the State Development Assessment Provisions (SDAP), version 3.0, effective 18 February 2022 and the State Code 23 Wind Farm Development Planning Guidelines (Planning Guideline), dated February 2022.

A computational noise model was created to predict the noise levels from the operation of the Project at the three sensitive receptors. The final project design may change the positions of the turbines due to micrositing, and the turbine make and model may change. This assessment has been based on the Goldwind 6.0MW, GW165 turbine.

Based on the results of the noise predictions, the noise emissions from the Project are expected to comply with the requirements of State Code 23 at all host and non-host sensitive receptors.

No other new or proposed wind farm developments have been identified within the vicinity of the Project, and cumulative impacts from mining activities associated with the existing Dugald River Mine are not expected to be problematic for achieving compliance with State Code 23.

The Planning Guideline outlines requirements for a construction management plan, which includes noise and vibration impact control measures to minimise noise and vibration impacts at sensitive receptors. Management and mitigation measures to reduce noise and vibration impacts associated with construction of the Project could include management of construction hours, consultation where required, site management practices and potential plant and equipment mitigation measures.

1.0 Introduction

AECOM Australia Pty Ltd (AECOM) was commissioned by MMG Dugald River Pty Ltd (MMG) to undertake a noise impact assessment for the proposed Dugald River Mine Wind Farm (the Project) within the Mining Lease Area of Dugald River Mine.

Dugald River Mine is located approximately 65 km to the north-west of Cloncurry in North West Queensland. The Project involves the construction and operation of eight wind turbines.

This report presents the noise impact assessment for the Project in support of a development application. The assessment was conducted in accordance with State Code 23: Wind farm development (State Code 23) of the State Development Assessment Provisions (SDAP), version 2.4, effective 16 November 2018 and the State Code 23: Wind Farm Development Planning Guidelines (Planning Guideline), dated February 2022.

The acoustic terminology used in this report is summarised in Appendix A.

2.0 Noise Criteria

2.1 Acoustic Amenity

The acoustic amenity performance outcomes listed in State Code 23 were used in this assessment. The acoustic amenity performance outcomes, as per State Code 23, are presented in Table 1.

Table 1 Extract from Table 23.1 of State Code 23

Performance Outcomes	Acceptable Outcomes
PO10 Development is sited and designed to protect the amenity of existing or approved **sensitive land uses** on **non-host lots** from acoustic impacts.	**A10.1** A separation distance of at least 1500 metres is achieved between **wind turbines** and existing or approved **sensitive land uses** on **non-host lots**. OR **A10.2** Where **wind turbines** are proposed within 1500 metres of existing or approved **sensitive land uses** on **non-host lots**, written agreements (**deeds of release**) from all affected **non-host lot** owners are provided accepting the reduced setback.
PO11 The predicted acoustic level at all noise affected existing or approved **sensitive land uses** on **host lots** does not exceed the criteria stated in table 23.2.	No acceptable outcome is provided.
PO12 The predicted acoustic levels at all noise affected existing or approved **sensitive land uses** on **non-host lots** does not exceed the criteria stated in table 23.3.	No acceptable outcome is provided.
PO13 Construction activities associated with the development avoid, or minimise and mitigate, adverse impacts on **environmental values, water quality objectives**, amenity local transport networks and road infrastructure.	No acceptable outcome is provided.

One non-host lot sensitive receptor, Receptor R03, has been identified in this assessment. The smallest separation distance of the wind turbines from Receptor R03 is 5,732 m, which satisfies the minimum 1,500 m separation distance stated in Acceptable Outcome A10.1. The site plan showing the separation distance and a table of the eight wind turbine separation distances from Receptor R03 are provided in Appendix G.

2.2 Operational Noise Limits

State Code 23 outlines acoustic amenity criteria for both host and non-host lots, where a host lot is defined as a parcel of land that accommodates any part of a wind farm development, and non-host lot is defined as a lot no part of which is used for wind farm or part of a wind farm. The criteria applicable for these are outlined in Table 2 and Table 3.

Table 2 Table 23.2 from the State Code 23 (host lots)

Noise description	Acoustic level does not exceed
The outdoor (free-field) night-time (10pm to 6am) A-weighted equivalent acoustic level (L_{Aeq}),	1. 45dB(A), or 2. The background noise (L_{A90}) by more than 5dB(A);

Noise description	Acoustic level does not exceed
assessed at all noise affected existing approved **sensitive land uses**	whichever is the greater, for wind speed from **cut-in** to rated power of the **wind turbine** and each integer wind speed in between referenced to **hub height**.

Table 3 Table 23.3 from the State Code 23 (non-host lots)

Noise description	Acoustic level does not exceed
The outdoor (free-field) night-time (10pm to 6am) A-weighted equivalent acoustic level (L_{Aeq}), assessed at all noise affected existing or approved **sensitive land uses**.	1. 35dB(A); 2. the background noise (L_{A90}) by more than 5dB(A); whichever is the greater, for wind speed from **cut-in** to rated power of the **wind turbine** and each integer wind speed in between referenced to **hub height**.
The outdoor (free-field) day-time (6am to 10pm) A-weighted equivalent acoustic level (L_{Aeq}), assessed at all noise affected existing or approved **sensitive land uses**.	1. 37dB(A), or 2. The background noise (L_{A90}) by more than 5dB(A); whichever is the greater, for wind speed from **cut-in** to rated power of the **wind turbine** and each integer wind speed in between referenced to **hub height**.

A free-field night-time A-weighted equivalent acoustic level (L_{Aeq}) of 45 dB(A) or background noise (L_{A90}) plus 5 dB (whichever is greater) should not be exceeded at these locations, as per State Code 23.

For all the sensitive land uses on non-host lots where landowners have not entered a commercial agreement with the wind farm proponent, a free-field night-time A-weighted equivalent acoustic level (L_{Aeq}) of 35 dB(A) or background noise (L_{A90}) plus 5 dB (whichever is greater) is applied.

Background noise monitoring has not been undertaken, as it is not necessarily required to demonstrate compliance with State Code 23. As such, the minimum outdoor (free-field) noise limits for host and non-host lots have been used for this assessment and are summarised in Table 4.

Table 4 Project Noise Limits

Receptor Type	Noise Limits L_{Aeq} dB(A)	
	Day (6am – 10pm)	Night (10pm – 6am)
Host lots	-	45
Non-host lots	37	35

2.3 Construction Noise and Vibration

Performance outcome PO13 for construction management is outlined in Table 23.2.1 of the State Code 23. The Planning Guideline specifies that a construction management plan is to be prepared by a suitably qualified person, identifying potential construction impacts and the proposed measures to be undertaken to avoid, manage, and mitigate the identified impacts.

This plan will include the following:

- Description and locations of sensitive land uses that may be affected by noise, vibration, and dust emissions from the construction work.
- Description of the activities and equipment likely to generate noise, vibration, and dust emissions.

- Description of the noise, vibration, and dust impact control measures to be implemented to minimise noise, vibration, and dust impacts at sensitive uses.
- Description of the methods to be used to monitor performance and receive, record, and respond to complaints.

Construction noise and vibration management from the construction of the Project is discussed further in Section 5.0.

3.0 Wind Farm Operational Noise Modelling

A three-dimensional computer noise model of the Project site was created in the acoustic modelling software package SoundPLAN Version 8.2, to predict operational noise levels for the Project. Environmental noise predictions were carried out using the algorithms from ISO 9613.2:1996 *Acoustics –Attenuation of Sound during propagation outdoors – Part 2: General method of calculation* and UK Institute of Acoustics - *A Good Practice Guide to the Application of ETSU-R-97 for the Assessment and Rating of Wind Turbine Noise* (2013), (IoA Wind turbines 2013) as implemented within the SoundPLAN software package and allowed by the Planning Guideline.

The following data was used to create the computer noise model:

- 10m ground contours from the Queensland Spatial Catalogue QSpatial have been used in the assessment. Given the separation distance between the wind turbines and the three sensitive receptors, as well as the relative flatness of the land between the wind turbines and the receptors, 10m contours have been deemed sufficient for the purpose of this assessment.
- Proposed Project layout containing eight wind turbines, dated 30 September 2022. The final layout is subject to change due to micro-siting during the detailed design phase. A single noise modelling scenario, based on the operation of eight wind turbines, has been developed.
- Three sensitive receptors have been identified within the vicinity of the Project. Two of the sensitive receptors are located within the Dugald River Mine mining leases, and one is a neighbouring residential property to the south. The receptors are described as follows:
  - Receptor R01: Dugald River Mine accommodation camp
  - Receptor R02: Dugald River Mine fly-camp and administration area
  - Receptor R03: Residential property on Land Parcel 92SP303378

An aerial view of the Project showing the location of the turbines and sensitive receptors is provided in Appendix B. Geographic coordinates of the turbines and sensitive receptors can be found in Appendix E and Appendix F, respectively.

The following parameters were entered in the SoundPLAN noise model, in accordance with the Planning Guideline:

- Atmospheric conditions at 10°C temperature and 70% relative humidity.
- 50% acoustically hard ground and 50% acoustically soft ground (0.5 ground factor).
- Barrier attenuation of no greater than 2 dB(A).
- 4 metre receptor height, as specified in the Planning Guideline when using ISO 9613:2 for conducting noise predictions.
- The model incorporates a 3 dB(A) correction where a concave ground profile exists between a wind turbine and a receptor where $h_m \geq 1.5 \cdot \frac{|h_s - h_r|}{2}$ as outlined in the Planning Guideline.
- Goldwind's 6.0MW, GW165 turbine model was chosen as the indicative model with which to complete the assessment. 1/3 octave sound power data was provided by Goldwind at hub height wind speed for from 12-14m/s. The worst-case noise scenario was used to complete the assessment; a hub height wind speed of 12m/s produced the greatest noise levels for the specified turbine model. The reference sound power level and spectrum, as entered in the model, is presented in Table 5. The sound power spectra used in modelling (20 Hz - 10 kHz) extends beyond the minimum sound power level reporting requirement between 63 Hz to 4 kHz stated in the Planning Guideline.
- The overall sound power levels for each integer wind speed from 6m/s to 12m/s are presented in Table 6.

- Based on the GW165 turbine model, the wind turbines were entered in the noise model at a hub height of 130 metres above ground level with a rotor diameter of 165 metres.

Table 5 GW165/5.6MW Sound power level spectrum (12m/s)

1/3 octave frequency band (Hz) sound power level, in dB(A)														
20	**25**	**31**	**40**	**50**	**63**	**80**	**100**	**125**	**160**	**200**	**250**	**315**	**400**	**Overall dB(A)**
64.6	68.8	72.7	78.1	83.2	86.2	90.2	92.5	95.1	98.2	99.5	100.6	101.8	101.6	
500	**630**	**800**	**1k**	**1.25k**	**1.6k**	**2k**	**2.5k**	**3.15k**	**4k**	**5k**	**6.3k**	**8k**	**10k**	
101.0	100.3	99.4	98.8	97.3	94.0	89.6	85.3	80.6	73.9	66.2	63.9	63.3	62.3	**110.5**

Table 6 Estimated overall sound power levels of GW165-6.0 MW at each integer wind speed from 6m/s - 12m/s

Wind speed at hub height (m/s)	Noise Level dB(A)
6.0	102.2
7.0	105.6
8.0	108.0
9.0	109.5
10.0	110.3
11.0	110.3
12.0	110.5

The intent of State Code 23 is that compliance will be confirmed by the successful contractor once the final turbine type and layout is known.

No penalty for tonality was applied (0.0 dB penalty) in the noise model. The Planning Guideline states that:

> *"A correctly operating wind turbine may exhibit sound with tonal characteristics. These characteristics can be minimised or avoided by careful design and/or mitigation measures. Wind farm developers should avoid the installation of wind turbines which exhibit sound with tonal characteristics by specifying the supply of wind turbines from a manufacturer which guarantees that the supplied wind turbines will not exhibit tonal characteristics at residences."*

Additionally, the Planning Guideline states that amplitude modulation has been taken into account in determining the noise criteria, and therefore no additional penalty or assessment of amplitude modulation has been applied. The Planning Guideline states that:

> *"Amplitude Modulation (AM) is an expected characteristic of wind turbine noise (commonly described as a 'swish'). Enhanced amplitude modulation (EAM) has been reported from a limited number of wind farms on limited occasions. Considerable research has been conducted and is ongoing to determine and fully understand the sources of amplitude modulation generation and the conditions which may enhance amplitude modulation to a level which is considered by receptors to be an adverse noise characteristic. Current international research is aimed at defining and measuring EAM further so that suitable assessment standards can be developed, if necessary."*

4.0 Wind Farm Operational Noise Levels

4.1 Wind Farm Noise

The predicted wind farm noise levels for the eight primary wind turbines are presented in Table 7. The noise levels are predicted for each integer wind speed between 6m/s and 12m/s.

Table 7 presents forecast receptor noise levels for the operation of the primary wind turbines at each integer wind speed between 6m/s and 12m/s.

Table 7 Predicted wind farm noise levels – Primary wind turbine locations (eight wind turbines)

Receptor ID	Noise limit dB(A)	Turbine integer wind speed (m/s)	Predicted noise level L_{Aeq} dB(A)
R01	Night – 45	6	33
		7	37
		8	39
		9	40
		10	41
		11	41
		12	41
R02	Night – 45	6	31
		7	35
		8	37
		9	39
		10	39
		11	39
		12	40
R03	Night – 35 Day – 37	6	16
		7	19
		8	21
		9	23
		10	24
		11	24
		12	24

The highest predicted noise level at a host lot receptor is 41 dB(A) L_{Aeq} at R01, which complies with the 45 dB(A) L_{Aeq} night noise limit. The highest predicted noise level at a non-host lot receptor is 24 dB(A) L_{Aeq} at R03, which complies with the 35 dB(A) L_{Aeq} night noise limit. Therefore, noise emission levels are predicted to comply with the noise requirements of State Code 23 for all receptors.

A map showing noise contours for the 12m/s turbine integer wind speed operation is provided in Appendix C. It is noted that the noise contour map is generated based on a grid of calculations which are interpolated to generate contours. The single point calculations shown above should be referred to for specific noise levels at each receptor.

Appendix D presents plots of the forecast noise levels against the criteria at each of the receptors.

4.2 Cumulative Impacts

No other new or proposed wind farm developments have been identified within the vicinity of the Project that are likely to result in combined or successive noise impacts with the Project.

Mining operation noise may contribute to cumulative noise levels at the sensitive receptors. The EA conditions for Dugald River Mine include operational mining noise limits, with the most stringent noise limit being 30 dBA L_{Aeq} during the night (10pm to 7am). Even if Dugald River Mine were to produce noise levels up to their night noise limit of 30 dBA L_{Aeq}, combined with the predicted highest wind farm noise level of 24 dBA L_{Aeq} at Receptor R03, this would still comply with the 35 dBA L_{Aeq} State Code 23 night noise limit. Therefore, cumulative noise impacts are not expected to be problematic with respect to compliance with State Code 23.

5.0 Wind Farm Construction Noise and Vibration

The Planning Guideline outlines requirements for a construction management plan, which includes noise and vibration impact control measures to minimise noise and vibration impacts at sensitive receptors.

This report addresses construction noise and vibration in general terms. Specific details of the construction methodology and equipment are not known at this early stage of the Project.

It is anticipated that the construction work may include excavation, rock hammering, drilling, bulldozing, crushing and screening, concrete batching and, subject to geotechnical conditions, possible blasting. Noise will be generated by mobile plant such as excavators, bulldozers, mobile cranes and the movement of heavy vehicles.

There is no legislation in Queensland that specifically sets construction noise limits. For construction activity in Queensland, the *Environmental Protection Act 1994* states that:

"A person must not carry out building work in a way that makes an audible noise –

a. On a business day or Saturday, before 6:30am or after 6:30pm; or

b. On any other day, at any time."

Thus, noise from construction activity is generally controlled through limiting the hours of operation, and through application of best practice management techniques.

A number of 'good practice' management and mitigation measures have been outlined below to reduce noise and vibration impacts associated with construction of the Project and to minimise the likelihood of adverse impacts to sensitive receptors:

- Management of construction hours to avoid or minimise noise impacts to sensitive receptors.
- Limitation of construction hours for noisy activities to Monday to Saturday where practicable.
- Construction work out of hours to be assessed on a case by case basis and the work program assessed against the noise impact on nearest residencies.
- Consultation with sensitive receptors and/or Council where warranted to communicate plans for construction works.
- Site management practices to minimise noise emission, including designated entry/exit points, equipment operational practices to minimise noise (e.g. avoid leaving equipment idling, minimise amount of reversing, training/induction for workers).
- Example measures to reduce noise emissions from construction plant include fitting exhaust mufflers, using reversing alarms that emit a broadband noise (e.g. white noise) rather than a beep, maintaining plant in good working order and following industry standard construction methodologies.

6.0 Conclusion

A noise impact assessment has been undertaken for the proposed wind farm at Dugald River Mine. Eight wind turbines are currently proposed for the wind farm. Noise emissions from operation of the Project have been predicted at the three sensitive receptors.

The final project design may change the positions of the turbines due to micrositing, and the turbine make and model may change. This assessment has been based on the Goldwind 6.0MW, GW165 turbine.

The smallest separation distance of the wind turbines from Receptor R03 satisfies the minimum 1,500 m separation distance stated in Acceptable Outcome A10.1. The predicted noise emission levels are provided in tabular format in Section 4.1 and as noise contours in Appendix C. The predicted wind farm noise levels comply with the State Code 23 noise criteria at the surrounding sensitive receptors.

As outlined in Section 4.2, no other new or proposed wind farm developments have been identified within the vicinity of the Project, and cumulative impacts from mining activities associated with the existing Dugald River Mine are not expected to be problematic for achieving compliance with State Code 23.

Construction noise and vibration is addressed in Section 5.0. A construction management plan can include noise and vibration impact control measures to minimise noise and vibration impacts at sensitive receptors as outlined in the Planning Guideline. Example management and mitigation measures have been outlined in Section 5.0 to reduce noise and vibration impacts associated with construction of the Project, including management of construction hours, consultation where required, site management practices and potential plant and equipment mitigation measures.

Appendix A

Acoustic Terminology

Appendix A Acoustic Terminology

Ambient Sound	The totally encompassing sound in a given situation at a given time, composed of sound from all sources near and far.
Audible Range	The limits of frequency which are audible or heard as sound. The normal ear in young adults detects sound having frequencies in the region 20 Hz to 20 kHz, although it is possible for some people to detect frequencies outside these limits.
Attended Measurement	Measurements that are attended by a person and measured with a sound level meter.
Decibel [dB]	The level of noise is measured objectively using a Sound Level Meter. The following are examples of the decibel readings of everyday sounds; 30 dB(A) A quiet library or in a quiet location in the country 45 dB(A) Typical office space. Ambience in the city at night 60 dB(A) City centre at lunch time 70 dB(A) The sound of a car passing on the Street 80 dB(A) Loud music played at home 90 dB(A) The sound of a truck passing on the Street 100 dB(A) The sound of a rock band.
dB(A)	A-weighted decibels. The ear is not as effective in hearing low frequency sounds as it is in hearing high frequency sounds. That is, low frequency sounds are not perceived to be as loud as high frequency sounds of the same dB level. The sound level meter replicates the human response of the ear by using an electronic filter which is called the “A” filter. A sound level measured with this filter switched on is denoted as dB(A). Practically all noise is assessed using the “A” filter. The sound pressure level in dB(A) gives a close indication of the subjective loudness of the noise.
Impulsiveness	Noise that comprises distinct impulses in the noise (bangs, clicks, clatters, or thumps) etc.
Intermittent	Stopping and starting at irregular intervals.
L_{Amax}	The A-weighted maximum sound pressure level measured over a given period.
L_{Aeq}	The A-weighted “equivalent noise level” is the summation of noise events that are integrated over a selected period of time.
$L_{Aeq,10min}$	The energy-averaged level of the total noise measured without adjustment for the character of the noise (e.g. tonal or impulsive), over a period of 10 minutes.
L_{max}	Maximum noise level of the measurement period.
L_{10}	Noise level exceeded for 10% of the measurement period. The L_{10} represents the intrusive noise level and is often used to represent traffic/music noise.
L_{90}	Noise level exceeded for 90% of the measurement period. This represents the background noise level excluding nearby sources.
$L_{w(A)}$	A ‘Weighted’ sound power level, measured in dB(A)
Tonality	A characteristic of noise, describing a sound that contains a perceptible pitch or tone. As a general rule, a prominent tonal component may be detected in one-third octave spectra if the level of a one-third octave band exceeds the level of the adjected bands by 5 dB or more.

Appendix B

Project Aerial View

Appendix B Project Aerial View



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N

DATUM GDA 1994, PROJECTION MGA ZONE 54

0 550 1,100 2,200

metres

1:40,000 (when printed at A3)

Legend

- Sensitive Receptor
- Wind Turbine (primary)
- Wind Turbine (potential)

DISCLAIMER: Map is to be read in conjunction with the Report 60663430-AC-LR-001

Dugald River Wind Farm
Turbine Layout and Sensitive Receptor Locations

PROJECT ID	60698169
CREATED BY	OB
LAST MODIFIED	OB - 05 Jul 2023
VERSION:	01

Figure

Appendix B - 01

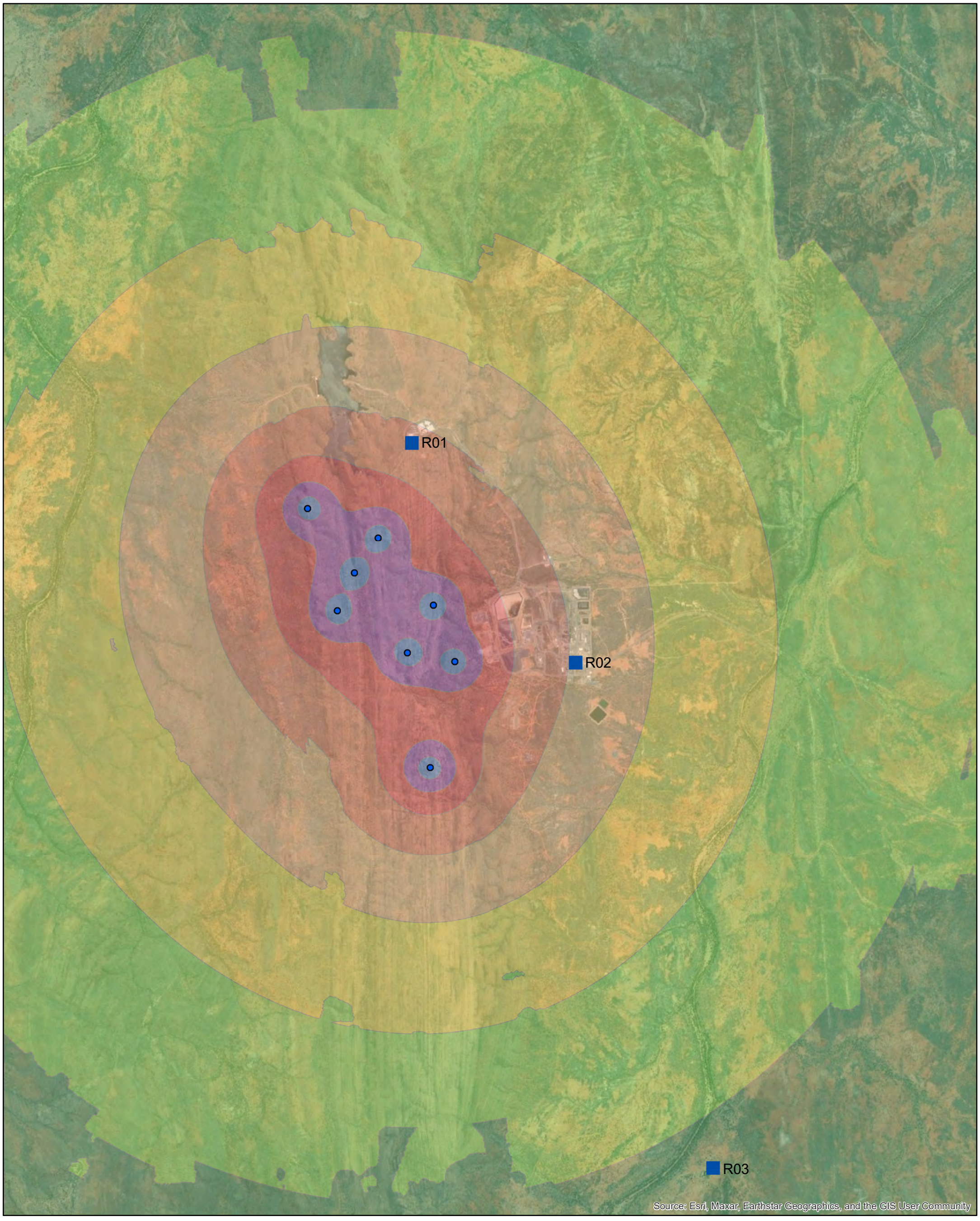
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A3 size

Appendix C

Noise Contour Plots

Appendix C Noise Contour Plots



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0 550 1,100 2,200

metres

1:40,000 (when printed at A3)

Legend

Grid Noise Contours

$L_{Aeq\ 10min}$ dB(A) Noise Levels at 4m above ground

- 0 - 25
- 25 - 30
- 30 - 35
- 35 - 40
- 40 - 45
- 45 - 50
- 50 - 55
- 55 - 60

- Sensitive Receptor
- Wind Turbine (primary)

DISCLAIMER: Map is to be read in conjunction with the Report 60663430-AC-LR-001

Dugald River Wind Farm
Primary Wind Turbines Only
$L_{Aeq\ 10min}$ Noise Contour Map
(Reference Winds Speed: 12m/s at Hub Height)

PROJECT ID	60698169
CREATED BY	OB
LAST MODIFIED	OB - 03 Jul 2023
VERSION:	01

Figure

Appendix C - 01

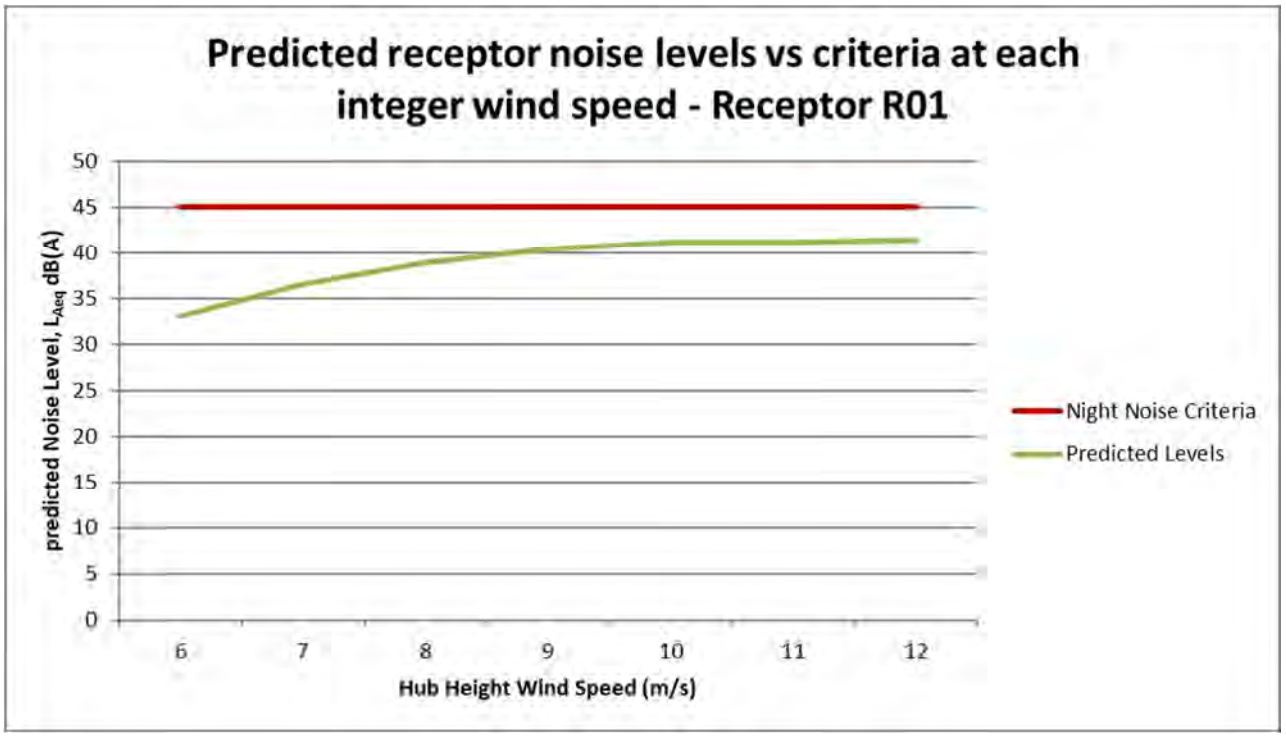
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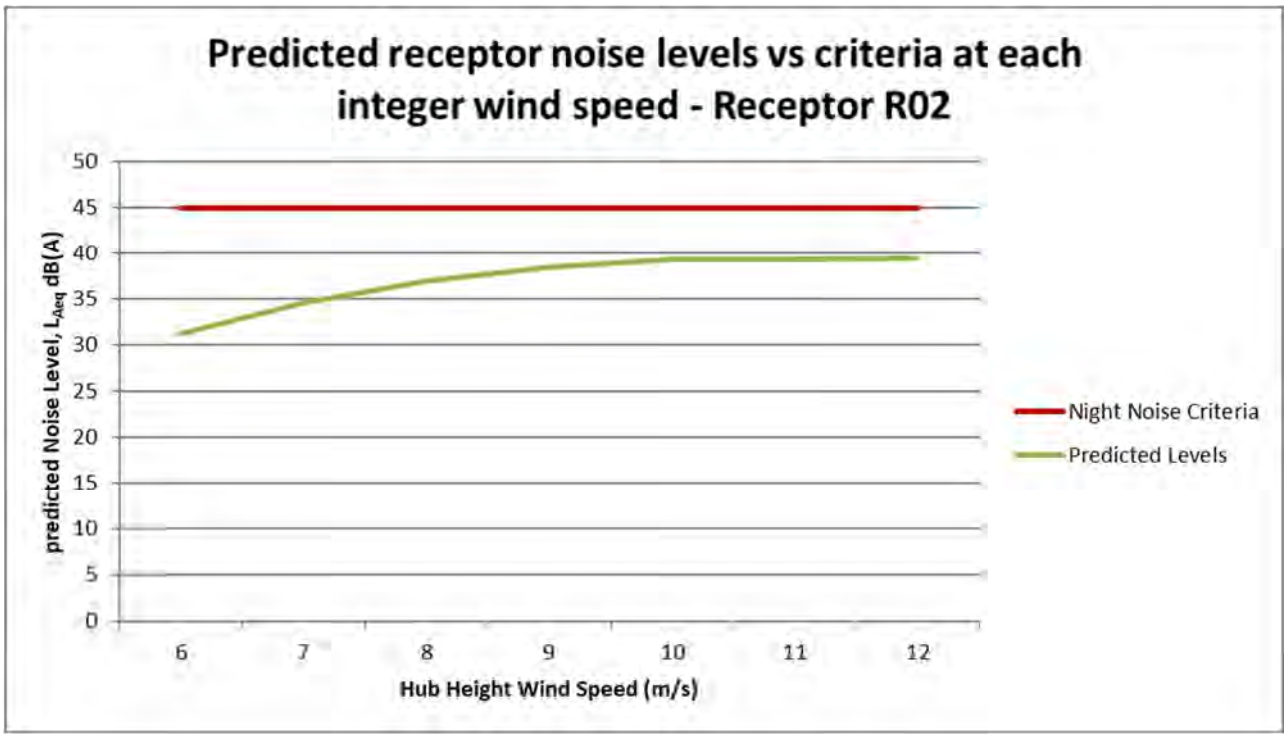
A3 size

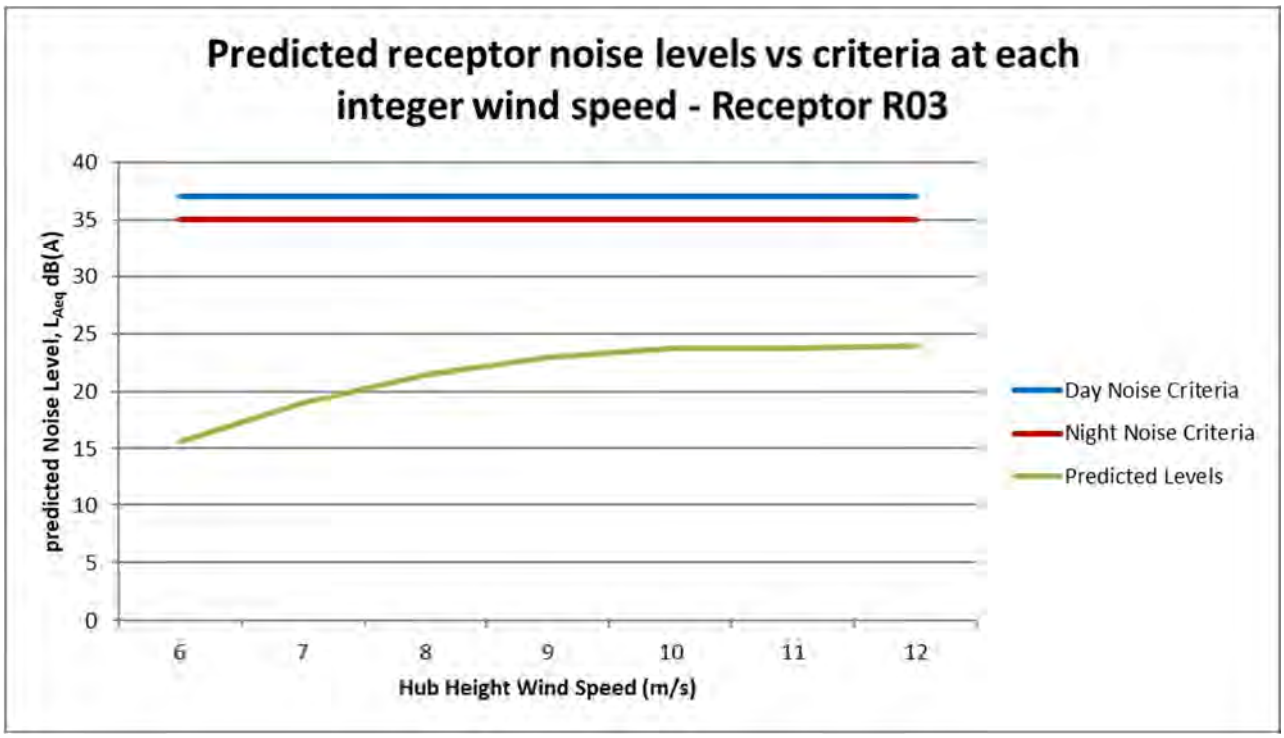
Appendix D

Predicted Noise Levels vs Criteria

Appendix D Predicted Noise Levels vs Criteria






Predicted receptor noise levels vs criteria at each integer wind speed - Receptor R03
predicted Noise Level, L_{Aeq} dB(A)
40
35
30
25
20
15
10
5
0
6
7
8
9
10
11
12
Hub Height Wind Speed (m/s)
Day Noise Criteria
Night Noise Criteria
Predicted Levels

Appendix E

Wind Turbine Locations

Appendix E Wind Turbine Locations

The assessed primary wind turbine locations are presented in Table 8.

Table 8 Wind Turbine Locations

Turbine Number	GDA 1994 MGA Zone 54	
	Easting	Northing
WTG-01	408926	7762060
WTG-03	409752	7761721
WTG-04	409275	7760871
WTG-05	410095	7760377
WTG-06	410651	7760276
WTG-07	410363	7759030
WTG-08	409475	7761311
WTG-09	410399	7760933

Appendix F

Sensitive Receptor Locations

Appendix F Sensitive Receptor Locations

The sensitive receptor locations considered in this assessment are presented in Table 9.

Table 9 Sensitive Receptor Locations

Receptor ID	GDA 1994 MGA Zone 54	
	Easting	Northing
R01	410144	7762838
R02	412060	7760264
R03	413668	7754347

Appendix G

Wind Turbine Setback Distances

Appendix G Wind Turbine Setback Distance

The setback distances for all eight wind turbines from the non-host sensitive receptor R03 are presented in Table 10.

Table 10 Wind Turbines Setback Distances from Receptor R03

Turbine Number	GDA 1994 MGA Zone 54		Separation Distance to R03 (m)
	Easting	Northing	
WTG-01	408926	7762060	9054
WTG-03	409752	7761721	8349
WTG-04	409275	7760871	7865
WTG-05	410095	7760377	7009
WTG-06	410651	7760276	6652
WTG-07	410363	7759030	5732
WTG-08	409475	7761311	8129
WTG-09	410399	7760933	7353



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0 550 1,100 2,200

metres

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Legend

- Receptor R03
- Wind Turbine

Dugald River Wind Farm
Turbine Setback Distance from Receptor R03

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Figure

Appendix G - 01

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A3 size