# Quarry Impact Assessment

## Winterbourne Wind Farm Quarry
## 'Bark Hut'
## Lot 95 DP1128816
## Walcha, NSW

August 2024



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## Quality Assurance

This document has been prepared, checked and released by Australian Resource Development Group Pty Limited.

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This document has been authorised by

Dr Justin Meleo

Date: 30 August 2024

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# 1 Project Overview

## 1.1 Background

WinterbourneWind Pty Ltd (WWPL) is proposing a temporary, project-specific quarry as development that is ancillary to the Winterbourne Wind Farm (WWF) Project. The quarry is being proposed as part of an Amendment to the development application for the WWF Project. The WWF Project has a current estimated demand of 1,000,000 tonnes (1 Mt) of quarry materials (*e.g.* road base/capping; concrete aggregates; gabion/drainage rock; and thermal bedding sand) over the estimated 3 – 4 year construction period. It is proposed that the majority of this material could be supplied from this quarry site. The sole purpose of the quarry would be to supply materials to the WWF Project only.

The quarry would be located within the existing WWF Project Area (refer **Figure 1**) (*i.e.* an 'on-site' quarry) and be located on project-associated land adjacent to Bark Hut Road, a key transport spine for much of the proposed project infrastructure, and immediately adjacent to the access track for wind turbines B177, B100A, B101A and B102).

Justification for the on-site quarry to be considered as development that is ancillary to the WWF Project is provided by the proposed quarry being temporary in nature, it occupying a very small proportion of the WWF Project Area, and having a clear nexus with the WWF Project, given it is proposed to be operated for the sole purpose of facilitating the construction of the WWF Project.

Australian Resource Development Group Pty Limited (ARDG) has been engaged to assist with the development of the quarry. Detailed site geological investigations undertaken by ARDG indicate that the quarry resource is suitable for the production of a range of products (*e.g.* roadbase, concrete aggregates, drainage rock) required for construction of the public road upgrades, wind farm access tracks, hardstand areas, turbine foundations and other associated civil works associated with the Project.

Approval for the transport of up to 500,000 tonnes per annum of material from the quarry site to the WWF Project is being sought as development that is 'ancillary development' to Electricity Generation Works as part of an amendment to the application (SSD 10471) that is currently being assessed by the NSW Department of Planning, Housing and Infrastructure (DPHI). An Environmental Protection Licence (EPL) would also be sought for the quarry operation, separate to the EPL required for the WWF Project.

Importantly, as materials for the public road upgrades associated with the WWF Project are proposed to be sourced from the quarry, and the public road upgrades will likely be required to be completed prior to commencement of construction works on the WWF Project, quarry establishment and operations will necessarily need to occur prior to any other construction works associated with the WWF Project. Therefore, the Project Approval will need to be conditioned to reflect this timeline.

The WWF Quarry (the quarry site) is located within the WWF Project Site Boundary on 'Bark Hut' (Lot 95 DP1128816), with direct access form the quarry site on to Bark Hut Road (part of the WWF construction haulage route).

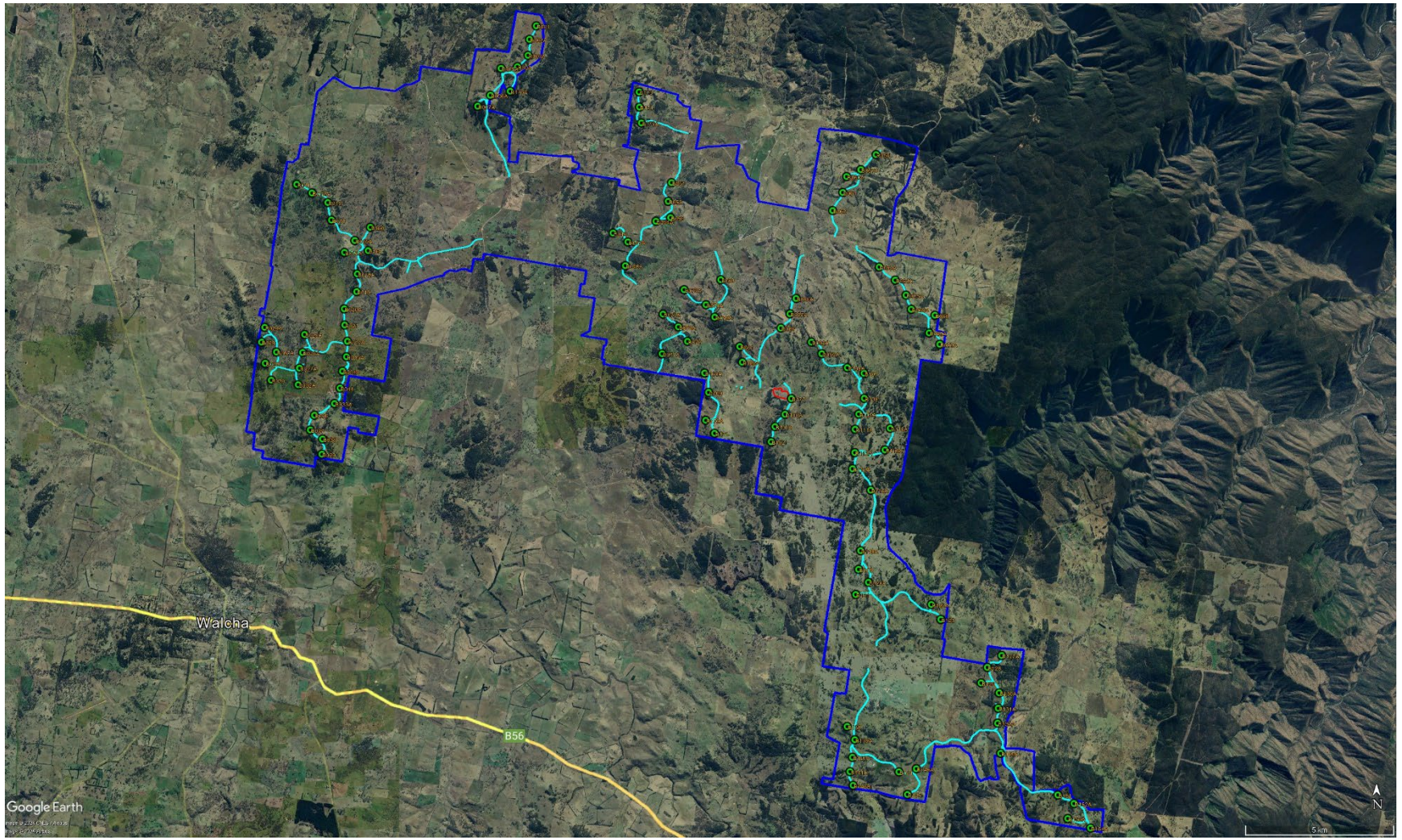



**Figure 1 – Winterbourne Wind Farm Quarry Location. Quarry location shown in red**

Given its location within the WWF Project Site close to where the quarry product will be required during construction, sourcing of construction materials from the quarry site (compared to sourcing from commercial quarries located considerable distances away in the broader region) would significantly reduce construction traffic on the broader local and regional road network. The key material benefits likely to result from the proposed quarry location for the local and broader community include:

- the removal of quarry haul trucks from the Oxley Highway and Thunderbolts Way, as well as from the township of Walcha;
- reduced construction traffic noise amenity impacts for residents and road users, in particular those located along the broader public road network;
- improved road safety (substantially reducing heavy/light vehicle interactions) along the broader public road network;
- reduced damage to the broader public road network by significantly reducing total distances travelled on the broad public road network.

Supply of quarry products from this on-site quarry would also reduce the carbon footprint of the WWF Project (via substantially reduced fuel consumption associated with haulage), and also provide significant construction cost savings, by significantly reducing the haulage distance for construction materials supplied to the Project.

## 1.2 Strategic Need and Benefits

WWPL has recognised the significant benefits associated with sourcing suitable quarry materials in proximity to the wind farm, ancillary works, and public road upgrades/repairs.

There are five (5) commercial quarries in the region ranging between 250 – 395 km in return haul distance that, combined, have the potential to supply all quarry materials required by the WWF Project. One other quarry located west of Walcha (return haul distance of 76 km) is capacity constrained and has the potential to supply only a very small quantity of the Project's materials demand.

Supply of materials to the WWF Project from any of these quarries would require haulage through Walcha. Assuming the currently estimated 1Mt project demand, and haulage by 32t truck and dog vehicles, approximately 62,500 truck movements would be required. The supply of quarry materials from an on-site quarry would therefore have very substantial benefits to residents/businesses of Walcha, as well as residents located on the wider road network and road users in general, by effectively constraining the movement of quarry haul trucks to (and close to) the Project area. Some additional benefits of an on-site quarry are summarised below:

- **Response to community**: the quarry has been proposed, in part, in response to community concerns with the movement of heavy vehicles (HV) along the road network and through Walcha. Therefore, the on-site quarry is a key mitigation strategy that directly addresses community concerns associated with WWF Project construction.
- **Reduced total haulage distance**: this very significant reduction in return haulage distance between the quarry site and the WWF Project also has the effect of substantially reducing

the total haulage distance on the broader public road network by approximately 9.8 million km (assuming 1Mt supply), compared to the alternative of sourcing all quarry material from more distant existing commercial quarries. It would also result in a lower overall disturbance to the road network and reduced requirement for public road upgrades and maintenance.

- **Risk management**: sourcing quarry materials from within the WWF Project area effectively transfers the quarry component of WWF construction traffic from the higher traffic volume (and therefore higher risk) regional road network to the lower traffic volume (and therefore lower risk) proposed haul route close to the WWF. This allows the WWF Project to have greater control of this HV traffic and therefore safety, given this haul traffic will operate in strict accordance with the WWF Traffic Management Plan (TMP).
- **Reduced driver fatigue**: the onsite quarry would reduce the potential for haulage driver fatigue with shorter commutes for drivers between the wind farm work fronts and the on-site quarry, compared to travelling from more distant quarries located in the broader region, all of which have very significant return haulage distances (250 – 395 km).
- **Vehicle interactions**: there would be a significant reduction in the number of potential light vehicle (LV) and HV vehicle interactions. Existing traffic is significantly lower on the local roads that form part of the WWF Project's proposed construction haul route, reducing vehicle interactions and the subsequent probability of road safety incidents with the public, compared to higher traffic volume roads on the broader road network (*e.g.* Oxley Highway / Thunderbolts Way / New England Highway).
- **Local Relationships**: most of the landholdings along the local road network are either associated with the WWF Project or have been directly consulted regarding the Project. This gives the WWF Project the ability to communicate more effectively the traffic impacts along the local road network, which would assist in mitigating the potential for safety incidents, when compared to this process for residents located further away from the WWF Project area and users of the broader regional road network.
- **Reduced HV fleet**: assuming a Project demand of 2000 t/day, sourcing quarry materials from within the WWF Project area would require a fleet of approximately five (5) heavy vehicles, compared to approximately 46 that would be required under the alternative scenario of sourcing all quarry material from commercial quarries in the region. Apart from the simplified logistics associated with a smaller haul fleet, this would have the benefit of reducing the strain on haul fleets in the region and associated workforce resources that are required for other renewable energy projects in the New England REZ and more broadly, on the demand for these resources in the region.
- **Carbon footprint**: an on-site quarry would also reduce the carbon footprint of the WWF Project (via substantially reduced fuel consumption associated with haulage), increase the financial viability of the Project's construction, and put downward pressure on the levelised cost of energy benefitting the end consumers of electricity, by significantly reducing the haulage distance and therefore cost for construction materials.

In summary, the use of a temporary Project-specific quarry to supply quarry materials to the WWF Project is considered to provide a very substantial overall benefit and improvement to the management of traffic and transport for the Project. Potential traffic and transport impacts can be managed and mitigated through appropriate intersection design and compliance with the TMP that will be required to be developed under a Development Consent for the WWF Project.

## 1.3 Alternatives and Options Considered

Various options for the development of a quarry in the vicinity of the WWF Project site have been investigated, including assessing potential site locations within and in close proximity to the WWF Project area. These investigations, however, determined that large areas of the WWF Project area are not suited to the production of quarry materials for the Project, due to the very deeply weathered soils and limited exposure of competent rock close to surface.

From a geological and topographic perspective, the WWF Quarry site is an ideal location for sourcing the optimum mix of raw materials required to produce high quality quarry products that can be viably extracted for the minimum amount of surface disturbance. In addition, the close proximity of the quarry site to the WWF Project and construction haulage route, its relative isolation from any sensitive receivers and the opportunity to utilise a suitable resource within an existing highly disturbed environment with good access, means that potential impacts of a quarry operation would be minimised, as would the haul distance for supply of materials to the WWF Project.

In relation to the proposed WWF Quarry, a review of the alternatives available identified a number of options:

- Do nothing.
- Seek alternative (*i.e.* on or near-site and/or offsite) suppliers of aggregate material to the WWF Project.

**Option 1 – Do Nothing**

- This option was considered, however, it would not meet the overall objective of providing quarry products to the WWF Project in a manner that minimises impacts to the local and broader community, in the most cost effective and efficient way.

**Option 2 – Alternative Suppliers**

- As discussed above, site investigations indicate that the majority of the WWF Project area does not contain geology suitable for the production of quarry materials for the Project.
- Sourcing quarry materials from the nearest, large commercial quarries located in the region was considered. The nearest, viable suppliers of all aggregates material for the WWF Project are located approximately 250 - 395 km (return trip) from the WWF Project (via the major regional road network). In addition, none of these suppliers has the capacity to provide materials to the Project as a single-source supplier (preferred in terms of maintaining consistency of quarry products supplied to the Project).

- As indicated above, if all quarry materials were transported to the WWF Project from these external suppliers, it would require an estimated 31,125 additional truck trips (*i.e.* 62,500 movements) on the broader local and regional road network.

Due to the potential social and environmental impacts associated with this number of additional truck movements, limitations on single source suppliers, as well as the physical impacts on the local and regional road network, sourcing materials from these quarries was considered to not be the preferred option.

# 2 Description of the Development

## 2.1 Quarry Resources

Geological and geotechnical investigations by ARDG (refer **Section 3.4.2**) have confirmed quarry resources of approximately 1 Mt within the extraction pit. The Project Site occurs within an area mapped by the NSW Geological Survey (Zone 56 Seamless Geology) as the Late Devonian age Lochaber Greywacke. This formation is described as comprising lithic wacke, slate, minor chert and jasper, and rare metabasalt.

Quarry resources within the extraction pit are dominated by sporadic outcrop and subcrop of meta-greywacke, which broadly define the strike of the hard, weathering-resistant greywacke units that dominate in this location. The resource from the extraction pit is ideally suited to producing the typical range of blended, in-specification quarry products required to support the construction of the WWF Project, including:

- significant volumes of durable wind-farm specification road base and sub-base products, required for creation of access tracks, hardstand areas, construction compounds and substation / transformer pads;
- coarse rubble and crushed rock products required for drainage mitigation works;
- densely graded base and sub-base products for targeted use within the wind farm development corridor and for use on public road upgrades (in accordance with the requirements of RMS3151 – Granular Base and Subbase Materials for Surfaced Road Pavements); and
- aggregates required for use in concrete for the construction of wind tower footings (in accordance with the requirements of AS2758.1 – Aggregates and Rock for Engineering Purposes – Part 1 Concrete Aggregates).

Investigative work is ongoing to determine the potential suitability of -5 mm manufactured sand (crusher dust) produced from processed basalt, for use in concrete (as a replacement to natural sand) and for the backfilling of electrical cable trenches.

## 2.2 Proposed Activities

It is estimated by the proponent that the WWF Project may require approximately 1 Mt of quarry materials to support the construction of the Project over an estimated period of 3 – 4 years. Accordingly, approval is being sought for a quarry operation with a limit of 500,000 tonnes per annum of material transported from the site. Construction and operation would be undertaken during daytime hours, being Monday to Friday 7am to 6pm and Saturday 8am to 6pm, with minor non-audible works to be undertaken outside of these hours (*e.g.* maintenance activities).

Key features of the WWF Quarry are illustrated in **Figure 2** and summarised as follows:

- Main extraction area (pit) excavated into the side of the hill, covering an area of approximately 4.45 ha from where a high- quality greywacke resource would be drilled, blasted and extracted, prior to processing. The pit would be developed to a floor level of approximately 1175 m AHD with a sump to 1170 m AHD. Extraction will be undertaken as two benches with a single bench wrapping around the north, eastern and southern sides with a maximum bench height of 15 m at the eastern end, significantly reducing in height to the west as a result of the sloping surrounding topography (refer **Figure 3**). The lower bench would be effectively excavated below natural ground level.
- Main Processing and Stockpiling Area covering an area of approximately 2.13 ha adjacent to the western edge of the Main Pit. Processing of extracted rock would be undertaken in this area using mobile crushing and screening equipment, with finished quarry products transferred to discrete stockpiles.
- Secondary processing, stockpiling and operations area covering an area of 3.88 ha. These areas would include secondary areas for processing and stockpiling, accommodate internal temporary administration (mobile crib room / toilet facilities), peripheral topsoil bunds, access tracks, light vehicle parking, and surface water management controls.
- Internal access road linking the operational areas with Bark Hut Road (8 m wide road surface with 1 m wide shoulders). The access road corridor would be approximately 150 m long and have a disturbance footprint of approximately 0.19 ha.
- Sediment basin covering an area of approximately 0.67 ha.
- Transport of processed quarry material to the WWF Project by (typically) a truck and dog fleet would be managed by the appointed civil contractor for the WWF on an 'as needs' basis during quarry operations.
- It is not proposed to construct a weighbridge. Extraction quantities will be calculated by belt / loader scales. All materials produced by the quarry will supply the WWF Project only.
- At the completion of quarry operations, the site will be rehabilitated in consultation with the landowner to determine an appropriate, safe and stable landform(s) that can facilitate ongoing rural activities. The processing / stockpiling areas and operational areas will be returned to pre-disturbance existing condition in consultation with the landowner (*e.g.* re-seeded with appropriate pasture grass) in accordance with all relevant approvals.

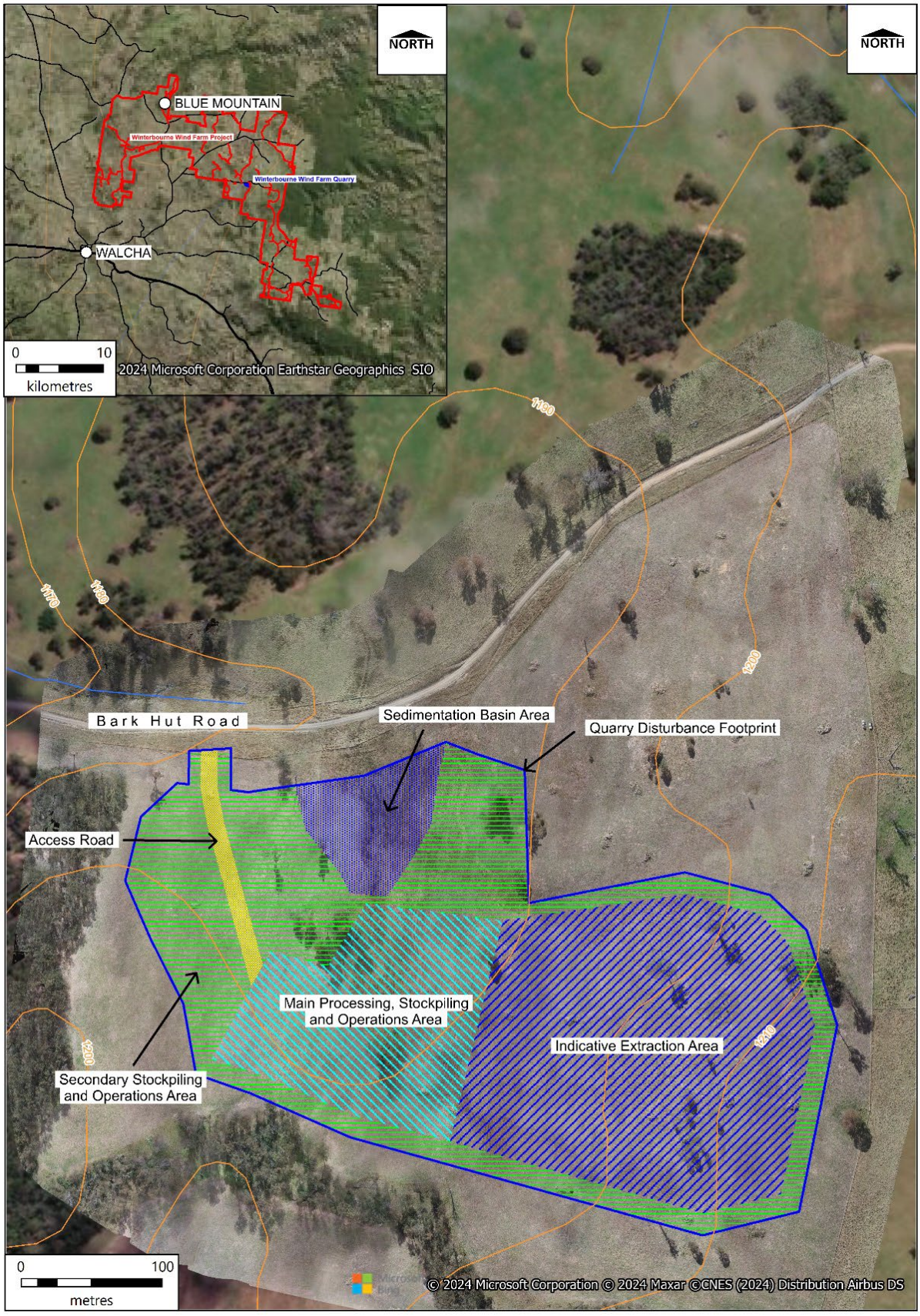



**Figure 2 – Winterbourne Wind Farm Conceptual Quarry Design**

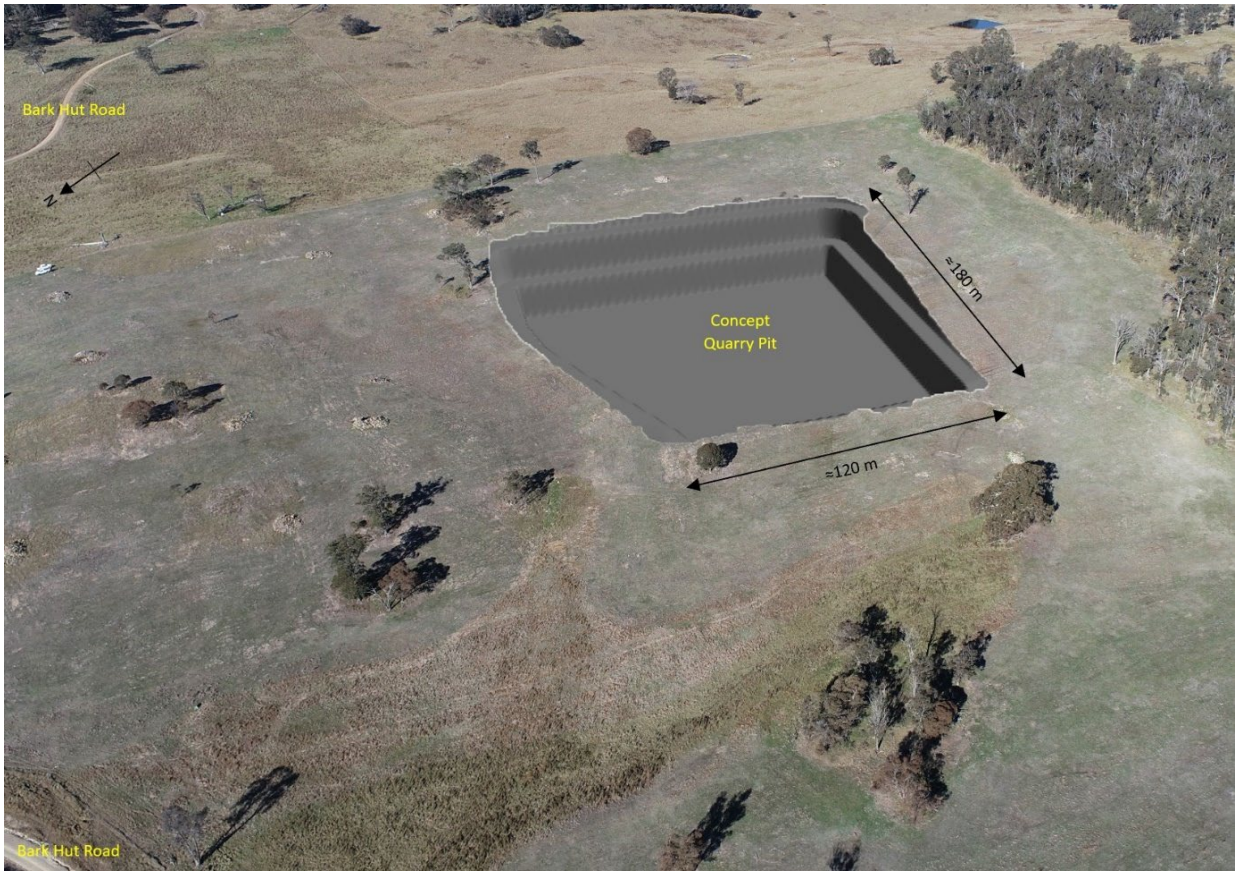



**Figure 3 – Oblique View of Winterbourne Wind Farm Conceptual Quarry Pit Design**

## 2.3 Project Timeframes

It is envisaged that initial site disturbance at the proposed quarry site will commence in mid to late-2026. Approval is being sought for quarry operations to commence prior to commencement of construction of public road upgrades/repairs and wind farm works, and continue for up to six months after the completion of any final rectification works to the public roads and wind farm works such as hardstand areas and access tracks. Construction of the wind farm and public road upgrades/repairs is anticipated to be competed over an approximately 3 – 4 year period. Upon completion of wind farm construction and public road rectification works, the temporary quarry will be decommissioned and rehabilitated.

All project approvals will need to be conditioned to reflect this timeline.

## 2.4 Site Establishment

At the commencement of the WWF Quarry the following site establishment works will occur:

- Delineation of Project disturbance boundaries from GPS survey control.

- Transport of mobile equipment (*e.g.* earthmoving, quarrying and crushing) and site infrastructure (*e.g.* site office / crib room) to the Project area via the approved WWF construction haulage route.
- Establishment of erosion and sediment control structures prior to initial site stripping/earthworks and construction of the processing and stockpiling areas.
- Ground disturbance activities including: initial site stripping/earthworks; vegetation clearing; blast hole drilling; initial quarry blast; establishment of initial quarry pit, processing /operational areas.
- Construction of the access road and entrance off Rotherwood Road.

## 2.5 Quarry Operations

The material in the quarry will be extracted through an excavator and truck operation. Extraction operations in the pit will be initiated via an initial blast to loosen up the rock prior to loading of material by excavator into dump trucks for transport to the processing area. Blasting will be required periodically to enable access to blasted rock in approximately 75,000 – 85,000 tonne quantities. Assuming a total materials demand of up to 500,000 tonnes per annum, this would equate to a blast frequency of approximately one every 6 – 8 weeks.

The blasting would be completed by an appropriately licensed and experienced contractor, with no requirement to store explosives and blast-related materials on site. Processing of raw feed at the quarry site would be undertaken progressively, following the completion of each blast, with material to be processed and stockpiled prior to load out.

Quarry products will be transported by the Project civil contractor/s directly to the various work fronts of the WWF in accordance with materials demand.

The approximate number of staff/workers expected to present on site at any one time are as follows:

- Prior to Commencement:
  - Drill and blast crew (2 – 3) (prior to initial blast and commencement of operations for a period of 7 – 10 days weather dependent). 8 – 10 crew will be present on the day for loading and firing of the shot.
  - Mobile plant and equipment operators (3 – 4) for site preparation / earthworks.
- During Operations:
  - Excavator operator.
  - Loader operator.
  - Production manager.
  - Quarry supervisor/manager.
  - General hand.
  - Drill and blast crew (2 – 3) (prior to each blast for a period of 7 – 10 days weather dependent). 8 – 10 drill and blast crew will be present on the day for loading and firing of each shot.

## 2.6 Ancillary Facilities

The proposed works include areas for processing, stockpiling, and overburden /topsoil storage areas (refer **Figure 2**). Mobile equipment will be used to crush and process extracted rock. Temporary administration and facilities (mobile self-contained units), and surface water management infrastructure will be located within the Project area.

The temporary administration / crib room facility will be a small (*e.g.* 6 m x 3 m) demountable facility containing a small sink (for washing coffee cups *etc*) which drains to a small external tank that will be emptied daily into the amenities (refer below). Water supply to the sink will be provided from an external tank that will be refilled as required. Potable water will be provided for staff in plastic containers (*e.g.* 10 - 20 litre) brought to the site. It is not proposed to have any shower / wash facilities on the site. The amenities will consist of self-contained 'portaloo' units that will be pumped out as required by a licenced contractor, with the wastewater disposed offsite at a licenced facility.

## 2.7 Equipment

**Table 1** provides an indicative list of equipment that will likely be used during construction and operation of the Project.

**Table 1 Indicative Equipment to be Used in the Project**

| Project Element | Indicative Equipment |
|---|---|
| Overburden/ bulk earthworks/ win material | • CATD10 dozer<br>• CAT336G excavator |
| Drill and Blast | • EPIROC T40<br>• Mobile explosives truck and associated plant/equipment |
| Crushing and manufacture | • CAT336G excavator<br>• McCloskey J50 V2 Jaw crusher<br>• Powerscreen Warrior 2400 Screen<br>• Powerscreen 1300 Maxtrak Cone crusher<br>• Powerscreen Chieftan 2100K Screen<br>• CAT980M Wheel loader |
| General | • Water cart (as required)<br>• Mobile crib room and toilet facilities<br>• Fuelco Klassic LTK12 self-bunded fuel unit |
| Haulage | • Truck and dog (WWF Project civil contractor) |

**NB:** The equipment listed above is indicative only and may be subject to revision

## 2.8 Hours of Operation

Construction and operation will be undertaken during daytime hours, being Monday to Friday 7am to 6pm and Saturday 8am to 6pm. It is anticipated that some activities may require works outside of these hours (*e.g.* maintenance). These works will be restricted to relatively non-audible activities to limit the potential impacts on surrounding areas.

## 2.9 Access and Transport Routes

Mobilisation / demobilisation of quarry plant and equipment to the site would be via the approved haulage routes of the WWF.

Transport of all material from the quarry site will be the responsibility of and undertaken by the appointed civil contractor/s for the WWF Project. Quarry materials will be transported directly from the site to Bark Hut Road, which forms part of the construction transport route for the WWF Project.

Further detail in relation to traffic is provided in **Section 4.11**.

## 2.10 Operational Water Requirements

The Project will require the use of water for dust suppression on the processing plant and across all disturbed areas of the site as required. Operational water requirements for the Project will be sourced from the surface water management system and topped up as required from an existing BLR bore (BLR 3821 – Work Site 3) located on Lot 95 DP DP1128816. Along with a number of other bores, this BLR bore will be the subject of an application to WaterNSW to convert it to a commercial production bore use for the Winterbourne Wind Farm. Water from this bore would be pumped directly to storage tanks located on site.

## 2.11 Proposed Rehabilitation and Key Mitigation Measures

At the completion of quarry operations, both the extraction pit and any disturbed areas will be rehabilitated in consultation with the landowner to determine an appropriate, safe and stable landform(s) that can facilitate ongoing rural activities. The processing / stockpiling area and operational areas will be stabilised and returned to pre-disturbance existing pasture condition in consultation with the landowner (*e.g.* re-seeded with appropriate pasture grass). Hard rock quarry benches will be stabilised through a combination of perimeter blasting and backfilling of the face with surplus shot rock with terminal slopes re-profiled to an overall slope no steeper than 1V:1.5H. Disturbed areas upstream of the extraction pit would be directed into the pit void, with any overflow directed by the retained SWMS to the sediment basins. Given the fractured nature of the geology od the site, the pit void would be unlikely to permanently hold water given losses through surface cracks in the floor and evaporative losses during the warmer months.

Surface water management structures will be left in place for continued use during and after the rehabilitation phase as required. Sediment fencing and controlled site access will be provided. All erosion and sediment control measures will be designed in accordance with relevant guidelines (*e.g.* 'Bluebook') and will be inspected, maintained and cleaned during construction and operation. Erosion and sediment controls will be established in accordance with an erosion and sedimentation

plan to be produced for the proposed works as part of the Environmental Management Plan (EMP) for the Project. Further details are provided in **Section 4.15.**

# 3 Description of the Site

## 3.1 Site Context

The quarry site is located on privately-owned land within the boundary of the Project Area of the WWF (refer **Figure 1**), with direct access to Bark Hut Road. A new site access point would be constructed (WWF entrance 28). The land is highly disturbed being predominantly cleared of overstorey vegetation and subject to grazing sheep for decades.

All extraction and processing works will be undertaken within the quarry site disturbance area (**Figure 2**)

## 3.2 Land Zoning

The quarry site is located on land zoned RU1 Primary Production under the Walcha Local Environmental Plan 2012. Extractive industries are permitted with consent on land zoned RU1.

## 3.3 Property Description and Land Ownership

The land on which the quarry site is located is described as follows:

- Lot 95 DP1128816 (privately owned) – quarrying, processing / operational areas and access road.

## 3.4 Existing Environment

### *3.4.1 Topography, Landform and Drainage*

The Project Site spans the western flank of a generally north-south trending ridge, as well as a shallow, north draining valley/swale that is coincident with a geological contact between a meta-greywacke dominated sequence of rocks to the east, and a meta-siltstone dominated sequence of rocks to the west (refer **Figure 4** and **Figure 5**). Elevations over the site range from approximately 1,210 m AHD in the east, to 1,190m AHD in the west, with the lowest elevations associated with the central swale (1,185-1,177 m AHD). No permanent or ephemeral drainage features are located on the site, however, when soils are saturated, the swale directs flow overland to the north via a culvert to a more incised gully located on the north side of Bark Hut Road.

### *3.4.2 Geology Resources and Soils*

*Regional Geology*

The Project Site occurs within an area mapped by the NSW Geological Survey (Zone 56 Seamless Geology) as the Late Devonian age *Lochaber Greywacke*. This formation is described as comprising lithic wacke, slate, minor chert and jasper, and rare metabasalt (refer **Figure 4**).

The *Lochaber Greywacke* outcrops extensively over the eastern half of the WWF and is dominated by metamorphosed sandstone comprised mainly of volcanic detritus of intermediate and felsic composition.

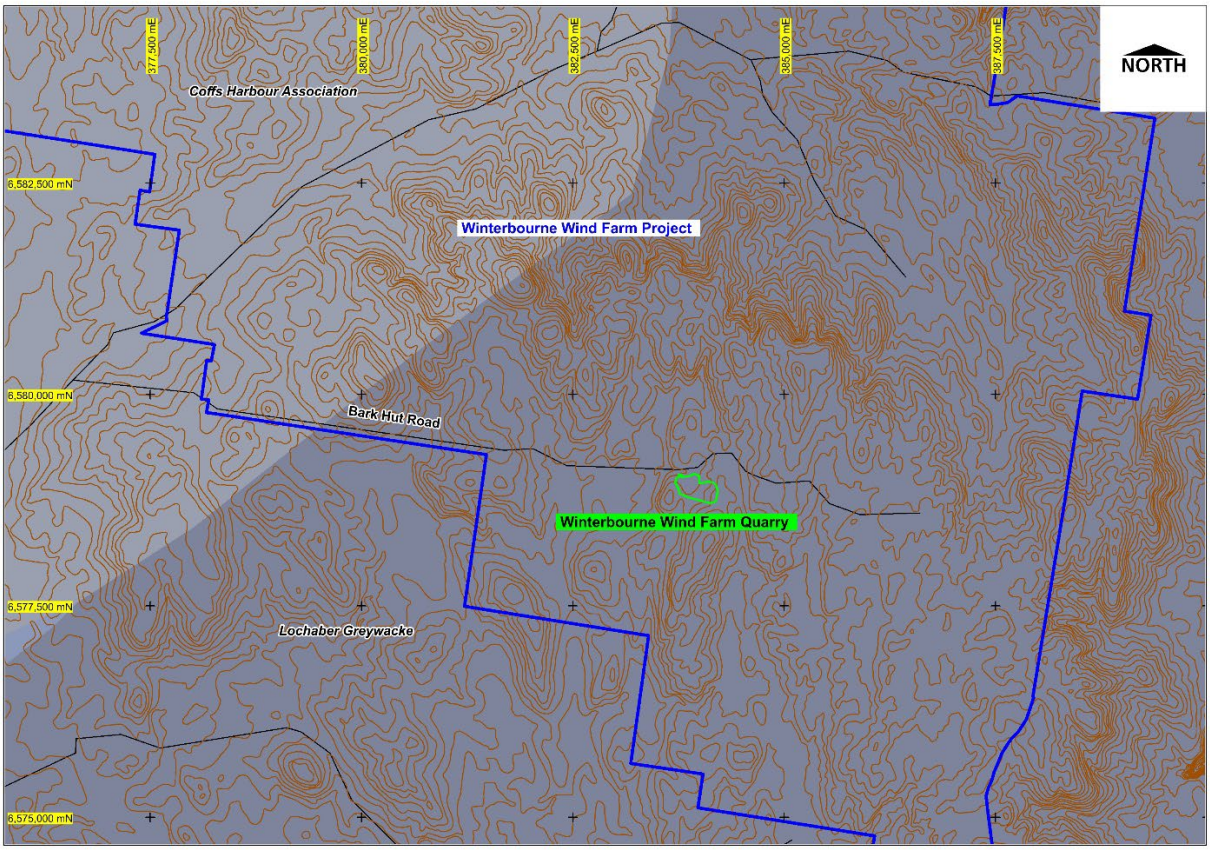



**Figure 4 – Simplified Regional Geology (NSW Geological Survey)**

*Project Site Geology*

The surface geology of the Project Site (**Figure 5**) is characterised by a bedded sequence of meta-greywacke (sandstone), meta-siltstone and shale. The sequence strikes north-northeast and dips at approximately 70 degrees (from horizontal) to the west-northwest.

The north-south trending gully that bisects the Project Site broadly defines the contact between two geological domains. The surface geology on the eastern side of the Project Site (Eastern Domain) is dominated by sporadic outcrop and subcrop of meta-greywacke, which broadly define the strike of the hard, weathering-resistant greywacke units that dominate in this location.

In contrast, the western side of the Project Site (Western Domain) is largely devoid of outcrop but contains abundant surface float of meta-siltstone and shale – rock types that are clearly less resistant to weathering than the meta-greywacke. Along strike to the north of the Project Site, metasiltstone and shale typical of the Western Domain outcrop extensively within the westerly draining gully that is located on the northern side of Bark Hut Road.

In general, the surface environment of the site is characterised by thick bands (10 – 30 m) of outcropping very hard unweathered greywacke, interspersed with thin bands of saprolite (extremely weathered in-situ shale), over which have formed thin clay soils.

Consequently, soil profile development is variable though mostly skeletal (0 – 0.3 m) in the areas of saprolite, with slightly deeper pockets (up to 1 m) of heavy clay sitting in direct contact with rock on the lower elevations of the site.

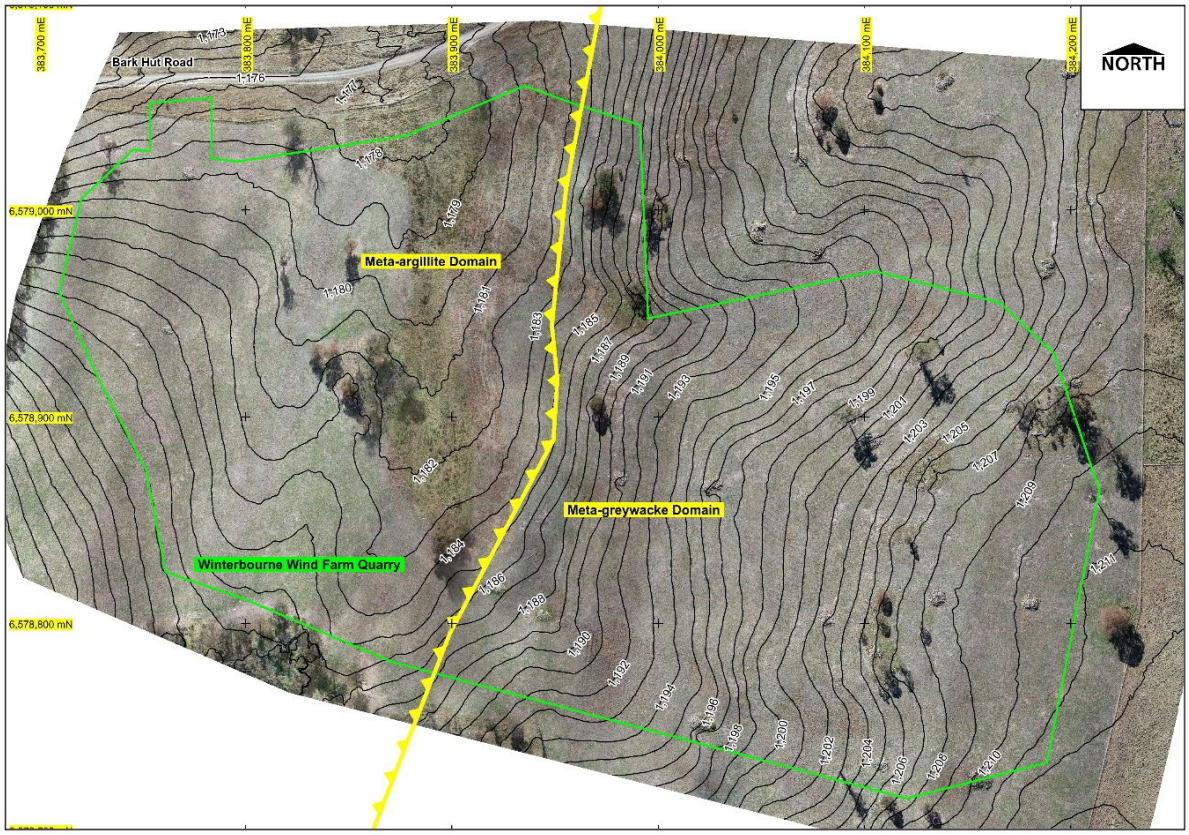



**Figure 5 – Project Site showing Geological Domains**

*Site Resource Investigations*

An initial program of percussion drilling was undertaken by ARDG over a five-day period during August 2023 to confirm the geological character of the Project Site. A total of 46, 89mm diameter, angled percussion holes were drilled using a top-hammer blasthole rig.

A diamond drilling program comprising 156.5 metres of core drilling was subsequently undertaken to confirm the suitability of the geology from the Western and Eastern Domains as a quarry source rock and to obtain core for geotechnical testing and petrographic analysis. The drilling program was undertaken by The Drillers Pty Ltd from Bendigo, Victoria, and comprised seven (7) angled HQ3 (61.1mm core diameter triple tube) holes that were drilled during October-November 2023. Drilling involved coring from surface, with holes drilled towards the east in order to intersect the dipping stratigraphy at a high angle.

Percussion drilling confirmed that meta-siltstone and shale units within the Western Domain are very thinly bedded and prone to weathering (refer **Figure 6**). From a quarrying perspective, these units alone are considered unsuitable source rock materials, given their strong foliation and propensity to create flakey 'aggregates' when crushed. Accordingly, the western side of the Project Site is not

considered to be an appropriate location for quarrying for the purpose of producing quarry products required by the WWF.

Drilling undertaken on the eastern side of the Project Site confirmed that that geology is dominated by generally hard, massive, medium-grained meta-greywacke beds (refer **Figure 7**), separated by much thinner interbeds of meta-siltstone / shale. The meta-greywacke is generally hard and competent and represents an excellent source rock for producing crushed rock and aggregates with uniform shape.

The weathering profile across the Eastern Domain is somewhat irregular, reflecting the interbedded nature of the geology. The depth of highly weathered material within the conceptual footprint of quarry development varies from less than a metre in the vicinity of some meta-greywacke beds to up to 6 metres over narrow bands of meta-siltstone.

Three-dimensional surface modelling of weathering data for drillholes within the conceptual quarry footprint has been used to enable quantification of the different weathering states of material that would be encountered within the quarry.

The weathering characteristics of the Eastern Domain are considered favourable for accessing a range of weathering states suited to producing blended road capping / road base products, whilst discrete beds of meta-greywacke could be selectively extracted and processed to produce high-quality aggregate products as well as -5mm manufactured sand for backfilling of power cable trenches (subject to acceptance of thermal resistivity properties). Consequently, geotechnical testing was focussed on the Eastern Domain geology.

| Australian Resource Development Group | Project: BARK HUT QUARRY PROJECT | | | Drill Hole: ARDG-BHD03 | Page: 1 of 2 |
|---|---|---|---|---|---|
| | *Collar Details* | | | *Hole Details* | |
| | *Easting:* | 383,777 mE | *Northing:* 6,578,976 mN | *Drilling Contractor:* | The Drillers Pty Ltd / Richard Brydon |
| | *Grid:* | MGA Zone 56 (GDA2020) | | *Drill Rig:* | Multidrill 300 |
| | *Elevation:* | 1,182.56 mAHD | | *Drill Method:* | HQIII |
| | *Dip:* | -60 degrees | | *Date Commenced:* | 29 October 2023 |
| | *Azimuth:* | 102 degrees grid | | *Date Completed:* | 30 October 2023 |
| | *Hole Depth:* | 25.1 m | | *Supervising Geologist:* | Damon Bird |

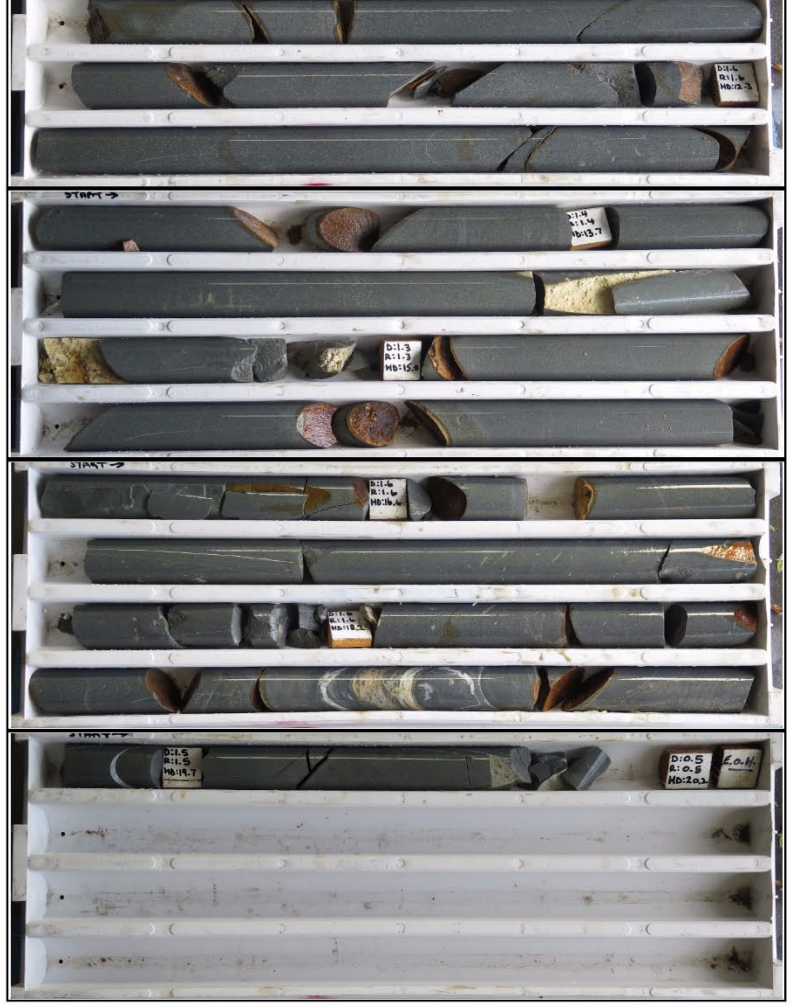
Dry core photographs

Wet core photographs

**Figure 6 – Drill core from ARDG-BHD03 through strongly bedded meta-siltstone and shale in the western part of the Project Site (Western Domain)**

| Australian Resource Development Group | Project: BARK HUT QUARRY PROJECT | | | Drill Hole: ARDG-BHD09 | Page: 1 of 2 |
|---|---|---|---|---|---|
| | *Collar Details* | | | *Hole Details* | |
| | *Easting:* | 384,094 mE | *Northing:* 6,578,779 mN | *Drilling Contractor:* | The Drillers Pty Ltd / Richard Brydon |
| | *Grid:* | MGA Zone 56 (GDA2020) | | *Drill Rig:* | Multidrill 300 |
| | *Elevation:* | 1,204.54 mAHD | | *Drill Method:* | HQIII |
| | *Dip:* | -60 degrees | | *Date Commenced:* | 03 November 2023 |
| | *Azimuth:* | 105 degrees grid | | *Date Completed:* | 11 November 2023 |
| | *Hole Depth:* | 20.2 m | | *Supervising Geologist:* | Damon Bird |

Dry core photographs



Wet core photographs

**Figure 7 – Drill core from ARDG-BDD09 through meta-greywacke in the eastern part of the Project Site (Eastern Domain)**

*Conceptual Quarry Design*

A conceptual quarry design (refer **Figure 2**) has been prepared to provide access to Eastern Domain geology in order to produce approximately 1.2 Mt of quarry materials likely to be required to support the construction of the WWF. The conceptual quarry design covers an area of approximately 4.45 hectares from where meta-greywacke and minor interbedded meta-siltstone would be drilled, blasted and extracted, prior to processing.

The proposed quarry would be developed to a floor level of approximately 1,175 metres AHD, with extraction undertaken from two benches, each with a height no greater than 15 metres. A catch bench ranging in width from 5-10 metres would be located at an elevation of approximately 1190 metres AHD. A sump may need to be constructed in the floor of the quarry extraction to manage any groundwater water ingress, and the size and location of a sump will be informed by current groundwater and surface water studies.

Extraction from the quarry would need to be staged in a manner that provides access to appropriate quantities of different materials (weathering states) to meet forecast quarry materials demand.

Rehabilitation of the completed quarry faces would be achieved via a perimeter blast that would result in a safe and stable rubble batter with an approximate overall slope of 45 degrees.

*Geotechnical / Slope Stability Considerations*

As indicated previously the geology of the extraction area is characterised by thick bands (10–30 metres) of outcropping, very hard unweathered metamorphosed greywacke, interspersed with thin bands of saprolite (extremely weathered in-situ shale), over which have formed thin clay soils. The sequence strikes north-northeast and dips at approximately 70 degrees (from horizontal) to the west-northwest.

The geotechnical conditions that will impact the conceptual quarry are expected to be predominantly influenced by sedimentary bedding, with potential for minor toppling failures in the western quarry face and potential for planar failures in the eastern quarry face (refer **Figure 8**). Given the northern and southern quarry faces will be oriented at a high angle to the strike of bedding, potential for failures on these faces associated with bedding is considered low.

Given the small-scale nature of the proposed quarry, geotechnical inspections by a qualified geotechnical engineer will be conducted at an early stage of quarry development once exposed faces can be examined. This will confirm whether the conceptual quarry design requires modification to address any identified areas of risk and to ensure safe and stable geotechnical conditions. A preliminary assessment of likely measures required to mitigate potential failure mechanisms on the eastern and western quarry faces would include regular inspections and scaling (as required); bunding and isolation of personnel from within several meters of the base of each quarry face; and potential reduction of the eastern quarry face angle to 70 degrees (from horizontal) to remove planar failure risk (refer **Figure 9**).

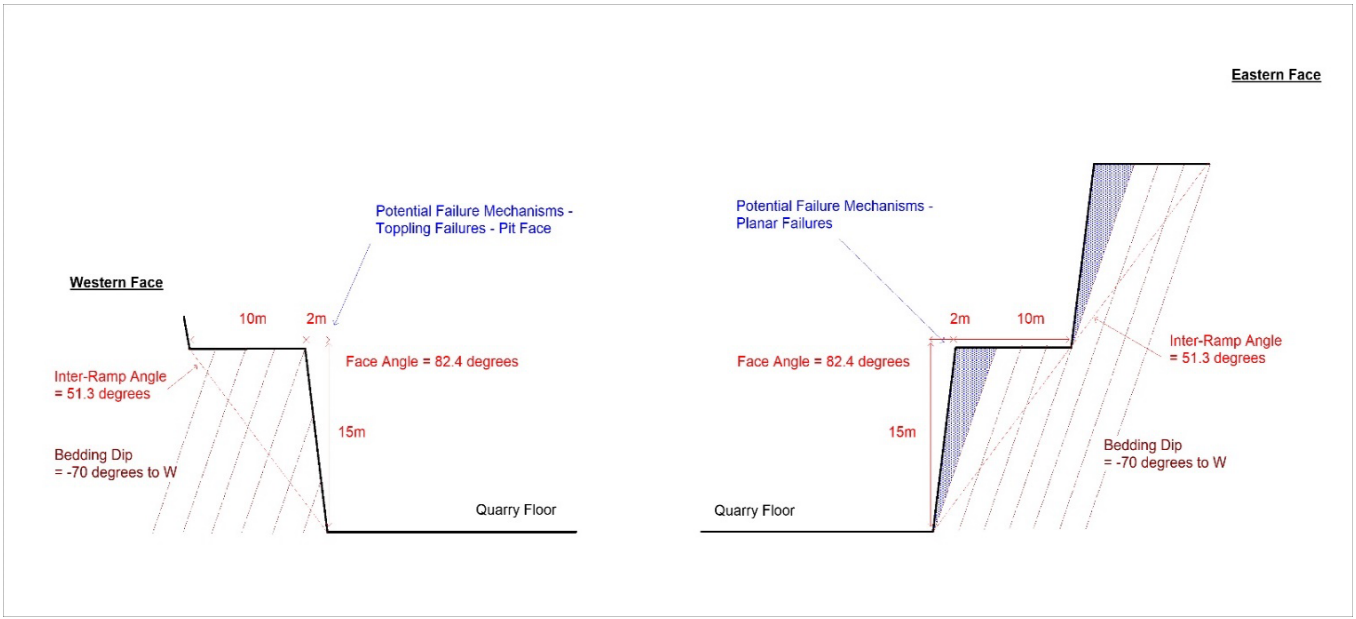



**Figure 8 – Schematic of Conceptual Quarry Pit and Potential Failure Mechanisms**

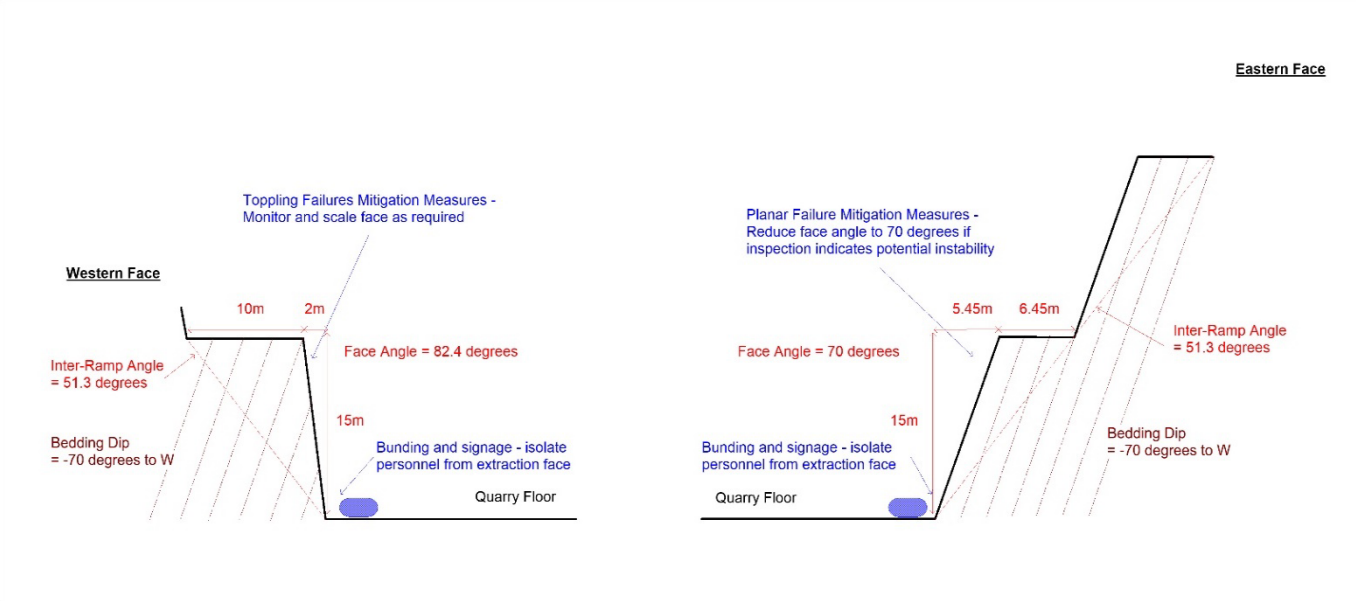



**Figure 9 – Schematic of Conceptual Quarry Pit and Mitigation for Potential Failure Mechanisms**

*Resource Quantities*

Geological modelling of percussion and diamond drilling information has enabled the quantity of key resource units to be estimated within the constraints of the proposed quarry design (refer **Table 2**).

| Table 2 Resource Quantity Estimates | |
|---|---|
| **Lithology** | **Total (t)** |
| Topsoil (surplus) | *(13,499)* |
| Meta-greywacke / meta-siltstone (saprolite / highly weathered) | 150,000 |
| Meta-greywacke / meta-siltstone (moderately weathered) | 100,000 |
| Meta-greywacke / meta-siltstone (slightly weathered to unweathered / fresh) | 958,280 |
| -5mm manufactured sand from aggregate production | 80,000 |
| **TOTAL** | **1,288,280** |

The resource volume estimates for different material types within the proposed quarry design are considered sufficient to cover the existing forecast demand (*i.e.* 1.2 Mt) for quarry materials, that includes:

- approximately 1 Mt of road capping and hardstand materials – this would be created primarily through blending of approximately 25% of highly weathered material with 75% moderately weathered to unweathered material (including -5mm manufactured sand from aggregate production if necessary).
- approximately 140 kt of concrete aggregates – produced primarily through processing of around 220 kt of slightly weathered to unweathered material, with an assumed aggregate yield of 66%. Note that -5mm manufactured sand produced from aggregate processing would be utilised in the production of road capping and hardstand materials and for backfill of power cable trenches if this material is confirmed by the wind farm principal contractor as having acceptable thermal resistivity properties. The proposed quarry design would also provide access to a surplus of 346 kt of material. It should be noted that some of this surplus would be utilised to create a stockpile pad adjacent to the western end of the proposed quarry (refer **Figure 2**).

### *3.4.3 Meteorology*

There are no known meteorological stations in the Walcha region (suitable for use in air quality modelling) however the DPHI operates a network of meteorological monitoring stations across NSW including several stations in the Northern Tablelands region. The closest DPHI station to the Project is at Armidale, over 50 km away. This station is unlikely to collect data that accurately represent conditions in the Project area, primarily due to terrain effects. Meteorological modelling has therefore been used in the Ai Quality Impact Assessment to derive conditions near the Project.

Meteorological modelling has been carried out to simulate conditions at the Project site for the 2023 calendar year. These data show that the prevailing winds at the Project site are likely to be stronger than at Armidale and from the east and west, with a relatively low proportion of calm conditions. The differences between the Armidale data and modelled site data can be explained by the higher elevation and more undulating terrain of the Project site.

### *3.4.4 Land Use and Sensitive Receptors*

Land use surrounding the Project area comprises agricultural activities, primarily grazing, with some minor cropping, consistent with the RU1 Primary Production land zoning. The WWF Project is seeking planning approval for up to 118 wind turbines and when constructed the turbines will be located on all sides of the quarry area (refer **Figure 1**).

A number of private dwellings represent potential sensitive receptors. The closest sensitive receptor not associated with the WWF Project (SR240) is located approximately 4.3 km to the south of the quarry site. This dwelling does not have a direct line of sight to the quarry site, with views being blocked by vegetation and/or topography. There are no other non-associated residences within 5 km of the WWF Quarry. (**Figure 10**).

### *3.4.5 Water Resources*

There are no defined drainage features on the site. As indicated in Section 2.10, water supply for dust suppression will be sourced from one of the existing BLR bores (BLR 3821 – Work Site 3) located on Lot 95 DP DP1128816. Along with a number of other bores, the BLR bore will be the subject of an application to WaterNSW to convert it to a commercial production use for the Winterbourne Wind Farm. Water from this bore would be pumped directly to storage tanks located on site.

A perched groundwater table was encountered during investigative drilling of the proposed quarry resource, which pools in relatively confined saturated zones of more weathered material with relatively high rates of transmissivity. A deeper groundwater table was also encountered from deeper bores drilled on site and nearby. A number of monitoring bores were established on site to provide data to inform the groundwater impact assessment.

Further detail on water resources, including groundwater levels measured in the monitoring bores is provided in **Section 4.3 and Section 4.4**.

### *3.4.6 Bushfire Risk*

The Project area is located on Bushfire Prone Land. A bushfire risk assessment in accordance with the provisions of Planning for Bushfire Protection (NSW Rural Fire Service, 2019) is presented in **Section 4.12**.

### *3.4.7 Visual Amenity*

While being on an elevated ridge, the quarry extraction areas will not be visible from any surrounding residences, though will be partially visible from Bark Hut Road, a key part of the WWF construction haulage route. Further assessment of visual amenity is provided in **Section 4.10**.

### *3.4.8 Biodiversity*

The Project area is located within existing highly disturbed grazing land, with some remnant scattered paddock trees. Further details on biodiversity are provided in Appendix D of the project Amendment Report.

### *3.4.9 Air Quality and Noise*

The existing air quality environment within and surrounding the Project area is influenced primarily by agricultural activities, primarily grazing (sheep and cattle).

The existing rural noise environment is therefore primarily influenced by wind-affected vegetation and noise associated with the rural setting (*i.e.* machinery and livestock).

Noise and air quality impacts are assessed in **Section 4.7** and **Section 4.9** respectively.


**Figure 10 – Dwellings within a 5 km radius of WWF quarry. All dwellings are 'associated' except for dwelling SR240**

# 4 Environmental Assessment

## 4.1 Landform and Topography

The Project will result in changes to the topography of the proposed extraction pit area, sediment basin and processing area. As detailed in **Section 2.11,** the site (including the extraction pit will be rehabilitated in consultation with the landowner to determine an appropriate, safe and stable landform(s) as well as facilitate ongoing rural activities where possible. The processing and stockpiling area and all other disturbed surfaces will be stabilised and returned to pre-disturbance vegetation cover in consultation with the landowner (*e.g.* re-seeded with appropriate pasture grass).

Hard rock quarry benches will be stabilised with terminal slopes re-profiled to 1:2 internally draining batters. As the proposed floor level of the Main Pit sits within the hard rock resource, rehabilitation of the quarry floor is not proposed. Any disturbed areas of the site above the pit will be reprofiled to direct surface runoff into the pit. Given the highly fractured nature of the geology, the pit floor would be unlikely to permanently hold water given losses through surface cracks in the floor and evaporative losses during the warmer months. The sediment basin would remain in place to collect any surface runoff form the site following quarry closure and rehabilitation, with a long-term function as a farm dam.

## 4.2 Contaminated Land

A search of the EPA's NSW Contaminated Lands Public Record Register did not identify any areas of contaminated land within the Project Area or surrounds. The land on which the proposed quarry is located has historically been used for grazing only and no potentially contaminating activities are known to have occurred within the Project area. Based on the land use history of the site, the potential for significant land contamination to be present is considered low.

The Project is not anticipated to result in any significant land contamination. Fuel for mobile equipment will be stored on site in a mobile self-bunded/contained fuel storage unit and only small quantities of grease and oil will be stored within the temporary site facilities.

Notwithstanding, management measures would be implemented as part of the Project and would include appropriate contamination management controls to minimise impacts, such as:

- Small quantities of grease and oil (for daily equipment maintenance checks) will be stored and handled on site appropriately to minimise the potential for contamination of the Project area.
- Spill kits and clean up protocols will be established for the operations and detailed in the Environmental Management Plan (EMP).
- If contaminated soils are uncovered during the works, all works within the vicinity would cease immediately and the NSW EPA and Walcha Council notified.

## 4.3 Surface Water

### *4.3.1 Overview*

A detailed Surface Water Impact Assessment (SWA) for the proposed quarry operation was prepared by Engeny (2024) in accordance with the SEARs for the Winterbourne Wind Farm Project and is provided in (**Appendix 1**). The SWIA included the preparation of a site water balance and consideration of potential licensing and WSP requirements, flooding impacts, water quality and quantity impacts, and impacts on water-related infrastructure. The SWIA also includes a detailed description of the proposed water management system, water monitoring program and other measures to mitigate surface water impacts. This section of the report provides a summary of the main findings of the SWIA.

### *4.3.2 Existing Environment*

The Project area does not intersect any ephemeral or perennial watercourses. The site drains via overland/sheet flow when soils are saturated to an ephemeral channel located on the northern side of Bark Hut Road. This channel drains via a series of farms dams to Dog Trap Creek, approximately three (3) km to the west of the quarry site. In turn Dog Trap Creek drains to Emu Creek, a tributary of the Apsley River.

An existing culvert is located immediately downstream of the proposed sediment basin that directs flows under Bark Hut Road towards the unnamed ephemeral creek to the north of the site. Net flow through the culvert is expected to reduce as a result of the runoff being contained by the Quarry WMS catchment. There are several farm dams within the vicinity of the Project Area. There is only one farm dam located downstream of the Quarry catchment, approximately 1.3 km west of the Project Area. Any spills from this farm dam drain via a narrow incised ephemeral channel to Dog Trap Creek.

#### *Water Quality*

Water quality monitoring was undertaken at one surface water (SW01) and two groundwater monitoring locations (GW01 and GW02) in the vicinity of the Project on 26 June 2024 (refer **Figure 11**). Water quality monitoring results are summarised as follows:

- At SW01, values for pH, EC and TDS were within the WQO range. The NOx (and Nitrate) result at SW01 (0.99 mg/L) exceeded WQO of 0.25 mg/L for aquatic ecosystems but was less than the Nitrate WQO of 400 mg/L for livestock drinking water. Results for nitrite and total oil and grease were below the limit of detection.

- Groundwater quality at GW01 and GW02 indicates close to neutral pH groundwater with low electrical conductivity and TDS concentrations. All results for nitrate, nitrate, NOx and total oil and grease were below the limit of detection at GW01 and GW02.

### *4.3.3 Proposed Water Management System*

Detailed description of the Project water management system (WMS) is provided in the SWIA. In summary the WMS will be comprised of one sediment dam and a series of drains and bunds to contain sediment water on the site and divert runoff from upstream clean water catchment areas, and a groundwater bore. Erosion and sediment controls will be designed and implemented generally in accordance with requirements outlined in Managing Urban Stormwater: Soils and Construction

Volume 1 (Landcom, 2004) and Volume 2E – Mines and quarries (DECC, 2008) (the 'Blue Book'). An assessment undertaken in accordance with the 'Blue Book' determined that based on the soil types on site a type-D sediment basin would be required. Based on these calculations the required design Sediment Basin volume is 4.6 ML. This volume is inclusive of the calculated settling zone of operational volume (2,936 $m^3$) and the sediment storage capacity (1,622 $m^3$).

Pumps will be used to dewater the Pit via a pipeline to the Sediment Basin when the basin has available storage capacity above the required settling zone capacity. The Sediment Basin will dewater to the Pit sump as required to ensure that the required settling zone capacity is available to contain runoff from the design storm event. Controlled releases are not expected to be required. Water captured on site will be used to meet operational demands and will be stored in Pit as needed to maintain Sediment Basin freeboard requirements. Should controlled releases be required due to excessive accumulation of the sediment water impeding operations, ARDG will apply for a licensed discharge point to be added to the site EPL with appropriate discharge criteria.

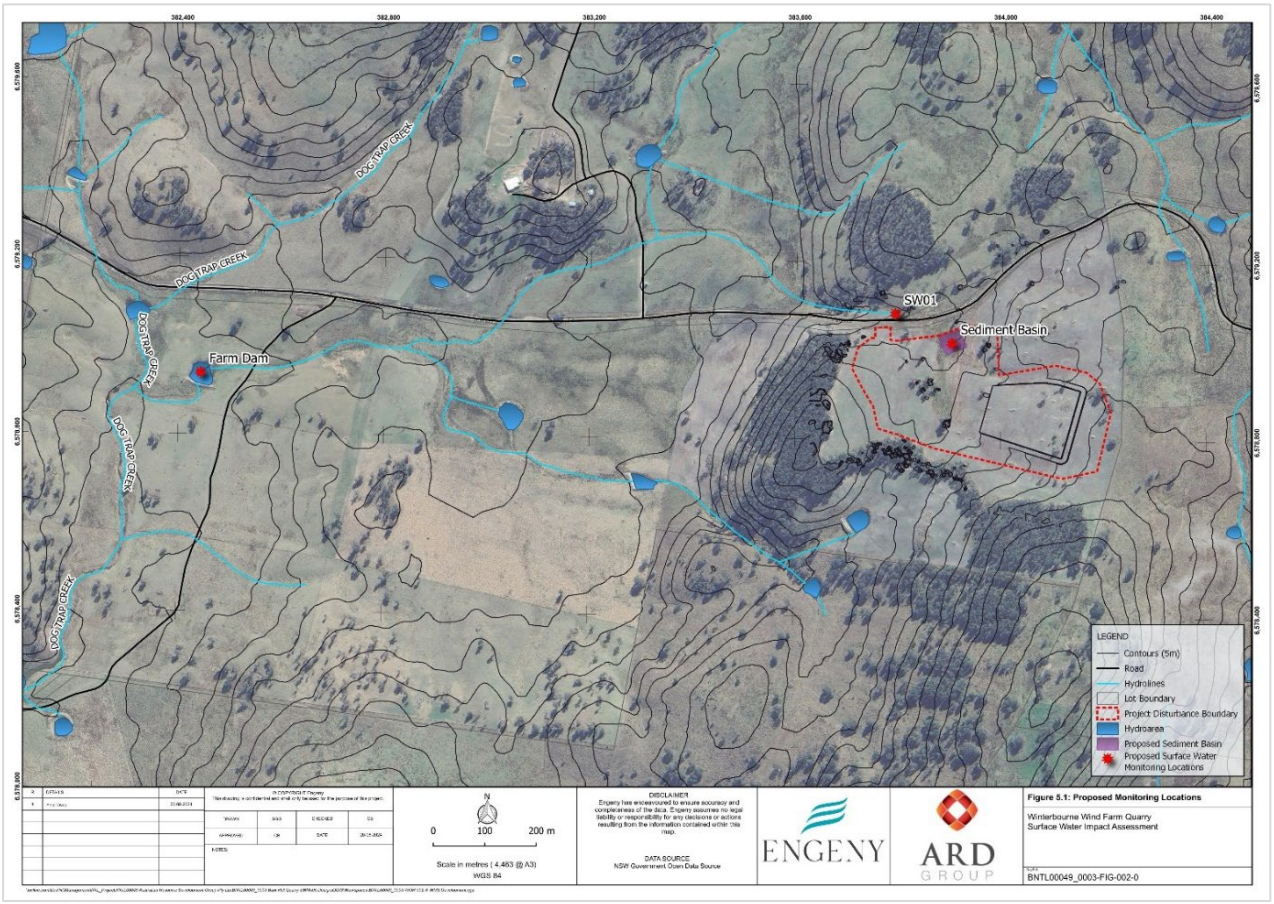



**Figure 11** – Existing / Proposed Surface Water Monitoring Locations

### *4.3.4 Water Balance*

A water balance model (WBM) representative of the proposed WMS was developed using the GoldSim software platform. The model simulates inflows from rainfall and runoff (including direct rainfall on water surfaces), outflows for dust suppression and process demands, and evaporative losses to assess future inventories and the frequency and volume of uncontrolled releases from the site.

Water sources included in the model were WMS catchment runoff and direct rainfall on water storages, groundwater inflows to the pits and a groundwater bore as a supplementary supply.

Modelled quarry water demands and losses include dust suppression on exposed areas and stockpiles, material processing, evaporation from water storage surfaces and evaporation of groundwater inflow seepage.

Water balance modelling results indicate that the quarry is likely to have:

- a water deficit (average 2.4 ML/yr; maximum 11.6ML during dry years) and a requirement for imports to meet operational demands
- limited requirements for discharge. Model results indicate that there is an approximately 85% chance that an overflow from the Sediment Basin will occur during the modelled life of quarry (four years). The average number of modelled overflow events per year is 1.4. This is consistent with the 1 – 2 spills per year indicated in Volume 2E of the 'Blue Book' as being typical of sediment basins sized to contain runoff from a 5 day 95$^{th}$ percentile rainfall event.

### *4.3.5 Impact Assessment*

*Water Quality*

Given all surface water runoff will be captured by the WMS which will prevent the potential for contamination of a water source, impacts to downstream water quality are considered to be negligible.

*Flow Regimes and Stream Stability*

The total catchment area for the Project is approximately 10.7 ha equating to an extremely minor portion (<0.001%) of the overall Macleay River Catchment. Reductions in downstream flow as a result of the diversion of the Project catchment are therefore considered to be negligible.

The expected reduction in catchment reporting to the downstream farm dam is 6.8% which would result in a slight reduction in flow reporting to the dam.

Given the net catchment reporting to the downstream environment will be reduced as a result of the Project and there are no proposed controlled discharges, impacts to stream stability are considered unlikely.

### *4.3.6 Licencing, Monitoring and Reporting*

*Licensing*

The quarry will be required to hold an EPL as it will be carrying out a premises-based activity listed in Schedule 1 of the *Protection of the Environment Operations Act 1997* (POEO Act), (i.e. Activity 19 Extractive activities, >30,000 tonnes/year). At this stage, the inclusion of a licensed discharge point on the EPL to permit controlled discharges from the WMS is not considered to be required.

All surface water runoff captured by the WMS will be to prevent the contamination of a water source. As such, all Project water storages are considered as excluded works under Schedule 1 of the Water Management (General) Regulation 2018 and therefore, exempt from requiring a WAL under Schedule 4 Clause 12 of the Water Management (General) Regulation 2018.

The proponent will obtain a WAL and sufficient entitlement to cover the maximum groundwater take associated with groundwater bores constructed to supply operational demands. Recent trades (between 2021 and 2024), water made available and water usage statistics for recent water years (2023/2024, 2022/2023) indicate there is sufficient market depth for sufficient WAL entitlements to be obtained. Groundwater inflows are expected to continue for a period of time post closure until water levels within the Pit have recovered above the pre-quarry groundwater levels. A WAL will therefore still be required in the post closure phase of the quarry project.

*Monitoring*

A surface water quality and quantity monitoring program for the Project is proposed, with monitoring to be undertaken as detailed in the SWIA. Water quality monitoring will assess a range of parameters with impact assessment criteria for receiving water quality downstream of the quarry will be developed in accordance with the Australian and New Zealand Guidelines for Fresh and Marine Water Quality (ANZG 2018).

*Reporting*

The proponent will be required to complete and submit an Annual Return to the NSW Environment Protection Authority (EPA) that it is anticipated to include a summary of an uncontrolled water discharges, monitoring, any complaints and a statement of compliance with EPL conditions. In the event that an incident occurs that threatens or causes environmental harm such as the contamination of water that does not meet EPL criteria, the proponent will notify the EPA immediately after becoming aware of the incident. The proponent will also provide a written report to the EPA within seven days of the date of becoming aware of the incident.

The proponent will submit an Annual Review to DPHI that will include a summary of the quarry WMS performance. It is anticipated that the Annual Review will include the annual site water balance results, water quality monitoring results and details of any incidents or complaints. If an environmental incident involving surface water occurs the relevant authorities (including DPHI and the EPA) will be notified and reports provided as required.

### *4.3.7 Mitigation Measures*

Management measures outlined below would be documented in the EMP and implemented to minimise the potential impacts to the surrounding environment:

- Erosion and sediment controls designed in accordance with the 'Blue Book'.
- Erosion and sedimentation controls checked and maintained on a regular basis (including clearing of sediment from behind barriers) and records kept and provided on request.
- Erosion and sediment control measures remaining in place until the works are completed, and areas are stabilised as part of rehabilitation activities.

*General Soil and Water Mitigation Measures*

The WMS for the site aims to protect the environmental values of receiving waterways by combining on-site retention of surface water runoff with regular monitoring and inspection of mitigation measures. Dirty water captured in the WMS will be reused for operational demands including dust suppression. No off-site discharge of 'dirty water' is proposed from the WMS. This will ensure that

the risk of suspended solids and turbid waters entering these waterways from the quarry site is minimised, and that the natural sediment load is not increased above and beyond that which currently occurs during design rainfall events.

The WMS design and management measures would be documented in the Environmental Management Plan (EMP) for the site and implemented to minimise the potential impacts to the surrounding environment. The primary objective of the WMS design is to ensure that suspended solids and turbid water are not discharged from the quarry site. This would be achieved by the following design elements and mitigation measures to be implemented including the following:

- Regular, scheduled inspection and pump out of the sediment basin will be undertaken to ensure that its design capacity is maintained to ensure maximum efficacy in the event of an exceedance of a design storm event. Water pumped out of the basin will be either re-used onsite for dust suppression or transferred to the extraction pit. No off-site discharge of surface water is proposed from the WMS. Any sediment removed from the settling zone of the basin will be incorporated back into the quarry product mix.
- To mitigate potential impacts in the unlikely event of exceedance of the design storm event that results in the basin capacity being exceeded, the basin will include a constructed, rubble lined spillway that will act to control the velocity of any spill and direct the flow through a sediment trap comprising geofabric / silt stop fencing.
- Installation of all erosion and sediment control measures as the first step in the process for site establishment and land disturbance.
- Clearly identifying and delineating areas required to be disturbed and ensuring that disturbance is limited to those areas.
- Minimising all disturbed areas and stabilisation of disturbed areas as soon as practicable.
- Construction of clean water diversion mounds to direct clean water runoff from any undisturbed upslope area away from disturbed areas, where practical. The diversion structures will be designed to ensure effective segregation of runoff within the site and surface water flow from undisturbed areas outside the site.
- Dirty water diversion to direct runoff from disturbed areas into the sediment basin.
- Construction of catch drains and diversion drains/mounds to capture runoff from disturbed areas and direct runoff into the extraction area following completion of extraction operations. Any excess drainage will be directed to the sediment basin, which will be retained after completion of operations on the site.
- Construction of other temporary erosion and sediment control measures, where required, such as sediment fences within the catchment area while permanent soil and water management structures are being established.
- Construction of drainage controls such as table drains on hardstand areas and toe drains on stockpiles if required.
- An in-pit sump and/or sediment basin may be excavated to manage surface runoff from within the extraction area(s) if required.

- Regular maintenance of all controls and inspection of all works and after storm events to ensure erosion and sediment controls are performing adequately.
- Immediate repair or redesign of erosion and sediment controls that are not performing adequately, as identified by field inspections.
- All the mitigation structures described above will be subject to regular, scheduled inspection, detailed in the operational EMP for the site, to ensure they are maintained and working effectively. This would include inspection during and after rainfall events.

The following measures will be implemented in relation to quarry haul trucks leaving the site:

- All heavy vehicle loads will be covered prior to leaving the site (in accordance with TfNSW requirements).
- Draw bars and tail gates will be inspected for all heavy vehicles prior to leaving the site to ensure that any loose material is removed.

The measures described above will significantly reduce the risk of any loose material (if present) being trafficked onto Bark Hut Road and the local road network.

## 4.4 Groundwater

A detailed Groundwater Impact Assessment (GIA) for the proposed quarry operation was prepared by GHD in accordance with the SEARs for the Project and with reference to the *Groundwater Assessment Toolbox for Major Projects in NSW – Overview Document* (DPE, 2022) and is provided in (**Appendix 2**). This section of the report provides a summary of the main findings of the GIA.

### *4.4.1 Existing Environment*

The project area is located within the New England Fold Belt Coast Groundwater Source which is managed by the Water Sharing Plan for the North Coast Fractured and Porous Rock Groundwater Sources. The New England Fold Belt Coast Groundwater Source is a fractured aquifer system with groundwater contained within and moving through fractures in the rock that have occurred due to folding and faulting of the rock formations (NSW DPI 2016a). Yields within the groundwater source are generally low, around 1 L/s, however, yields up to 10 L/s may be obtained from highly fractured fault systems (NSW DPI 2016a). Groundwater is typically recharged by direct rainfall infiltration which, combined with mineral leaching, has resulted in good quality water over time (NSW DPI 2016a).

At the project, groundwater observations during drilling, monitoring and pump testing indicate a confined fractured rock aquifer which is overlain by a clay/saprolite aquitard which allows for some vertical leakage. Groundwater monitoring, pump testing, and groundwater observations during drilling are further discussed in **Appendix 2**.

The hydro-stratigraphy of the project area consists of:

- Clay/saprolite aquitard (and weathered profile), average thickness 16 m, overlying
- Confined fractured rock aquifer, up to 50 m thick, from 13 m to 17 m below ground level

Groundwater levels at the project have been monitored since 23 January 2024 via a series of nine (9) monitoring bores (refer **Figure 12**). Groundwater levels are monitored by dataloggers at one-hour intervals. Since monitoring began, groundwater levels have remained relatively stable. Diurnal

fluctuations (up to 0.06 m) are observed in all monitoring bores, which are consistent with phases of the moon. Average groundwater levels in the fractured rock aquifer range from 1,186.3 m AHD at ARDG-BHPZ02 to 1,189.5 m AHD at ARDG-PGW02. The standing water level within the aquitard reflects soil saturation and infiltrating rainfall recharge. The water level within the aquitard does not represent a shallow groundwater system.

### *4.4.2 Groundwater Quality*

Groundwater was sampled by ARDG at bores ARDG-PGW01 and ARDG-PGW02 on 26 June 2024 and analysed for major ions, nutrients, total metals, pH, EC and oil and grease. The groundwater in both bores is similar and of good quality. pH is circumneutral and ranges from 6.5 to 6.84. pH is within the guideline range for all WQOs. EC is relatively fresh at 523 – 566 µS/cm, however it exceeds the guideline value of 350 µS/cm for aquatic ecosystem health. In summary, total concentrations of metals, cyanide, nitrate/nitrite and oil and grease were all below detection limits.

### *4.4.3 Groundwater Dependent Ecosystems*

The background document for the WSP for the North Coast Fractured and Porous Rock Groundwater Sources 2016 (DPI 2016a) refers to the High Priority Groundwater Dependent Ecosystem Map (DPI 2016b) which was reviewed to identify any high priority GDEs within the New England Fold Belt Coast Groundwater Source. The nearest high priority GDEs are located near the Macleay River to the east, approximately 70 km from the project site. The GDEs are classified as karst springs.

The *Probable Vegetation Groundwater Dependent Ecosystems – Northern Rivers and Namoi* datasets (DPE Water 2022) was reviewed to identify highly probable GDEs in the vicinity of the project site. The dataset indicates there are areas of low to high probability GDEs within 10 km of the project. Only low probability GDEs were identified with the project disturbance boundary.

High probability GDEs are associated with:

- Dog Trap Creek (approximately 7 km to the southwest)
- Snake Creek (approximately 4.5 km to the southwest) and
- Oxley Wild Rivers Nature Reserve (approximately 6 km to the east)

Based on the groundwater bores which target the fractured rock aquifer, groundwater flow is controlled by topography.

Snake Creek and its tributaries to the east of the project have an elevation of approximately 1,240 m AHD to 1,260 m AHD and are therefore too high in elevation to be points of discharge for groundwater at the project. Dog Trap Creek and its tributaries to the west of the project have an elevation of approximately 1,160 m AHD to 1,180 m AHD and could potentially to be a point of discharge for the groundwater at the project. Dog Trap Creek and its tributaries however are dry for much of the year, with flow depending on rainfall. It is therefore unlikely that these water courses are reliant on groundwater baseflow. The project is therefore unlikely to have an impact on aquatic GDEs or baseflow.

### *4.4.4 Landholder Bores*

A search of the Australian Groundwater Explorer (BOM 2024) and Water NSW (2024) was undertaken to identify registered bores in the vicinity of the project. The search identified 11 bores within an approximate eight-kilometre radius. Nine bores were reported to be water supply bores (stock and domestic) and are likely to be basic landholder rights bores. The purpose of two bores was unknown.

The nearest basic landholder rights bore (GW307759) is located approximately 2.7 km from ARDG-PGW02. The most conservative predicted radius of drawdown of the development is 378 m. GW307759 is well outside the influence of the quarry pit's radius of drawdown and therefore no drawdown is expected to occur at any of the registered bores as a result of dewatering the quarry pit. The impact of the quarry pit therefore meets the NSW AIP Level 1 Minimal Impact Considerations for Landholder Bores.

### *4.4.5 Conceptual Hydrogeological Model*

A conceptual hydrogeological was developed based on drilling and groundwater monitoring data, downhole logs and core photographs provided by ARDG and interpreted geology. In summary, the following model parameters were applied to the assessment of potential impacts of the proposed quarry on groundwater:

- The groundwater flow system occurs in a confined fractured rock aquifer within the Lochaber Greywacke.
- The hydrostratigraphy of the project area consists of two hydrostratigraphic layers:
    - Clay/saprolite aquitard
    - Confined fractured rock aquifer
- Groundwater levels only have a minor response to rainfall recharge.
- Groundwater is recharged by rainfall infiltration and subsequent leakage through the clay aquitard, and by direct rainfall recharge outside of the project area where the fractured rock outcrops.
- Based on the groundwater bores which target the fractured rock aquifer, groundwater flow is controlled by topography.
- Groundwater within the fractured rock aquifer is unlikely to contribute to baseflow to the nearby ephemeral creeks.

The conceptual hydrogeological model is shown in **Figure 13** as one cross section (A-A') through the project area. Cross section A-A trends northwest to southeast through the centre of the proposed pit. All monitoring and production bores have been offset onto the cross section.

The final quarry pit shell is shown in **Figure 14**. The groundwater level shown as a light-blue-dashed line in **Figure 14.** represents pre-quarrying and pre-pumping conditions and is based on average groundwater levels. The soil saturation/infiltrating rainfall level is shown as a dark-blue-dashed line in the figure. The top of the confined fractured rock aquifer is shown as a yellow-dashed line.

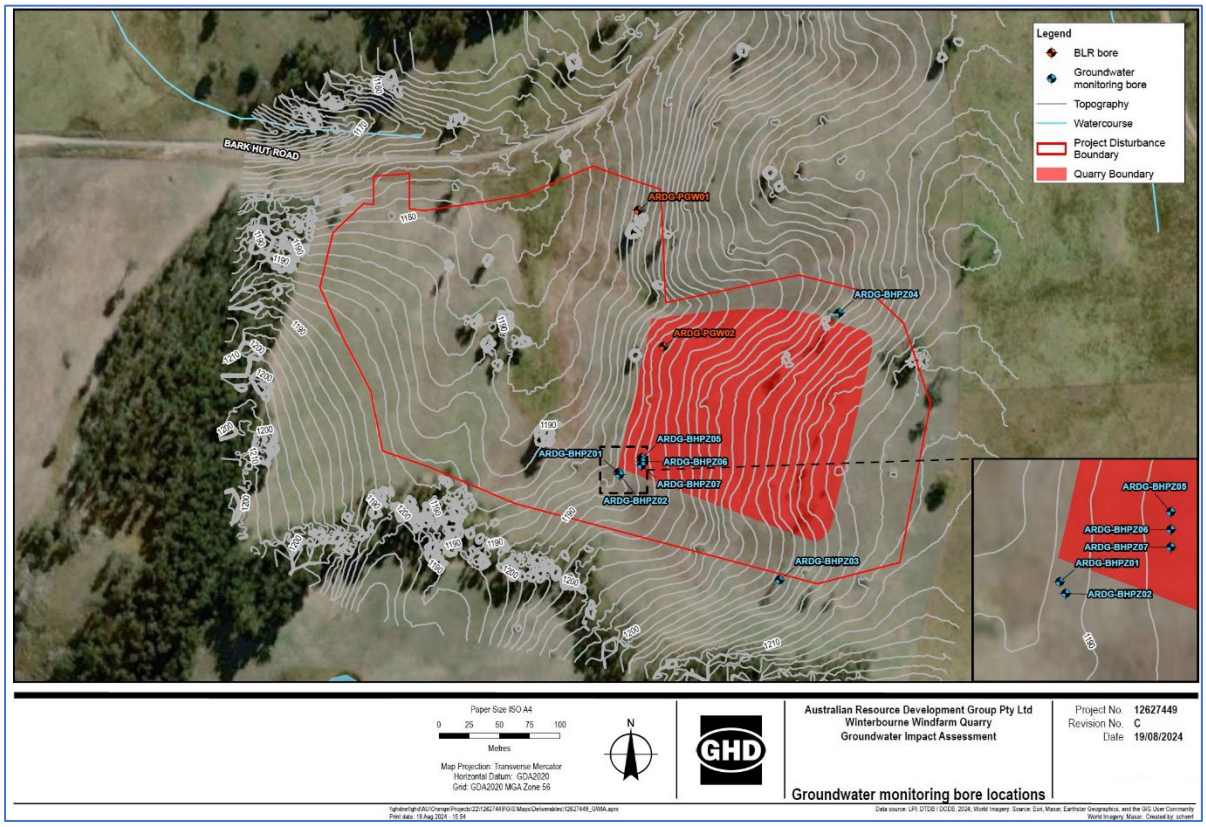



**Figure 12 – Groundwater Monitoring Bore Locations**

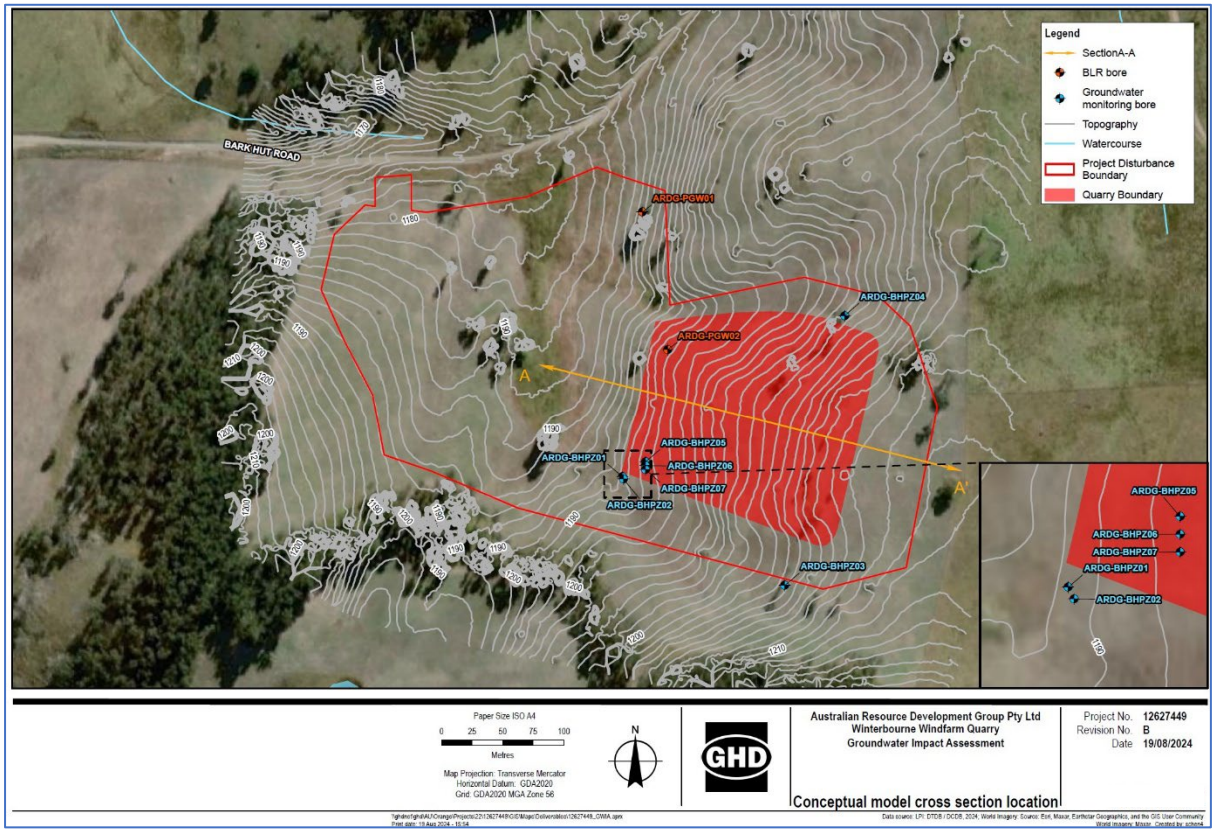



**Figure 13 – Conceptual hydrogeological Model Section Location**

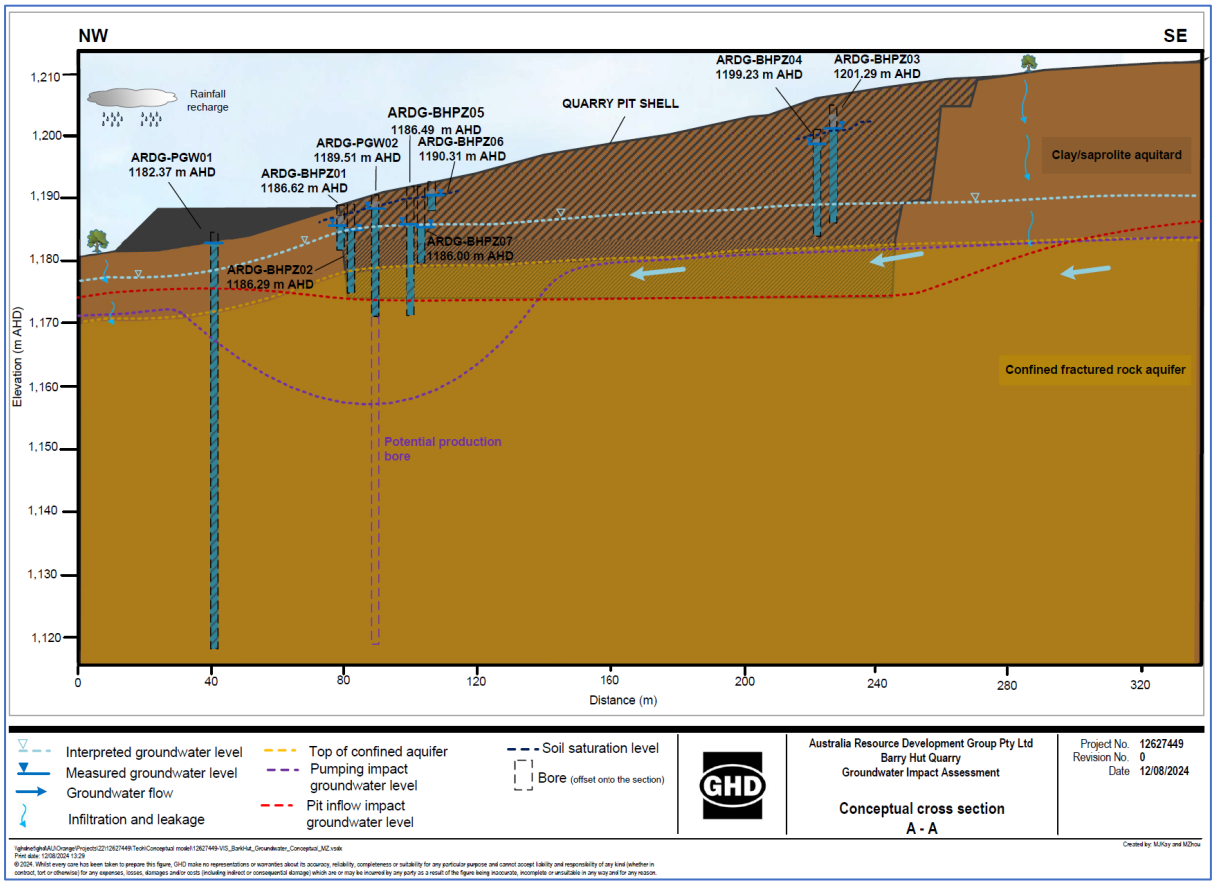



**Figure 14 – Conceptual Hydrogeological Model Cross Section**

Pumping from the potential (conversion of ARDG-GW02 to a) production bore will lower the groundwater level in the vicinity of the project (purple-dashed line, based on a pumping rate of 0.5 L/s, after three years continuous pumping). During development, groundwater inflow into the pit will cause additional groundwater drawdown in the vicinity of the project. The predicted drawdown impact from pit inflows is shown as a red-dashed line (based on a radius of influence of 378 m).

### *4.4.6 Impact Assessment*

A summary of the potential impacts of the quarry on groundwater are provided below.

*Pit Inflow*

Impacts are not predicted until the pit depth reaches below the water table, however the magnitude of any inflows to the pit are dependent on the rate of pumping from a production bore located close to the pit. For a continuous pump rate of 0.3 – 0.5 l/s at a potential production bore located close to the pit, annual inflows are modelled as 10.6 – 4.8 ML/year respectively.

*Existing Bores*

Cumulative impacts have been assessed for the project. The total drawdown will be the drawdown impact from both pit inflows and pumping from the potential production bore. Drawdowns greater than 0.46 m are not expected to occur at any of the registered bores and therefore the cumulative impact of the project therefore meets the NSW AIP Level 1 Minimal Impact Considerations for Landholder Bores.

*Groundwater Dependent Ecosystems*

The nearest high priority GDEs are located near the approximately 70 km from the project site. These GDEs are well outside the predicted radius of drawdown of the quarry pit and production bore and therefore will not be impacted by drawdown associated with the project.

No areas of probable vegetation GDEs within the most conservative predicted radius of drawdown (378 m) have been mapped as part of the *Probable Vegetation Groundwater Dependent Ecosystems – – Northern Rivers and Namoi datasets (DPE Water 2022).* The impact of the quarry pit therefore meets the NSW AIP Level 1 Minimal Impact Considerations for GDEs.

Highly probable vegetation GDEs associated with Snake Creek have been mapped as part of the *Probable Vegetation Groundwater Dependent Ecosystems — Northern Rivers and Namoi datasets (DPE Water 2022)* within the predicted radius of drawdown (5 km) of a production bore. The highly probable vegetation GDEs associated with Snake Creek are located approximately 4.5 km to the southwest of a potential production bore. Based on a continuous pumping rate of 0.5 L/s for three years, no drawdown is predicted to occur at the highly probable GDEs. The impact of the quarry pit therefore meets the NSW AIP Level 1 Minimal Impact Considerations for GDEs.

*Groundwater Quality*

The project and associated production bore are not expected to cause any significant change in groundwater quality or in the beneficial use of the groundwater. Major ion analysis of groundwater does not indicate any previous or potential oxidation of sulfide minerals. The project is not expected to result in the generation of acid groundwater. Additionally, no processing waste or tailings are to be produced or emplaced at the project site.

Quarrying activities may increase groundwater recharge in the post closure phase which may result in a localised improvement in groundwater quality.

*Cumulative Impacts*

Cumulative impacts have been assessed for the project. Drawdowns greater than 0.46 m are not expected to occur at any of the registered bores, and therefore the cumulative impact of the project therefore meets the NSW AIP Level 1 Minimal Impact Considerations for Landholder Bores.

No drawdown is expected to occur at any of the highly probably GDEs and therefore there is unlikely to be an impact any potential GDEs. The cumulative impact of the project therefore meets the NSW AIP Level 1 Minimal Impact Considerations for GDEs.

*Post Closure*

At the end of development, the groundwater table will be locally depressed to 1,175 m AHD. With time, groundwater levels in the aquifer surrounding the quarry pit will recover until equilibrium within the system occurs, and a pit lake forms within the final void. The pit lake is likely to be an area of enhanced recharge for the confined aquifer. Once the system is in equilibrium, the flux of water within the pit lake will only be from rainfall and evaporation. During the recovery stage however, groundwater inflows will occur, and a WAL will still be required in the initial post closure phase of the project.

Recovery of groundwater levels post closure has not been modelled in this assessment. Water level recovery in the final void however has been modelled in the Surface Water Impact Assessment for the project.

Any enhanced recharge that occurs as a result of the quarry in the post closure phase would reduce the time required for groundwater levels to recover. The increased groundwater recharge in the post closure phase may also result in a localised improvement in groundwater quality.

It is recommended that groundwater monitoring continues in the post closure period however, so that groundwater level recovery can be monitored, and predictions made regarding how long a WAL may be required after the project is completed.

*WAL Requirements*

The project is located within the New England Fold Belt Coast Groundwater Source which is managed by the WSP for the North Coast Fractured and Porous Rock Groundwater Sources. Any interference or extraction of groundwater at the project requires a WAL under the WM Act.

Modelling indicates that a WAL would be required to obtain approximately 9.5 ML/year to 15.8 ML/year for direct take (production bore). A WAL would also be required to obtain for approximately 4.8 ML/year to 10.6 ML/year for passive take (groundwater inflows).

Based on recent trades (between 2021 and 2024), water made available and water usage statistics for recent water years (2023/2024, 2022/2023) there is sufficient market depth for a licence of this magnitude.

### *4.4.7 Mitigation and Management Measures*

A groundwater monitoring program will be detailed in the Environmental Management Plan prepared for the quarry operations. The purpose of the groundwater monitoring program is to:

- Measure dewatering performance;
- Assess potential impacts to groundwater levels and quality on other groundwater users in the vicinity;
- Identify groundwater issues such as potential large drawdowns at receptors as early as possible;
- Provide data which can be used to calibrate the analytical model and update the groundwater inflow predictions; and
- Measure groundwater level recovery post closure and provide data which can be used to predict how long a WAL may be required after the project is completed.

The monitoring program should be established prior to the commencement of the project.

Bores should continue to be monitored whilst they are not affected by the quarry operations. It is recommended that groundwater levels initially be monitored quarterly. Once groundwater inflows occur, it is recommended that the monitoring frequency increase to monthly.

It is recommended that water quality be monitored quarterly in all monitoring bores for the first two years after the project commences (or until they are affected by quarry operations). The monitoring program should be reviewed every two years to determine if monitoring results indicate that less frequent monitoring would still provide a reasonable level of data to enable the impacts to be reliably detected.

Once the quarry pit extends below the top of the confined aquifer, the monitoring program should also include monitoring of groundwater inflow into the quarry. Measuring groundwater take is a

requirement from a licensing perspective and the measured inflows can also be used to calibrate the analytical model and provide updated predictions. Groundwater inflow rates should therefore be accurately recorded.

Groundwater quality monitoring requirements post closure should be reviewed as part of closure planning with a focus on understanding the impacts of groundwater recharge from a recovering pit lake on the local groundwater system. Groundwater levels should continue to be monitored in the post closure phase until groundwater levels stabilise and/or regulation requirements are met. Monitoring locations and frequency in the post closure period should be identified as part of the quarry closure planning process and be informed by monitoring undertaken during the life of project, updated predictions of pit lake recovery and likely water quality and risks presented from pit lake recovery.

The groundwater monitoring program will provide a safeguard against any impacts that have not been identified in this assessment. If unforeseen impacts are identified during monitoring ARDG will be able to amend the dewatering operation and/or the monitoring program to prevent further reductions in groundwater levels and/or quality.

## 4.5 Biodiversity

Biodiversity aspects of the proposed quarry are assessed as part of the Amended Biodiversity Development Assessment Report, included as Appendix D of the project Amendment Report.

## 4.6 Heritage

Heritage aspects of the proposed quarry (both Aboriginal Heritage and Historic Heritage) are assessed as part of the Amended Heritage Assessment Report, included as Appendix E of the project Amendment Report

## 4.7 Noise

### *4.7.1 Noise Criteria*

A Noise Impact Assessment (NIA) has been prepared by Sonus (2024) to assess the potential impact of the project in accordance with the NSW *Interim Construction Noise Guideline* (ICNG). A full copy of the NIA is provided in **Appendix 3**, with the outcomes of the assessment summarised in the section below.

The ICNG provides an emphasis on implementing "feasible" and "reasonable" noise reduction measures and does not set mandatory objective criteria; rather it sets "management levels" based on the existing background noise environment. The existing background noise environment is defined by the rating background noise Level (RBL), which is determined from the lower tenth percentile of the measured background noise levels (LA90, 15 minute) in the environment. This effectively represents the quietest periods of the environment, down to a specified minimum RBL. Background noise levels have not been measured at each location, as such the minimum rating background noise level as per the Noise Policy for Industry have conservatively been used (refer **Table 3**).

| Table 3 Minimum Rating Background Noise Level | |
|---|---|
| **Time of Day** | **Minimum Rating Background Noise Level (dB(A)** |
| Day (7 am–6 pm) | 35 |
| Evening (6 am–10 pm) | 30 |
| Night (10 pm–7 am) | 30 |

For the purpose of the assessment, it has been assumed that the WWF Quarry will operate some equipment that is considered to be annoying, including 'beeper' style reversing alarms, rock drilling and rock breaking activities, and as such, a 5dB(A) penalty has been applied to predictions at non-associated residences.

**Table 4** provides a summary of the noise criteria for the operation of the WWF Quarry from the ICNG.

| Table 4 Construction Noise Management Level Summary | | | | |
|---|---|---|---|---|
| **Land Use** | **Time of day** | | **RBL dB(A)** | **Noise Management Level dB(A)** |
| Residential | Recommended Standard Hours | Monday to Friday 7 am – 6 pm<br>Saturday 8am to 1 pm | 35 | 45 |
| | Outside Recommended Standard Hours | Saturday 7am – 8am and 1pm – 6pm<br>Sunday or Public Holidays 7am – 6pm | 35 | 40 |
| | | Evening (6pm – 10pm) | 30 | 35 |
| | | Night (10pm – 7am) | 30 | 35 |

The proposed use of a local quarry will inherently minimise traffic noise as the material from the quarry would otherwise be transported from a greater distance to the site. Notwithstanding, an assessment has been made against the NSW *Road Noise Policy* (RNP).

**Table 5** provides a summary of the road traffic noise criteria for the operation of the WWF Quarry from the RNP.

| Table 5 Road Traffic Noise Assessment Criteria for Residential Land Uses | | |
|---|---|---|
| **Type of project/land use** | **Assessment Criteria – dB(A)** | |
| | **Day (7am – 10pm)** | **Night (10pm – 7am)** |
| Existing residences affected by additional traffic on existing local roads generated by land use developments | LAeq, (1 hour) 55 (external) | LAeq, (1 hour) 50 (external) |

### 4.7.2 Noise Assessment

*Quarry*

The construction noise assessment has considered the concept layout of the quarry and the location and noise generation from equipment that will be used in the quarry operations.

The assessment considered each of these noise sources operating concurrently throughout the 15-minute assessment period1. "Worst-case" and "typical" usage cases have been made for time the noise sources would operate during the assessment period.

Environmental noise predictions have been made using the CONCAWE noise propagation model within the SoundPLAN noise modelling software. The modelled conditions correspond to CONCAWE weather category 5 during the day/evening and CONCAWE weather category 6 at night. The modelled weather conditions are described as "noise-enhancing meteorological conditions" in accordance with Fact Sheet D of the NSW Noise Policy for Industry.

Based upon information provided for the proposed quarry operations, two scenarios were considered for:

1. – The "worst-case" (highest possible) 15-minute noise levels during use of the WWF Quarry (refer to **Figure 15**.

2. – The typical2 15-minute noise levels expected for most of the time during use of the WWF Quarry, (refer to **Figure 16)**.

Based on the noise model, it was found that the highest noise level at the non-associated residence (receiver SR240) is predicted to be less than 20 dB(A) during both the worst-case and typical operation scenarios, including the application of a 5 dB penalty. The predicted noise levels easily achieve the (most onerous) Saturday 7am – 8am and 1pm – 6pm NML of 40 dB(A).

The highest predicted noise level at the associated residences (specifically, receiver SR119) is 44 dB(A) under typical operation and 46 dB(A) under worst-case operation. However, the predicted noise levels for associated receivers are provided for information only. As SR119 is an associated receiver, it is assumed that a higher noise level would be agreeable during the quarry operations.

*Road Traffic*

Based upon the maximum expected road traffic volumes during construction, the predicted road traffic noise levels at receiver SR058 are shown in **Table 6**. The predictions show that the applicable road traffic noise criteria can be met at the nearest sensitive receiver on Bark Hut Road, with or without the WWF Quarry.

**Table 6 SR058 Road Traffic Noise Predictions**

| Time | Criteria | Scenario Predictions dB(A) | |
|---|---|---|---|
| | | With WWF Quarry | Without WWF Quarry |
| Day (Peak Hour) | LAeq (1 hour) ≤ 55 dB(A) externally | 49 | 49 |

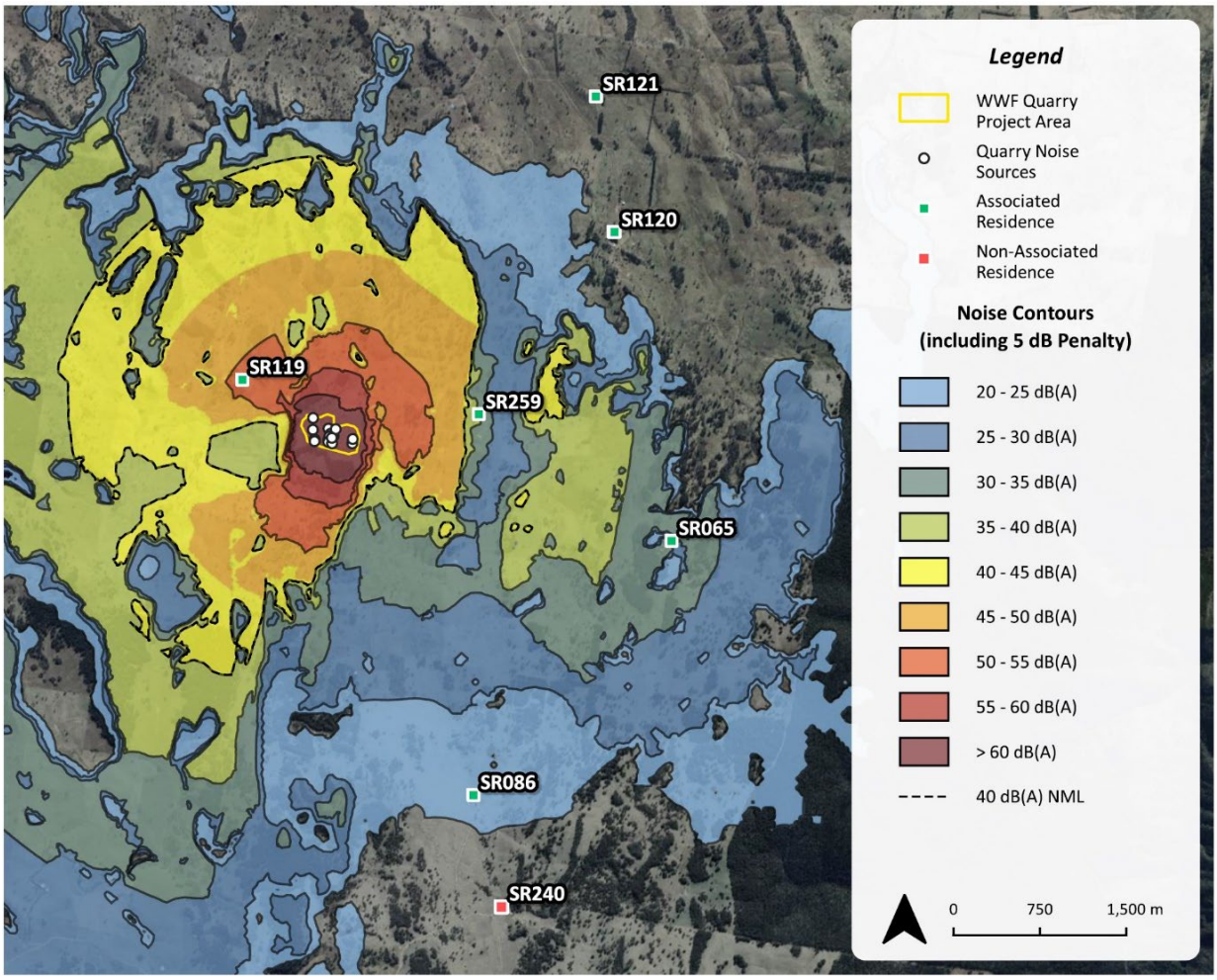



**Figure 15 – Worst-case noise levels during operation of quarry**

*Assessment Conclusions*

Based upon the noise predictions, it was found that the highest noise level at the nearest non-associated residence (Receiver SR240) is predicted to be less than 20 dB(A) during both worst-case and typical operation scenarios. The predicted noise levels easily achieve the (most onerous) Saturday 7am – 8am and 1pm – 6pm NML of 40 dB(A).

Noise levels up to 46 dB(A) were predicted at the nearest associated residence (Receiver SR119) during worst-case operation of WWF Quarry, however as SR119 is an associated receiver, it is assumed that a higher noise level would be agreeable during the quarry operations.

Decommissioning noise is not considered to be louder than the noise associated with operation and will therefore achieve the NMLs.

An assessment of traffic noise associated with the WWF Quarry confirms that the NSW Road Noise Policy will be achieved at both associated and non-associated residences.

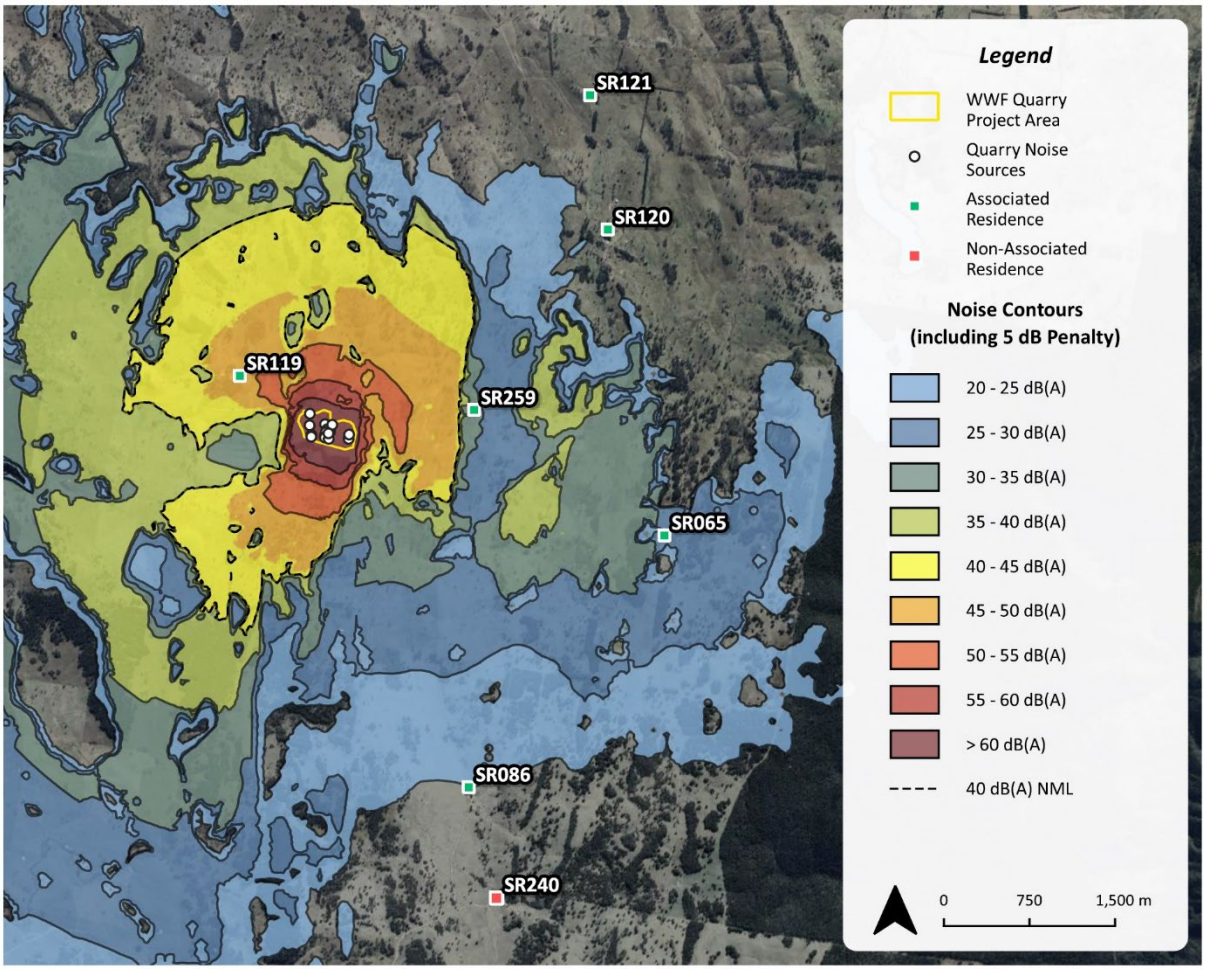



**Figure 16 – Typical noise levels during operation of quarry**

### *4.7.3 Noise Mitigation*

The majority of the works will be undertaken during daytime hours, being Monday to Saturday 7am to 6pm. It is anticipated that some of the proposed works may require works outside of these hours (including Sundays) such as maintenance, however these will be restricted to relatively non-audible activities to limit potential impacts on surrounding areas.

Notwithstanding that the assessment determined that noise associated with both the quarry and road traffic meets the requirements of both the ICNG and NSW Road Noise Policy, there are a number of control measures or operational procedures that will be implemented to manage noise emissions onsite. These measures will be documented in the EMP and will be implemented depending on operational and meteorological conditions. Managing noise at the site will include a mix of measures including, for example:

- Construction and operation works will be undertaken during daytime hours, being Monday to Saturday 7am to 6pm. Relatively non-audible maintenance and other works undertaken outside of these hours if necessary.
- Machinery used in construction will be maintained to appropriate operating standards.

- The use of broadband reversing alarms instead of beeper style alarms on mobile equipment.
- The management of mobile machines as required to minimise adverse noise impacts during adverse weather conditions when meteorological conditions enhance the noise propagation towards sensitive receiver locations.
- Using equipment with efficient muffler design.
- Regular inspection and maintenance of equipment in general.
- Scheduling the use of noisiest equipment at the least-sensitive time of day where practicable.

## 4.8 Blasting and Vibration

A Blasting Impact Assessment (BIA) has been prepared by Enviro Strata Consulting (2024) to assess the potential impact of blasting within the Project's extraction area on sensitive receptors, including private residences and infrastructure. The BIA has been prepared to address the likely blasting impacts of the development (including ground vibrations, overpressure, flyrock, visual and fumes/odour), in addition to an assessment of cumulative impacts, having regard to the relevant ANZECC guidelines. A full copy of the BIA is provided in **Appendix 4**, with the outcomes of the assessment summarised in the section below.

### *4.8.1 Methodology*

The BIA followed the guidelines presented in the Australian and New Zealand Environment and Conservation Council (ANZECC) guideline *Technical Basis for guidelines to minimise annoyance due to blasting overpressure and ground vibration* (ANZECC, 1990) and *Australian Standard AS 2187.2-2006 Explosives – Storage and use* and covered a 4 km radius of impact representing the likely range of impacts.

*Receivers*

The BIA has identified six (6) privately owned residential receptors within 4 km of the proposed WWF quarry site, all associated with the WWF project. Note that the closest receptor, located to the north-west of the quarry site is also associated with the quarry project directly (i.e. residence owned by the quarry site landowner, though unoccupied).

Residences located in excess of 4 km from the Project were not assessed, as significant impacts are considered highly unlikely beyond this distance, based on the maximum charge mass proposed for use.

Walcha, the nearest town to the quarry, is located 20 km to the south-west of the quarry site. At this distance, any potential impact from blasting is considered negligible, well below the threshold of human perception, and therefore does not necessitate an assessment.

Items of public and private infrastructure that have potential to be impacted by vibration and/or overpressure impacts from blasting were also identified in the vicinity of the Project Area within a 100 m to 1,500 m range of the proposed extraction area. The public and private infrastructure facilities, heritage sites and significant natural features that were assessed in the BIA are listed below:

- Public road, specifically Bark Hut Road, located at a minimum distance of 180 m from the quarry pit boundary.

- Existing LV Powerlines (located to the North) with the closest timber power pole situated 490 m from the quarry pit boundary.
- Nearest proposed underground LV power cables located adjacent to Bark Hut Road, a minimum distance of approximately 0.15 km from the quarry pit boundary.
- Nearest proposed WWF tower located a minimum distance of 0.185 km from the quarry pit boundary.
- Nearest proposed laydown area located a minimum distance of 0.1 km from the quarry pit boundary.
- Proposed 330 kV transmission line easement located a minimum distance of approximately 1.5 km from the quarry pit boundary.
- Proposed groundwater bore located a minimum distance of 100 m from the quarry pit boundary.

*Project Staging*

The geology of the Project Area has been extensively surveyed using detailed surface mapping and a percussion and diamond drilling program undertaken by ARDG (refer **Section 3.4.2**). From a quarrying perspective, the dominant rock formation targeted in this Project is a high-quality greywacke. The geological assessment model determined a requirement for two benches with a maximum bench height of in the order of 15 m deep each with steeply designed highwalls. The Project is expected to operate for approximately 3 – 4 years with hard rock extraction (and therefore blasting) taking place in the extraction pit area only.

Blasting will be undertaken Monday to Friday (between 9 am and 5 pm) while drilling activities will be undertaken Monday to Friday (between 7 am and 6 pm), and on Saturdays (from 7 am to 3 pm). It is anticipated that on average, one blast will be fired every 6 to 8 weeks.

*Modelling*

For assessment purposes, a ground vibration predictive model was used based on data and modelling of a small coal mine comparable to the proposed quarry operation (*i.e.* the mine used charge masses in the order of 42-225 kg, covering various blasts that include overburden and interburden blasts).

The airblast overpressure monitoring results (from the comparable mine) were plotted and together with other parameters, resulted in the development of the airblast predictive model for the site.

*Blast Emission Criteria*

A summary of blast emission criteria used in the assessment is presented in **Table 7**. Further detail on the sources and rationale is provided in the BIA in **Appendix 4**.

| Table 7 Summary of Blast Emission Criteria | | |
|---|---|---|
| **Aspect** | **Vibration Criteria (mm/s)** | **Airblast Criteria (dBL)** |
| Private residences [1] | 5 (for 95% of blasts)<br>10 (not to be exceeded) | 115 (for 95% of blasts)<br>120 (not to be exceeded) |
| Unoccupied infrastructure (public roads and bridges, timber power poles, buried communication cables and wind turbines, groundwater bores) | 100 | N/A |

Note: 1. Applies to buildings and sheds only (after ANZECC (1990))

### *4.8.2 Assessment Results*

*Community*

*Ground Vibration*

All potential ground vibration exposure results were well below (ranging 0.1 – 2.6 mm/s) the applicable private residential receptor limits specified as 5 mm/s (for 95% of blasts) and 10 mm/s (not to be exceeded) under all modelled blast scenarios. As a result, no additional blast control measures are required to comply with the ground vibration criteria for residences.

*Airblast Overpressure*

All potential airblast overpressure results were below (ranging from 95 – 115 dBL) the applicable private residential receptor limits specified as 115 dBL (for 95% of blasts) and 120 dBL (not to be exceeded) under all modelled blast scenarios.

*Infrastructure*

*Ground Vibration*

All maximum estimated vibration exposures for infrastructure are below (ranging 1 – 87 mm/s) the vibration limits specified as 100 mm/s for all blast scenarios considered. As a result, no additional blast control measures are required to comply with the ground vibration criteria for infrastructure.

*Flyrock*

Flyrock impact on adjacent residences and infrastructure is considered to be able to be fully managed, and potential risks mitigated, due to the application blasting techniques to ensure that all flyrock is contained within the boundary of Lot 95. Therefore, it is concluded that the flyrock risks for residential receptors and infrastructure will be managed adequately through implementation of procedures to be detailed in a Blast Management Plan for the site.

### *4.8.3 Mitigation and Management Measures*

The recommended blast emission control measures for the Project to minimise blasting impacts (including ground vibration, airblast overpressure and flyrock impacts) on the surrounding environment are as follows:

- Use of ground vibration and airblast predictive models to estimate potential impacts for critical receptors.
- Use of appropriate charge mass design and avoidance of overcharging holes.
- Use of an appropriate initiation sequence to minimise the possibility of hole interactions, ideally aiming for single hole initiation.
- Application of appropriate quality stemming material and stemming height to facilitate explosives confinement and therefore minimise airblast overpressure emissions, stemming ejection and/or flyrock incidents.
- Maintain appropriate burden specification for the front row holes to avoid face bursts and related flyrock incidents.
- Other management measures to be implemented will include the following:
    - Blast Monitoring System – Due to the limited number of private residences in the area, the monitoring system for private residences should consist of two (2) monitoring stations to capture ground vibration and airblast overpressure impacts from blasting at the Project site (including residence SR119 and SR259.
    - Temporary Road Closure – Due to the close proximity to a public road (Bark Hut Road), a temporary road closure for the duration of the blast will be required. To ensure the safety of the public, the quarry will develop and implement a procedure for temporary closure of the road as part of the Blast Management Plan and seek approval from Walcha Council.
    - Pre-Blast Assessment Protocol – to manage blasting and to minimise the impacts on the surrounding area. The protocol would be reviewed on a regular basis to address the physical changes in the quarry.
    - Residence Notification System – to provide information on the dates and times of proposed blasting to the private residences in close proximity.

## 4.9 Air Quality and Greenhouse Gas Emissions

A detailed Air Quality impact Assessment (AQIA) was prepared by Airen Consulting and is provided in **Appendix 5**.

The Project disturbance areas include the proposed extraction pit(s), and processing/stockpile areas. The nature of the proposed works means there may be dust created during construction and operation. Activities that have the potential to impact air quality through dust creation include:

- Blasting of the extraction pit.
- Development of a processing and stockpiling area adjacent to the extraction pit.
- Extraction, processing, stockpiling and loading of material.

A detailed numerical model assessment of the potential air quality impacts was undertaken (Airen, 2024) which involved identifying the key air quality issues, characterising the existing environment, quantifying emissions to air and modelling the potential impact of the Project on local air quality. The key air quality issues were identified as operational dust, post-blast fume and diesel exhaust. These issues were the focus of the assessment. Greenhouse Gas (GHG) emissions were also estimated in accordance with recognised methodologies.

A detailed review of the existing environment was carried out including an analysis of historically measured concentrations of key quality indicators from regional monitoring stations. The review showed that air quality in many parts of NSW, including the New England, is heavily influenced by climatic conditions such as drought. However, due to the absence of any significant sources of air pollution, the concentrations of key air quality indicators near the Project are expected to be well below acceptable (EPA) levels.

The key outcomes of the modelling and subsequent assessment were as follows:

- The Project would not cause adverse impacts with respect to dust concentrations or deposition levels, based on modelling which showed all air quality criteria were well below and therefore compliant at all sensitive receptors. Modelling results indicated compliance with all air quality criteria at all sensitive receptors, with results for the nearest receptor (SR119 – associated landowner, 1 km northwest) summarised below:
  - 24-hour average $PM_{10}$ concentration: < 5 µg/$m^3$ (*EPA criterion = 50 µg/$m^3$*)
  - Annual average $PM_{10}$ concentration: < 0.5 µg/ $m^3$ (*EPA criterion = 25 µg/$m^3$*)
  - 24-hour average $PM_{2.5}$ concentration: < 2 µg/ $m^3$ (*EPA criterion = 25 µg/$m^3$*)
  - Annual average $PM_{2.5}$ concentration: < 2 µg/ $m^3$ (*EPA criterion = 8 µg/ $m^3$*)
  - Annual average TSP concentration: < 1 µg/ $m^3$ (*EPA criterion = 90 µg/ $m^3$*)
  - Deposited dust concentration: < 0.2 g/$m^2$/year (*EPA criteria = 2 g/$m^2$/month [incremental] and 4 g/$m^2$/month [cumulative]*)
  - Maximum 1-hour average $NO_2$ concentration: < 111 µg/$m^3$ (EPA criterion = 164 µg/$m^3$)
- Post blast fume emissions are not expected to result in any adverse air quality impacts, based on modelling which showed compliance with air quality assessment criteria at all sensitive receptors.
- Emissions from diesel exhausts associated with off-road vehicles and equipment are not expected to result in any adverse air quality impacts, based on modelling which showed compliance with air quality assessment criteria at all sensitive receptors.
- The direct GHG emissions from the Project (*i.e.* Scope 1) are estimated to average 2,186 t $CO_2$-e per year. These emissions represent a very small fraction of Australia's emissions. In addition, the Project is estimated to save in the order of 10,747 t $CO_2$-e when compared to sourcing the WWF materials from existing, more distant quarries.

Based on this assessment, it was concluded that the Project is a relatively small, temporary, and remote operation that is unlikely to cause any adverse air quality impacts at sensitive locations. The Project will have significant benefits in terms of avoided GHG and diesel particulate emissions relative to alternate sources of quarry material for the WWF.

The modelling showed that off-site dust concentrations and deposition levels would be well below the relevant EPA assessment criteria. Therefore, an appropriate air quality management strategy would include standard mitigation measures such as:

- Minimising the area of disturbed land at any one time;
- Adopting controls for haul road dust emissions;
- Use of water sprays when drilling if / as required;
- Use of water sprays on stockpile areas if / as required; and
- Visual monitoring to identify excessive dust generation.

Due to the low predicted levels of all assessed emissions at the nearest sensitive receptors, particulate and depositional dust monitoring is not considered to be warranted. The implementation of reactive controls such as additional watering or sprays in the event of visible dust emissions from activities which can be controlled (*e.g*. haulage emissions and crushing / processing operations) is considered sufficient to manage potential impacts.

Mitigation of GHG emissions will be inherent in the development of the quarry plan. The mitigation measures to minimise the level of GHG emissions from the Project will include:

- Planning and designing of operations to minimise fuel usage and to maximise energy efficiency;
- Maintenance of plant and equipment to minimise fuel consumption and associated emissions; and
- Training staff on improvement strategies to minimise fuel usage and maximise energy efficiency.

## 4.10 Visual Amenity

The quarry area is not visible from any surrounding residences, being blocked by either topography and/or vegetation. The quarry operations and pit would be visible from Bark Hut Road. However, given the low traffic volumes on this road (only two residences located east of the quarry site) and in the context of the proposed WWF infrastructure located adjacent the eastern boundary the quarry site (e.g. contractor laydown/internal access road/wind turbine), the visual impact of the quarry site is considered to be low and consistent with the overall visual impact of the WWF.

Notwithstanding, the following measures will be implemented to mitigate visual impacts of the operation:

- Ensuring that areas of disturbance are kept to the minimum practicable at any one point in time.
- Rehabilitation of disturbed areas as soon as practical.
- Return of disturbed areas to pasture consistent with current land uses in the long term.

## 4.11 Traffic

Traffic aspects of the proposed quarry are assessed as part of the Amended Traffic Impact Assessment Report, included as Appendix H of the project Amendment Report. Notwithstanding, the following analyses assume a total Project quarry materials demand of 1 Mt and average load of 32 t per truck, which equates to a total of 31,250 trips (62,500 movements).

No single quarry in the region has the potential to be a single source supplier for the WWF project, given existing markets and limitations on resource base and approved extraction limits. The nearest quarries with the potential to supply quarry materials the WWF Project are located at Guyra, Currabubula, Winton, Ardglen and Willowtree. On average, these quarries have an approximate 316 km round trip to the WWF Project. Compared to delivery from these commercial quarries, the supply of all quarry materials from the WWF Quarry to the WWF Project would:

- remove approximately 62,500 truck movements from the arterial (*i.e.* Oxley / New England Highway; Thunderbolts Way) and broader regional and local road network;
- reduce haulage by trucks on these road networks by approximately 9.9 million km; and
- reduce greenhouse gas emissions by approximately 10,747 t $CO_2$-e associated with the reduction in fuel usage resulting from the reduced haulage distance.

This reduction in overall construction traffic and kilometres travelled on the public road network is a major benefit of the proposed quarry project, which will result in improved safety and amenity on the local and regional road network by effectively containing all quarry truck movements to the WWF Project area and in turn, a significantly shorter segment of the public road network. The very significant reduction of this WWF construction traffic from the local and regional road network would create very significant, tangible benefits for the local and broader community by:

- reducing construction traffic noise amenity impacts for residents along these road network and in particular townships such as Walcha);
- improving road safety (substantially reducing heavy/light vehicle interactions); and
- reducing heavy vehicle wear and potential damage to the local and regional road network by significantly reducing total distance travelled on the local and regional road network.

## 4.12 Hazards

### *4.12.1 Bushfire Risk Assessment*

An assessment of the proposal in accordance with Planning for Bushfire Protection (PBP) (RFS, 2019) is provided below.

The Project Area is identified as bushfire prone land by the NSW Rural Fire Service (RFS) bushfire prone land mapping (RFS, 2021) (refer to **Figure 17**). Extensive areas surrounding the Project Area have been subject to clearing associated with historical agricultural activities which reduces the bushfire risk in these cleared areas.

The Project Area and surrounding land is mapped as Category 3 Vegetation on the RFS mapping, which represents lower bushfire risk. This vegetation category is consistent with isolated stands of remnant vegetation and grassland. Areas associated with Category 3 Vegetation is generally also land subject to ongoing land management practices that actively reduce bushfire risk. Areas of remnant vegetation immediately adjacent the Project Area to the south and west is mapped as Category 1 Vegetation though are relatively isolated and connectivity of vegetation across the landscape is limited.


**Figure 17 – Bushfire Prone Land Mapping. Category 1 vegetation shown in red, Category 3 vegetation is shown in yellow.**

Section 8.3 of PBP provides assessment guidelines for *Other non-residential development*, of which the proposed WWF Quarry is a type. Section 8.3.6 of PBP – *Mining (underground and open cut) and petroleum production* most closely resembles the proposed operations of the proposed WWF Quarry. PBP states that assessment with this part should be undertaken "*with consideration to the same provisions detailed in section 8.3.5 for wind and solar farms*".

All quarry site infrastructure (plant and equipment), as well as any temporary demountable buildings (*e.g.* mobile crib room and toilet facilities) will be located within the quarry operations area. Given the nature of the quarry operations area (bare ground, no vegetation), the site infrastructure will be located a minimum 10 m from the site boundary, thereby creating a minimum Asset Protection Zone (APZ) of 10 m within the footprint of the quarry operations area, as required under Section 8.3.5 of PBP.

An Environmental Management Plan (EMP) will be prepared for the WWF Quarry prior to the commencement of any construction works on the site. A Bush Fire Emergency Management and Operations Plan (BFEMOP) will be prepared in accordance with the requirements of Section 8.3.5 of PBP and be included in the EMP. The BFEMOP will include the following:

- Details of measures to prevent or mitigate fires igniting.
- Description of work that should not be carried out during total fire bans.
- Details of the availability of fire-suppression equipment, access and water. Details of an emergency access will be provided in the Plan.
- Details of storage and maintenance of fuels and other flammable materials.
- Notification process to the local NSW RFS Fire Control Centre for any works that have the potential to ignite surrounding vegetation, proposed to be carried out during a bush-fire fire danger period to ensure weather conditions are appropriate.
- Appropriate bush fire emergency management planning.

### *4.12.2 Hazardous Materials*

A preliminary risk screening was undertaken for the Project in accordance with Chapter 3 of the State Environmental Planning Policy (Resilience and Hazards) 2021 (Resilience and Hazards SEPP). The preliminary risk screening involves identification and assessment of the storage of specific dangerous goods classes that have the potential for significant off-site effects. A development is considered 'potentially hazardous' and requires a Preliminary Hazard Analysis (PHA) if the storage or transport of hazardous substances exceeds specific screening thresholds.

**Table 8** provides a list of the hazardous materials to be stored within the Project Area, dangerous goods classes of the materials, storage quantities and screening thresholds. Based on the quantities listed in **Table 8** none of the hazardous materials to be stored at the Project are above screening thresholds and a PHA is not required. Vehicle movements for the transport of hazardous materials to the site will also be well below transportation screening thresholds. Note that explosives and explosive precursors will not be stored on site and therefore do not trigger screening requirements.

## 4.13 Waste

The proposed works will adhere to the following typical waste management principles:

- Waste avoidance and reduction at the source.
- Waste re-use.
- Waste recycling.
- Waste removal and disposal.

The Project will generate minimal waste as all material produced by the quarry will be either used in construction of RPWF or in quarry rehabilitation works.

Further, the Project will generate minimal quantities of general waste. Any general waste would be disposed of or recycled via an appropriately licensed waste contractor.

| Table 8 Hazardous Materials Inventory | | | | | |
|---|---|---|---|---|---|
| **Material** | **Storage Type and Location** | **ADG Code1 Class** | **Quantity** | **Screening Threshold** | **PHA Required?** |
| Diesel | Above ground self-bunded tank (Operations Area) | C1 | 1 x 20 kL[2] | No screening thresholds for combustible liquids | No |
| Unleaded petrol | Packages (Operations Area) | 3 (II) | 200 kg | < 5 tonne – screening distance does not apply | No |
| Engine and hydraulic oils | Packages (Operations Area) | C2 | 3,000 kg | No screening thresholds for combustible liquids | No |
| LPG | Packages (Operations Area) | 2.1 | 100 kg | 10 tonne | No |
| Welding gases (*e.g.* acetylene) | Packages (Operations Area) | 2.1 | 30 kg | 10 tonne | No |
| Aerosols | Packages (Operations Area) | 2.1 | 50 kg | 10 tonne | No |
| Paints and solvents | Packages (Operations Area) | 3 (III) | 50 kg | < 5 tonne – screening distance does not apply | No |

**Notes:** 1. Australian Dangerous Goods Code
2. 20 kL of diesel has a mass of approximately 17,200 kg.

Wastes generated from the on-site maintenance and servicing of machinery will be managed by the manufacturer or certified mechanics. All service materials (including waste grease/oils) and packaging will be removed by the servicing personnel.

The only drill rig to be utilised on the site is a blast hole percussion drill rig, with a dust extraction system. The rig does not use water or any muds / additives to facilitate drilling by lubricating the holes. As such, there would be no 'drillers mud' generated. The small pile of drill cuttings generated by the drilling of each blast hole would be incorporated into the quarry blast.

Any waste generated by the Project will be managed by way of appropriately licensed waste contractors. No on-site disposal of general waste will occur. In order to minimise the generation of waste and maximise re-use of waste products, where practicable, the following practices will be implemented on site:

- All waste oil and grease will be collected and will be removed from the site and managed by servicing personnel.
- Workshop wastes including oil filters and tyres will be removed from the site by the mechanics providing replacement parts.

- All office paper and general waste originating from the office and amenities will be placed in appropriate containers, removed from site and recycled at an appropriate waste management facility.

With these controls in place, it is expected that the impacts associated with waste generation and disposal resulting from the Project can be effectively managed.

## 4.14 Social and Economic Impacts

It is considered that there are negligible negative socio-economic impacts as a result of the proposed WWF Quarry project due to the isolated nature of the Project. Noise and Air Quality impact assessments presented in this report indicate that potential emissions associated with the project can meet appropriate criteria due to the relatively isolated location of the project.

As indicated in **Section 4.11**, the project will result in a significant tangible benefit to the community through a very large reduction in construction haulage traffic on the wider public road network associated with the WWF Project.

During the construction of the Project and the initial delivery of equipment, road users of the surrounding road network may experience short delays. No detours will be required and any delays experienced as a result of the proposed works is considered to be minor. The majority of the works will be undertaken during daytime hours, being Monday to Saturday 7am to 6pm.

To ameliorate the potential impacts, the following mitigation measures will be implemented:

- All works will be undertaken in accordance with the mitigation measures outlined above and summarised in **Section 5.0**.
- Machinery used in construction will be maintained to appropriate operating standards.

## 4.15 Site Rehabilitation

The proponent is committed to the effective rehabilitation and closure of the quarry at the cessation of operations. The overarching objective for the site is that the final landform is safe, stable and non-polluting having regard to the proposed end land use for the site and surrounding areas.

Rehabilitation at the quarry will address the long-term stabilisation of both quarried and disturbed areas, including stabilisation of the quarry benches in the extraction pit, with the final pit voids to remain after closure. All final landform slopes (including retained highwalls) will be assessed for long term geotechnical stability having regard to the risk profile presented by the final landform and potential access to the site. It is anticipated that the site sediment basin will remain, and the landform outside of the extraction pit will be shaped to be free draining to the pit void and sediment basin. All infrastructure not required by the landowner for post-closure land uses will be removed.

The proposed rehabilitation strategy for the site has been developed with regard to a number of key principles and includes:

- rehabilitation objectives, methodology, monitoring programs, performance standards and proposed completion criteria;
- nominated final land use, having regard to any relevant strategic land use planning or resource management plans or policies; and

- the potential for integrating this strategy with any other rehabilitation and/or offset strategies in the region.

Due to the nature of the pit design (which is dictated by the geology of the resource), the location of processing and handling infrastructure, and relatively short-term nature of the operation (3 – 4 years), there are limited opportunities for progressive rehabilitation of the site.

The ability to return the entire site to a viable grazing paddock is limited due to the extraction pit void being entirely located withing the extent of the hard rock deposit and the desire of the landowner for the sediment basin to be retained as an additional water storage dam for the rural property.

Notwithstanding, the remainder of the site (*i.e.* processing and operations area) can be rehabilitated to provide a return to the current grazing landuse activities. The potential for formation of a water storage within the void would also provide additional end land use opportunities associated with the water storages including emergency bushfire fire-fighting water supply opportunities.

A conceptual final landform and life of operations rehabilitation management strategy relevant to achieving these landuse outcomes will be detailed in the Environmental Management Plan (EMP). The conceptual final landform shown in **Figure 18** is based on a final land use focused erosion and sediment control and promoting the re-establishment of grazing activities on the site consistent with landowners current rural / grazing landuse.

The exact timing of individual rehabilitation works will be dependent upon on the completion of quarry operations which will be dictated by the construction timetable of the WWF Project.

### *4.15.1 End Land Use/Rehabilitation Objectives*

The conceptual end land use opportunities identified for the quarry have been developed in consideration of the objectives of the Walcha LEP 2012. As noted in **Section 3.2** the quarry site is located on land zoned RU1 Primary Production. The objectives of the RU1 zone are:

- *To encourage sustainable primary industry production by maintaining and enhancing the natural resource base.*
- *To encourage diversity in primary industry enterprises and systems appropriate for the area.*
- *To minimise the fragmentation and alienation of resource lands.*
- *To minimise conflict between land uses within this zone and land uses within adjoining zones.*
- *To protect the agricultural value of rural land.*
- *To maintain the rural landscape character of the land in the long term.*
- *To ensure that development does not unreasonably increase demand for public services or public facilities.*
- *To ensure that development for the purposes of extractive industries, underground mines (other than surface works associated with underground mines) or open cut mines (other than open cut mines from the surface of the flood plain) will not—*

*(a) destroy or impair the agricultural production potential of the land or, in the case of underground mining, unreasonably restrict or otherwise affect any other development on the surface, or*

*(b) detrimentally affect the quantity, flow and quality of water in either subterranean or surface water systems, or*

*(c) visually intrude into its surroundings, except by way of suitable screening.*

Rehabilitation at the quarry will therefore focus on re-establishing vegetation that is consistent with the primary industry production within the constraints presented by the void and resultant potential water storage. Opportunities to enhance vegetation within the retained void is limited by the hard rock environment and lack of topsoils on the site, as well as the (potential) proposed use of the void for water storage.

Instead, the proposed conceptual land use is the revegetation of the processing and operations area to pasture, with endemic pasture species suited to growing in shallow soil environments and the retention of access to the void for emergency purposes, including accesses to the pit void for water access purposes.

Due to the nature of the proposed quarry and limited post-closure opportunities, progressive rehabilitation or earlier consideration of alternate post-closure options is not considered warranted.

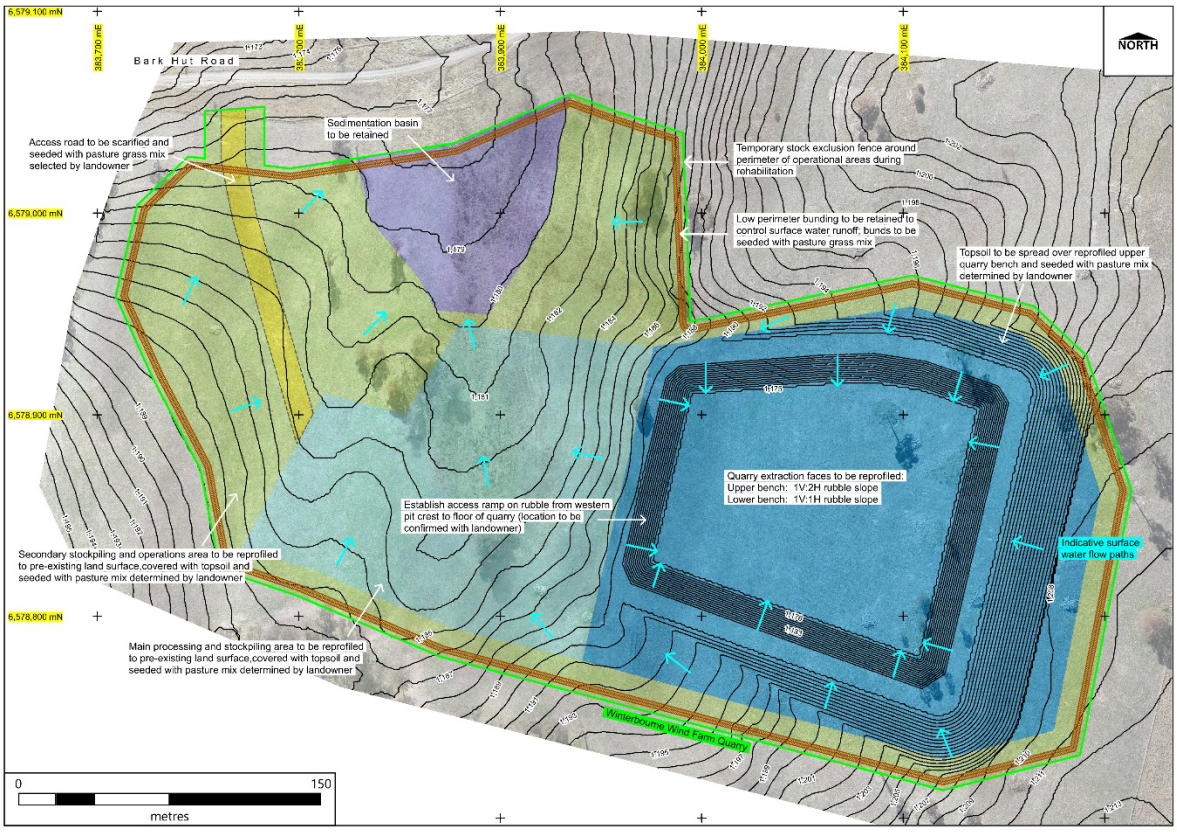



**Figure 18 – Conceptual Quarry Rehabilitation Plan**

*Rehabilitation Objectives*

The Quarry Closure Plan will describe the key requirements of final landform design, revegetation, water drainage and the future sustainability of the site. There are a number of key considerations to be taken into account in designing the rehabilitation objectives, including safety, legal requirements, key physical constraints (such as climate, location, topography, soils) and landholder / stakeholder input.

Based on the consideration of these factors, and in particular the site's location within land subject to existing intensive grazing, the rehabilitation objectives for the Project are:

- creation of a safe, stable and non-polluting landform
- decommissioning and removal of all surface infrastructure (unless retention is approved by the detailed closure planning process as agreed with the landowner)
- retention of a final void which will has the potential to store water available for biodiversity and water use purposes
- retain vehicle access to the final void for future use and emergency access purposes.

*Final Landform*

The proposed conceptual final landform will consist of stable internal pit face slopes, horizontal benches, flat or gently sloping surrounds and a pit void. Opportunities for selected battering of high walls will be considered as part of the detailed quarry closure processes but will be subject to safety, and future land use constraint considerations.

### *4.15.2 Proposed Rehabilitation Methodology*

The total surface area available for rehabilitation at any one point in time will be limited due to the nature of extractive operations at the quarry, the progressive vertical expansion of the active quarry pits and stepped development of benches in the extraction pit The extraction pit and ancillary areas will generally not become available for rehabilitation until active operations have fully exhausted resources in that area and ancillary areas for processing, stockpiling and laydown activities are not required. All disturbance associated with the Quarry operations will be contained with the approved disturbance footprint.

At the end of the proposed operational life of the quarry, onsite infrastructure and associated facilities not required for the post-closure land use will be decommissioned and removed from the site. Closure monitoring and maintenance works will continue until it can be demonstrated that all completion criteria have been achieved (refer to **Section 4.14.3**).

Rehabilitation practices will be detailed in the EMP and will include the following key management measures to be implemented throughout the quarry establishment and operational stages:

- **Quarry bench management** – bench slopes in the extraction pit will be reprofiled to no steeper than 1V:1.5H and 1V:3H respectively to produce a safe and stable surface.
- **Topsoil management –** topsoil material for rehabilitation will be sourced from soil stored on-site which has been stockpiled as part of the initial site preparation processes, although it is noted that the soil resource across the disturbance area is limited, and importation of additional material

from other areas of the WWF may be required at the time of rehabilitation. Where practicable, any mulched vegetation will also be included to promote on-site growth medium availability. Prior to use for rehabilitation purposes, topsoil material will be analysed at a NATA registered laboratory to determine the application requirements for any soil ameliorants, if necessary.

- **Habitat enhancement –** while proposed tree clearing is very limited, the salvage of any hollow bearing trees, hollow logs, and fallen timber will be undertaken, where practical, during the vegetation clearing process. These resources will be stockpiled within the operations area along with topsoil stockpiles, with both being spread across flatter areas of the shaped landform once complete. The relocation of these habitat resources into post-quarrying rehabilitation areas is aimed at increasing habitat complexity, in order to make these areas more habitable for native species.

- **Weed and pest management –** Weed and pest species may be inadvertently introduced to the quarry through vehicle movements or could invade naturally into disturbed areas following the removal of cover crop and other vegetation. Weed and pest management strategies will be detailed in the EMP to ensure populations are appropriately controlled throughout the life of the quarry.

- **Revegetation –** A major issue to be considered in the revegetation of the surrounding processing / operational areas is the shallow rock underlying the entire site. Topsoil and substrate depth and/or the ability of plant root systems to penetrate the subsoil is crucial to ensure plant survival, to allow access to water and support for root systems. Revegetation of the site processing / operational areas with shallow soil material (*e.g.* outcrop areas or shallow rock) will require scarifying of any compacted surfaces, spread of stockpiled topsoil and importation of soil if required, prior to the spread of an appropriate pasture grass species mix in consultation with the landowner.

### *4.15.3 Monitoring and Completion Criteria*

The scope of the rehabilitation monitoring program will be detailed within the detailed Quarry Closure Plan and in the EMP. The rehabilitation monitoring program will define responsibilities, record keeping requirements, inspection requirements and timing and include an annual rehabilitation monitoring program, which will be linked to TARPS (Trigger Action Response Plans) contained within the quarry EMP.

The key objectives of rehabilitation monitoring will be to:

- include regular inspections of rehabilitated areas;

- assess progression towards the rehabilitation objectives of the Project; and

- inform the timely implementation of TARPS which cover unexpected deviations from the expected successional pathways in rehabilitation areas.

Preliminary completion criteria will be used to demonstrate achievement of rehabilitation objectives and performance standards as outlined in **Table 9**.

| Table 9 | Preliminary Closure and Rehabilitation Completion Criteria |
|---|---|
| **Aspect** | **Preliminary Completion Criteria** |
| Decommissioning | Removal of all infrastructure that does not have a potential post-quarrying use |
| | All demolition work has been undertaken in accordance with *AS2601-2001: The Demolition of Structures*, or its latest version |
| | Implementation of appropriate security measures to minimise the potential for unauthorised access during the transition period to the intended final land use |
| Landform | No significant erosion is present that would constitute a safety or water quality issue |
| | Contour banks are stable and there is no evidence of overtopping or significant scouring as a result of runoff |
| | Surface is free of any hazardous materials |
| | Landform survey confirms constructed landform is generally in accordance with the approved landform design, including heights detailed in the relevant approval documentation |
| | Rehabilitated areas are designed to be free draining (excluding the catchment areas of final void) |
| Water | Runoff and discharge water quality complies with any documented EPL requirements |
| Vegetation | Revegetation areas containing pasture species in accordance with landowner requirements |
| | More than 75% of revegetation is healthy and growing as indicated by rehabilitation monitoring |

Dependent upon the outcomes of the rehabilitation monitoring, the scope of post-closure rehabilitation care and maintenance activities will include the following:

- weed control;
- erosion and sediment control;
- revegetation (direct planting and/or reseeding) of rehabilitation areas that may have failed or not achieve desired species density;
- maintenance fertilising as required;
- watering/irrigation as required;
- repair of fence lines, safety measures, access tracks and other general related land management activities.

# 5 Summary of Management Measures

An Environmental Management Plan (EMP) will be prepared for the Project prior to the commencement of any construction works and will include all mitigation measures included in this SEE. A summary of the mitigation measures for potential impacts of the development are detailed in **Table 10**.

**Table 10 Summary of Mitigation Measures**

| Potential Impact | Mitigation Measures |
|---|---|
| Landform and Topography | • Development of extraction pit to be in accordance with design. At the completion of quarry operations rehabilitation of the site will be implemented in accordance with the rehabilitation plan detailed in the EMP, to provide an appropriate, safe and stable landform(s) that can facilitate ongoing grazing activities. |
| Contaminated Land | • Grease and oil will be stored and handled on site appropriately to minimise the potential for contamination of the Project area.<br>• Spill kits and clean up protocols will be established for the operations and detailed in the EMP.<br>• If contaminated soils are uncovered during the works, all works within the vicinity must cease immediately and Walcha Council notified. |

| Table 10 Summary of Mitigation Measures | |
|---|---|
| **Potential Impact** | **Mitigation Measures** |
| Water | • The proposed WMS for the Project will be designed to meet the requirements Managing Urban Stormwater: Soils and Construction (Blue Book) (Volumes 1 and 2E – Mines and Quarries) (Landcom, 2004 and DECC, 2008).<br>• Construction of clean water diversion mounds/drains upslope of areas to be disturbed to direct clean water runoff away from disturbed areas, where practical. The diversion drains will be designed to ensure effective segregation of sediment-laden runoff and allow clean surface water to return to natural watercourses.<br>• Dirty water catch mounds/drains to capture runoff from disturbed areas and direct runoff into the sediment basin. At completion of the Project runoff from disturbed areas will be directed into the extraction area. Any excess water will be directed to the sediment basis, which will be retained after completion of operations on the site.<br>• Erosion and sedimentation controls are to be checked and maintained on a regular basis (including clearing of any accumulated sediment at barriers) and records kept and provided on request.<br>• Erosion and sediment control measures are not to be removed until the works are complete, and areas are stabilised as part of rehabilitation activities.<br>• Minimising all disturbed areas and stabilisation of disturbed areas as soon as practicable.<br>• Construction of other temporary erosion and sediment control measures, where required, such as sediment fences within the catchment area while permanent soil and water management structures are being established.<br>• Regular maintenance of all controls and inspection of all works and after storm events to ensure erosion and sediment controls are performing adequately.<br>• Construction of drainage controls such as table drains at roadsides and on hardstand areas and toe drains on stockpiles as required.<br>• Immediate repair or redesign of erosion and sediment controls that are not performing adequately, as identified in field inspections. |
| Biodiversity | • Refer to Appendix D of project Amendment Report |
| Heritage | • Refer to Appendix E of project Amendment Report |

| Table 10 Summary of Mitigation Measures | |
|---|---|
| **Potential Impact** | **Mitigation Measures** |
| Noise and Vibration | • The majority of works will be undertaken during daytime hours, being Monday to Saturday 7am to 6pm.<br>• Machinery used in construction will be maintained to appropriate operating standards.<br>• The use of broadband reversing alarms instead of beeper style alarms on mobile equipment.<br>• The management of mobile machines as required to minimise adverse noise impacts during adverse weather conditions when wind conditions or inversion conditions enhance the noise propagation towards sensitive receiver locations.<br>• Using equipment with efficient muffler design.<br>• Regular inspection and maintenance of equipment in general.<br>• Scheduling the use of noisiest equipment at the least-sensitive time of day where practicable.<br>• Complying with quarry hours of operation.<br>• Blasts will be design and undertaken by an appropriately qualified and experienced contractor.<br>• Potential blasting impacts will be managed through:<br>o Blasts being undertaken during the least sensitive part of day (*e.g.* early afternoon).<br>o blasting under favourable meteorological conditions where possible.<br>o notification of closest residences prior to blasting activities.<br>o monitoring of blasts.<br>o proactive response to any issues raised by residences. |
| Air Quality | • Operating a water cart to minimise wind-blown dust from exposed areas as required.<br>• Limiting dust generating quarry operations and increasing dust suppression activities during periods of unfavourable meteorological conditions.<br>• Minimising the area of disturbed land at any one time<br>• Adopting controls for haul road dust emissions<br>• Review of meteorological conditions prior to blasting<br>• Water sprays on stockpile areas and exposed areas as required<br>• Visual monitoring to identify excessive dust generation |
| Visual Amenity | • Ensure that areas of disturbance are kept to the minimum practicable at any one point in time. |
| Traffic | • Restrict vehicle speeds on access road to 40km/hr<br>• Haul drivers to operate in accordance with the WWF Traffic Management Plan and Driver's Code of Conduct |
| Bushfire Hazard | • A Bush Fire Emergency Management and Operations Plan (BFEMOP) will be prepared in accordance with the requirements of Section 8.3.5 of PBP |

| Table 10 Summary of Mitigation Measures | |
|---|---|
| **Potential Impact** | **Mitigation Measures** |
| Waste | • All waste oil and grease will be collected and will be removed from the site by an appropriately licensed contractor with all relevant waste tracking documentation completed.<br>• Workshop wastes including oil filters and tyres will be removed from the site by the mechanics providing replacement parts.<br>• All office paper and general waste originating from the office and amenities will be placed in appropriate containers for collection by Council or a licensed contractor for disposal/recycling at an appropriate waste management facility. |
| Social and Economic | • All works will be undertaken in accordance with the mitigation measures outlined in this table.<br>• Machinery used in construction will be maintained to appropriate operating standards. |
| Rehabilitation | • All works to be undertaken in accordance with the detailed Quarry Closure Plan |

# 6 Site Suitability

The WWF Quarry is located within existing intensively grazed rural land that also conforms with low conservation value grassland (PCT 568 – Broad-leaved Stringybark shrub/grass open forest of the New England Tableland Bioregion).

The quarry site is significantly separated from surrounding rural residences, with the nearest non-associated residence located > 4 km form the site, while the quarry area and extraction pit are shielded by the surrounding topography and vegetation from surrounding residences.

The Project area is considered suitable for the proposed development for the following reasons:

- The Project is located within a RU1 Primary Production zone and the development is consistent with the objectives of the zone.
- The Project landscape is heavily modified, comprising an existing intensive grazing landuse, limiting the potential for adverse ecological impacts, notwithstanding the classification of the vegetation on the site as PCT 568.
- The Project is compatible with surrounding rural land uses and can coexist with this land use.
- The Project is located well away from residences areas and any environmentally sensitive areas.
- The topography of the site provides visual and acoustic shielding from the surrounding residences.

## 6.1 Benefits of the Project

The key benefits of the Project include:

- The quarry will provide an on-site supply of quarry products to the construction contractor of the WWF Project.
- On-site supply of all quarry materials from the proposed quarry would:
    - remove approximately 62,500 truck movements from the broader local and regional road network; and
    - reduce haulage by trucks on the broader local and regional road network by approximately 9.8 million km.
- The quarry is located away from major population centres and incompatible land uses and has suitable buffers to residential and environmentally sensitive areas.
- The disturbance area of the Project currently consists of highly disturbed grazing land and notwithstanding the presence of PCT 568, potential ecological impacts of this development are minimal and can be offset as part of the broader biodiversity offsetting associated with the WWF Project.
- The environmental impact of the proposed quarry can be managed within acceptable environmental standards with the implementation of appropriate controls as documented and implemented in accordance with an EMP.
- At the completion of the project, it is intended that the quarry site will return to its existing intensive grazing landuse in accordance with the requirements of the landowner.

# 7 References

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# Appendix 1

## Surface Water Impact Assessment

Prepared by Engeny(Australia) Pty Ltd

ENGENY

# AUSTRALIAN RESOURCE DEVELOPMENT GROUP

## Winterbourne Wind Farm Quarry

### Surface Water Impact Assessment

NTL00049_0003-REP-001-2

28 AUGUST 2024

# DISCLAIMER

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| Rev | Date | Description | Author | Reviewer | Project Mgr. | Approver |
|---|---|---|---|---|---|---|
| 0 | 21/08/2024 | Draft for Client Comment | Lucy Stanton and Sarah Green Goldberg | Chris Bonomini | Sarah Green Goldberg | Chris Bonomini |
| 1 | 26/08/2024 | Client Issue | Lucy Stanton and Sarah Green Goldberg | Chris Bonomini | Sarah Green Goldberg | Chris Bonomini |
| 2 | 28/08/2024 | Client Issue | Lucy Stanton and Sarah Green Goldberg | Chris Bonomini | Sarah Green Goldberg | Chris Bonomini |
| **Signatures:** | | |  |  |  |  |

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# 1. INTRODUCTION

## 1.1 Project Description

Winterbourne Wind Pty Ltd (WWPL) is proposing a temporary, project-specific quarry (the Winterbourne Wind Farm (WWF) Quarry (the Quarry)) as development that is ancillary to the WWF Project (SSD-10471). The quarry is being proposed as part of an Amendment to the WWF Project currently being prepared. The WWF Project has a current estimated demand of 1Mt of quarry materials (e.g. road base/capping; concrete aggregates; gabion/drainage rock/ TR sand) over the estimated 3 – 4 year construction period. It is proposed that the majority of this material could be supplied from this quarry site. The sole purpose of the quarry would be to supply materials to the WWF Project only.

Australian Resource Development Group Pty Limited (ARDG) has been engaged to assist with the development of the quarry. Detailed site geological investigations undertaken by ARDG indicate that the quarry resource is suitable for the production of a range of products (e.g. road base, concrete aggregates, drainage rock) required for construction of the public road upgrades, wind farm access tracks, hardstand areas, turbine foundations and other civil works associated with the Project.

The quarry would be located upon Lot 95 DP1128816, within the existing WWF Project Area (i.e., an 'on-site' quarry) and be located on project associated land adjacent to Bark Hut Road, a key transport spine for much of the proposed infrastructure, and immediately adjacent to the access track for wind turbines B177, B100A, B101A and B102 (refer to Figure 1.1).

Approval for the transport of up to 500,000 tonnes per annum of material from the quarry site to the WWF Project is being sought as development that is 'ancillary development' to Electricity Generation Works as part of an amendment to the application (SSD-10471) that is currently being assessed by the NSW Department Planning and Environment (DPE). An Environmental Protection Licence (EPL) would also be sought for the quarry operation, separate to the EPL required for the WWF Project (refer to Section 5.3.1).

Justification for the quarry as ancillary development to the WWF Project is that it is temporary in nature, occupying a very small proportion of the WWF Project Area, and having a clear nexus with the WWF Project, given it is proposed to be operated within proximity to where the quarry products would be required to facilitate the construction of the WWF Project.

As the proposed location for the quarry is within the WWF Project Site Boundary, sourcing of construction materials from the quarry site would significantly reduce construction traffic on the broader local and regional road network (when compared to sourcing from commercial quarries located considerable distances away in the broader region). The key material benefits likely to result from the proposed quarry location for the local and broader community include:

- A very significant reduction in the number of quarry haul trucks from the Oxley Highway and Thunderbolts Way, as well as from the township of Walcha;
- Reduced construction traffic noise amenity impacts for residents and road users, in particular those located along the broader public road network;
- Improved road safety (substantially reducing heavy/light vehicle interactions) along the broader public road network;
- Reduced damage to the broader public road network by significantly reducing total distances travelled on the broad public road network.

Supply of quarry products from the Quarry would also reduce the carbon footprint of the WWF Project via substantially reduced fuel consumption associated with haulage. Additionally, it would provide a significant reduction in overall construction costs by significantly reducing the haulage distance for construction materials supplied to the Project.

The proposed Quarry layout is shown in Figure 1.2.

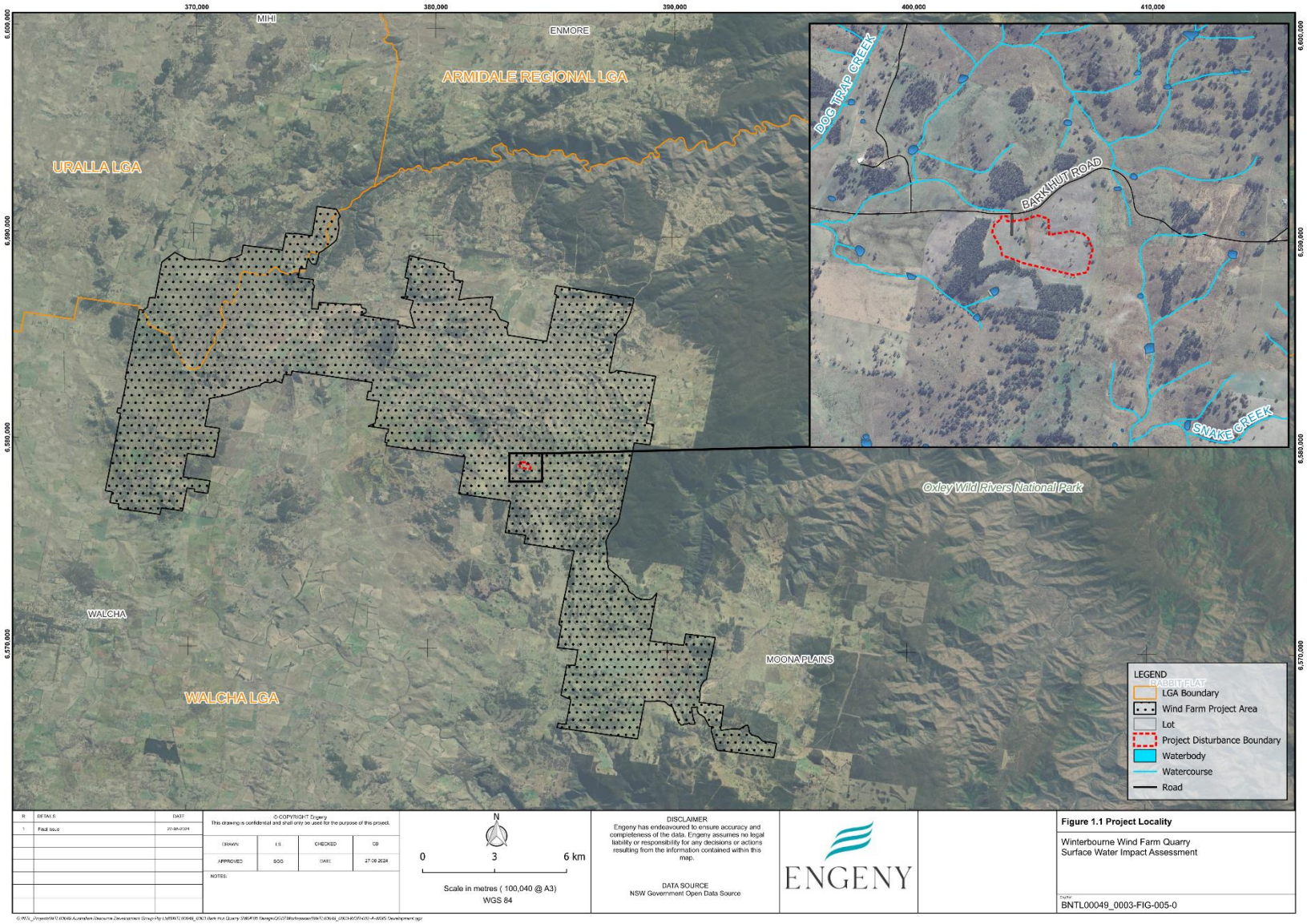



**FIGURE 1.1: PROJECT LOCALITY**

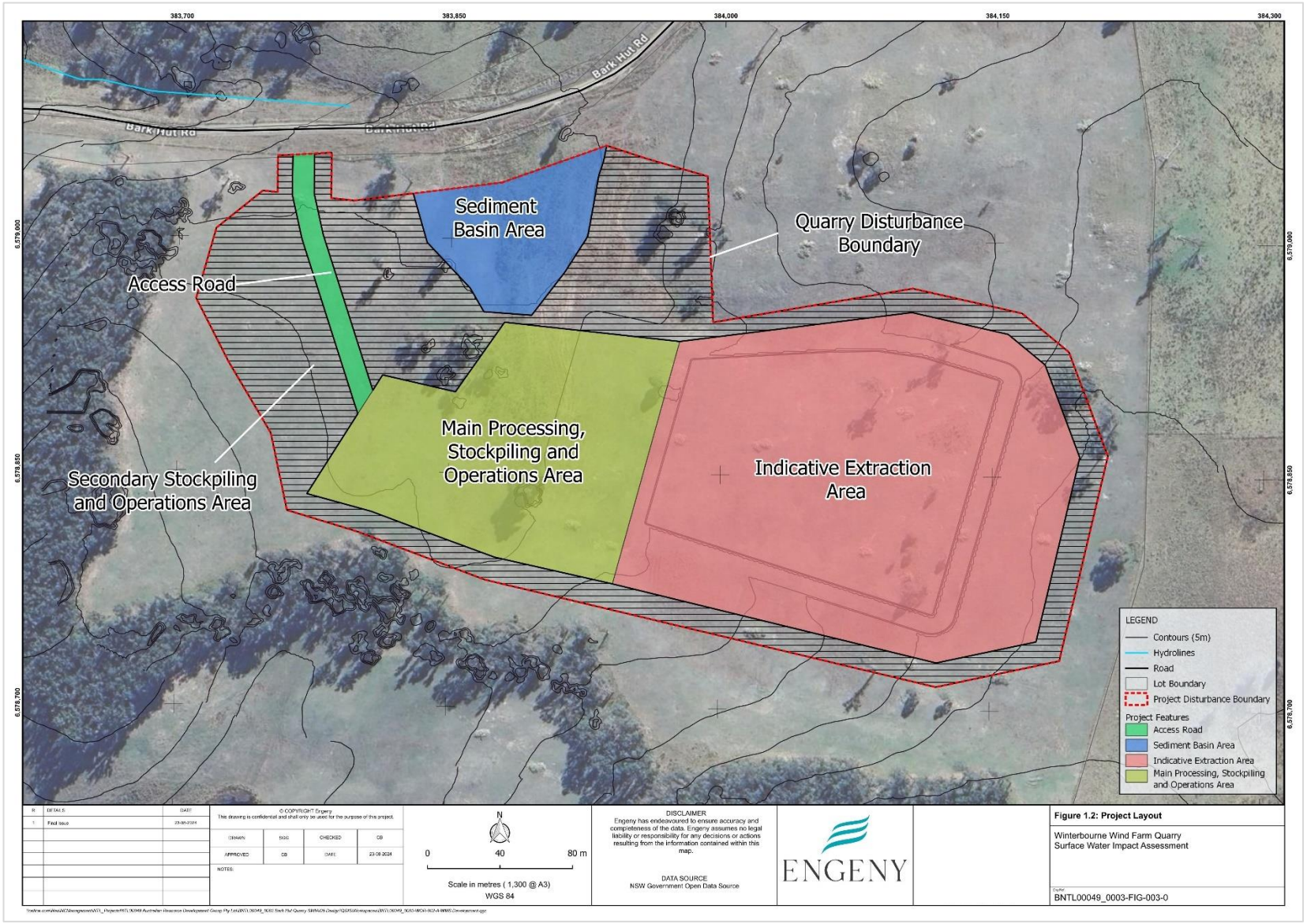



**FIGURE 1.2: PROJECT LAYOUT**

## 1.2 Secretary's Environmental Assessment Requirements

This SWIA has been prepared to address the Secretary's Environmental Assessment Requirements (SEARs) created for the greater WWF Project, dated 19 March 2024.

**TABLE 1.1: SECRETARY'S ENVIRONMENTAL ASSESSMENT REQUIREMENTS**

| Requirement | Section(s) |
|---|---|
| Water and Soils | |
| The EIS must: | |
| • Quantify water demand, identify water sources (surface and groundwater), including any licensing requirements, and determine whether an adequate and secure water supply is available for the development; | Section 2, Section 3 |
| • Assess potential impacts on the quantity and quality of surface and groundwater resources, including impacts on other water users and watercourses; | Section 2.5 |
| • Where the project involves works within 40 metres of the high bank of any river, lake or wetlands (collectively waterfront land), identify likely impacts to the waterfront land, and how the activities are to be designed and implemented in accordance with the DPI *Guidelines for Controlled Activities on Waterfront Land* (2018) and (if necessary) Why Do Fish Need to Cross the Road? Fish Passage Requirements for Waterway Crossings (DPI 2003); and *Policy & Guidelines for Fish Habitat Conservation & Management* (DPI, 2013); and | Section 2 |
| • Describe the measures to minimise surface and groundwater impacts, including how works on steep gradient land or erodible soil types would be managed and any contingency requirements to address residual impacts. | Section 4.2 |

## 1.3 Potential Surface Water Impacts

The Project has the potential to have the following impacts on surface water resources:

- Minor reduction in runoff to the surrounding catchment as a result of runoff from the quarry Water Management System (WMS) catchment being retained by the Project.
- Potential adverse water quality impacts on downstream receiving waters during all phases of the project (construction, operation and closure) as a consequence of:
  - Erosion and transport of sediment from exposed surfaces in stormwater discharges to the surrounding environment.
  - Other pollutants such as hydrocarbons (e.g. fuel/oil leaks or spills) entrained in stormwater discharges to the surrounding environment.
  - Residual elevated nitrate concentrations as a result of blasting activities.

Potential surface water impacts have been assessed in subsequent sections of this report.

# 2. SURFACE WATER CONTEXT

## 2.1 Catchment

The Project is located within the Macleay River Catchment, which covers an approximate area of 11,450 km$^2$ and stretches about 405 km from the headwaters of the Gara River in the West to the tributary of the mouth of the Macleay River at South West Rocks (refer to Figure 2.1).

The Macleay River is a major river located in the mid-north coast of NSW. Tributaries reporting to the Macleay River include the Apsley, Styx, Chandler, Tia, Dyke, and Yarrowitch rivers, and the Commissioners Waters. These tributaries pass through several gorges and waterfalls, as well as the Oxley Wild Rivers National Park. The rivers act as the primary water supply within the region and provide a reliable source for use by local councils, water utilities, livestock grazing, and agriculture.

The total catchment area for the Project is approximately 10.7 ha equating to an extremely minor portion (<0.001%) of the overall Macleay River Catchment. Reductions in downstream flow as a result of the diversion of the Project catchment are therefore considered to be negligible. The Project Area does not interact with any major rivers or tributaries, however, several small streams and water bodies surround the disturbance boundary.

There are several farm dams near the proposed Project Area, however, only one farm dam (hereafter referred to as Farm Dam) will have its catchment impacted by the Project. The Farm Dam is shown in Figure 2.2 and the expected reduction in catchment area reporting to this Farm Dam is provided in Table 2.1. The expected reduction in catchment reporting to the downstream farm dam is 6.8% which would result in a slight reduction in flow reporting to the dam. The landholder of the lot on which the Farm Dam is located is also the landholder for the proposed Quarry location. The landholder has been consulted regarding the catchment reduction and any minor reduction in flows to the Farm Dam will be compensated by making water captured in the Quarry WMS available to the landholder.

There is an existing culvert located immediately downstream of the proposed sediment basin that directs flows under Bark Hut Road towards the unnamed ephemeral creek to the north of the site. Net flow through the culvert is expected to reduce as a result of the runoff being contained by the Quarry WMS catchment.

The Project catchment is further detailed in section 4.2.1.

**TABLE 2.1: REDUCTION IN CATCHMENT AREA REPORTING TO THE FARM DAM**

| Existing Farm Dam Catchment Area (ha) | Catchment with Quarry (ha) | Catchment Reduction (%) |
|---|---|---|
| 157.7 | 147.0 | 6.8% |

## 2.2 Surface Hydrology

All mapped 'defined' watercourses within the Project Area have been identified from the NSW Department of Climate Change, Energy, the Environment and Water (DCCEEW) published hydroline dataset (2018). The Project Area is situated upon a ridgeline that is elevated towards the east and descends to the west, typically directing surface water in a northwestly direction.

There are several first and second order drainage lines near the Project Area, with the closest watercourse being an unnamed creek located immediately downstream of the site. This unnamed ephemeral creek is around 40 m north of the Project Area boundary and flows in a westerly direction, converging with another unnamed creek approximately 900 m west of the Project Area before flowing into Dog Trap Creek. The perennial Dog Trap Creek is the closest named watercourse to the site, located approximately 1.4 km west of the Project Area (Figure 2.1). Dog Trap Creek flows southwest into Emu Creek, a tributary of the Apsley River. As the proposed Quarry is located upon a ridge line and does not interfere directly with hydrological features, no flood impacts are expected.

There are several farm dams within the vicinity of the Project Area. There is only one farm dam located downstream of the Quarry catchment, approximately 1.3 km west of the Project Area. Any spills from this farm dam drain via a narrow incised ephemeral channel to Dog Trap Creek.

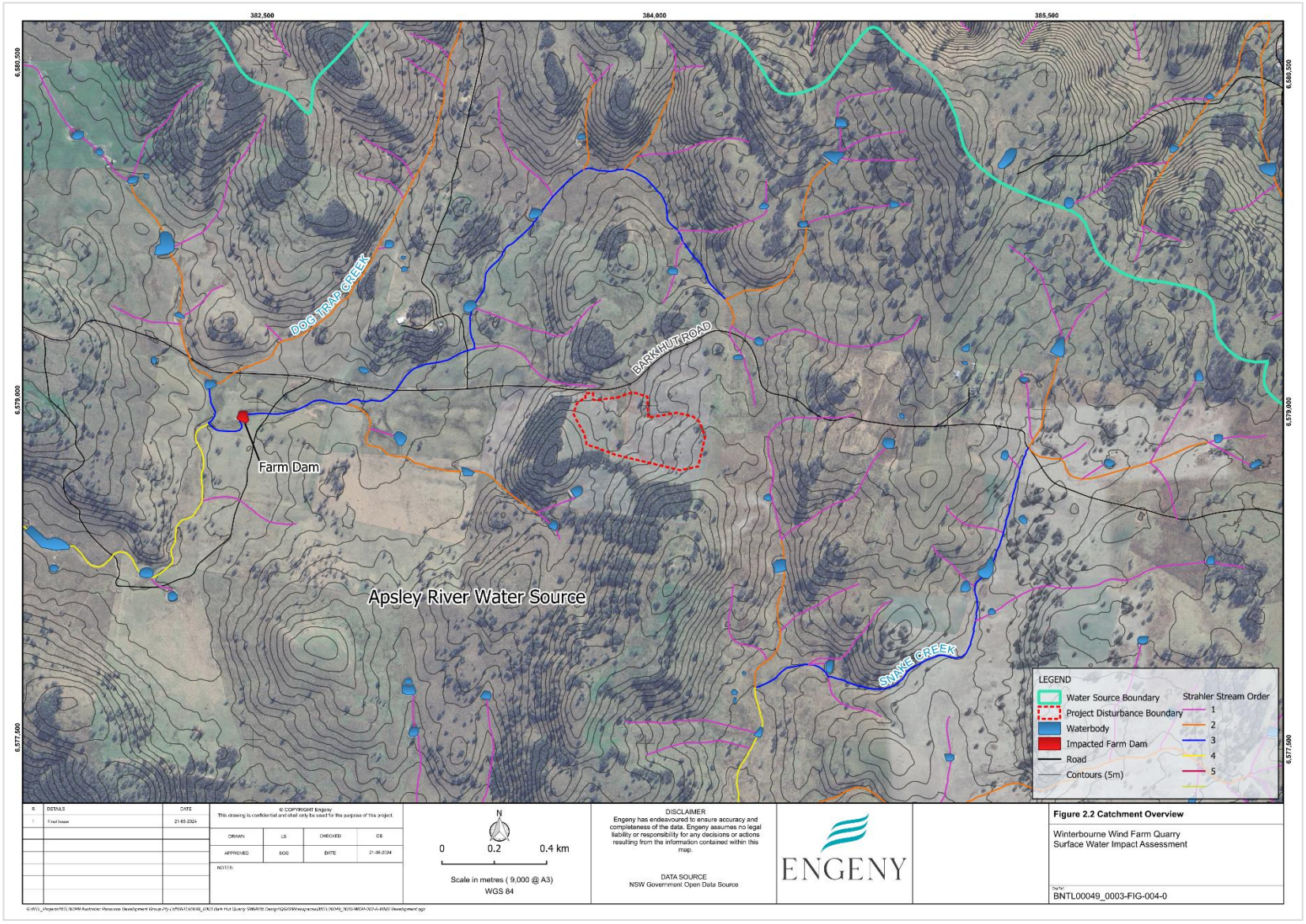



**FIGURE 2.1: WINTERBOURNE WIND FARM QUARRY CATCHMENT OVERVIEW**

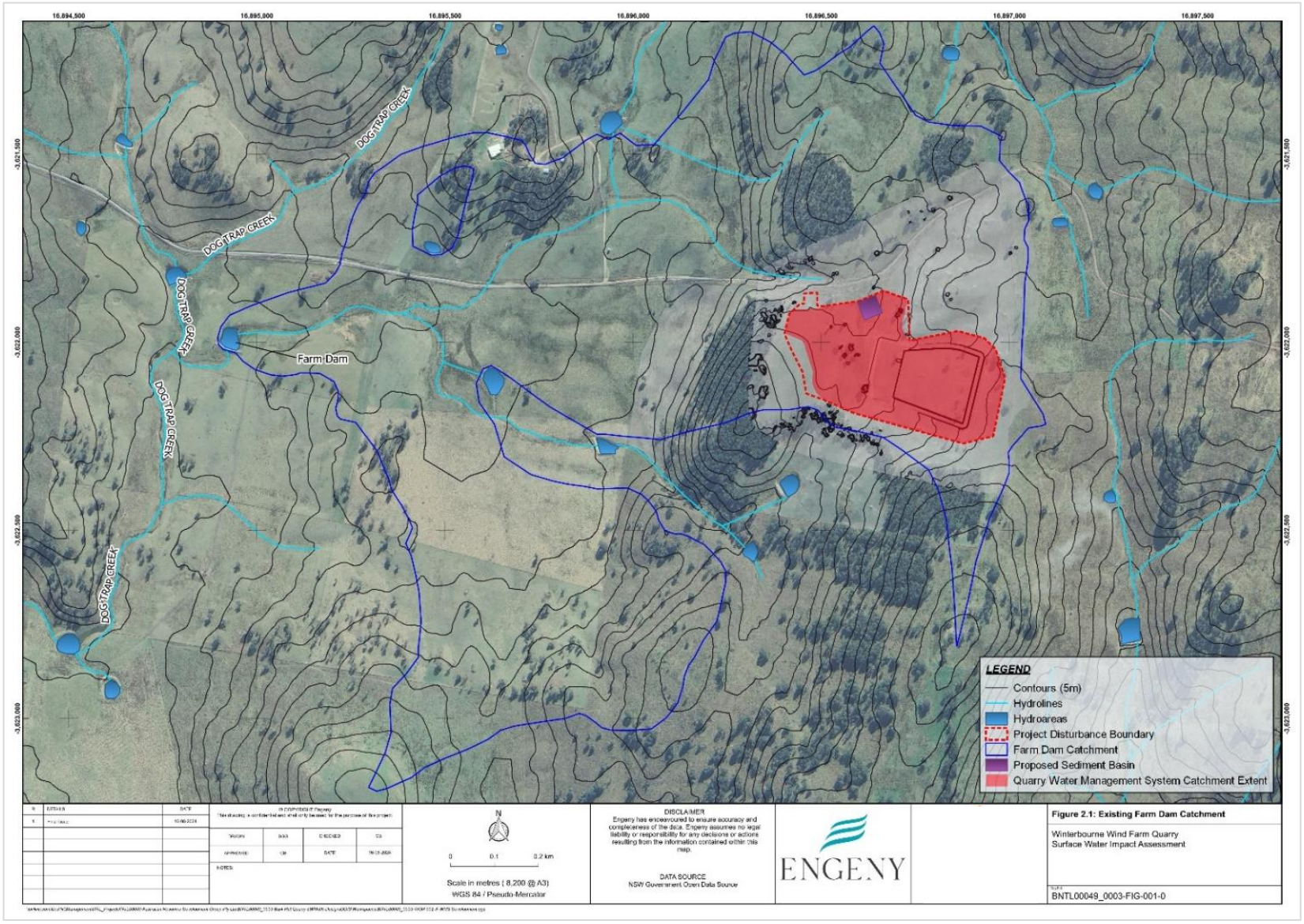



**FIGURE 2.2: EXISTING CATCHMENT REPORTING TO THE FARM DAM**

## 2.3 Topography and Soils

The Project is located at the base of the Baynes and Green Mountain ranges, located to the east of the Project Area, associated with the mountainous Cunnawarra National Park. The landscape consists of gorges and valleys of the Great Escarpment with corresponding hills and ridges. To the west, elevation is typically 1130m AHD toward the valley floor of Dog Trap Creek corresponding to valleys or depressions.

Publicly available soil properties and hydrogeological landscape data (Department of Climate Change, Energy, the Environment, and Water, 2022) relevant to the Project Area was sourced from the 'Sharing and Enabling Environmental Data in NSW' (SEED) Portal. The soil properties are tabulated in Table 2.2 and hydrogeological landscape data in Table 2.3 and indicate that the Project Area soils:

- Have low erodibility, resistant to detachment;
- Are fine textured (topsoil and subsoil);
- Are saline which contributes to a moderate instream EC;
- Are slightly to moderately acidic pH; and
- Have limited fertility, indicated by a low to moderate Cation Exchange Capacity and low to moderate organic carbon concentration.

**TABLE 2.2: MODELLED SOIL PROPERTIES**

| Parameter | Soil Profile | | |
|---|---|---|---|
| | 0-30cm Depth | 30-60cm Depth | 60-100cm Depth |
| Soil Erodibility, k factor (as used in the Revised Universal Soil Loss Equation (RUSLE)) | 0.05-0.06 | 0.05-0.06 | 0.05-0.06 |
| Clay Percentage (%) | >30-40 | >25-30 | >25-30 |
| Silt Percentage (%) | >25-30 | >25-30 | >25-30 |
| Sand Percentage (%) | >50-60 | >50-60 | >40-50 |
| pH (CaCl2) | >5.5-5 | >5-5.5 | >5-5.5 |
| Cation Exchange Capacity (cmolc/kg) | >10-15 | >10-15 | >10-15 |
| Soil Organic Carbon Concentration (%) | >0.5-1% | >0.25-0.5% | >0.25-0.5% |

**TABLE 2.3: HYDROGEOLOGICAL LANDSCAPES**

| Overall Salinity Hazard | Land Salinity | Instream EC |
|---|---|---|
| Moderate | High | Moderate |

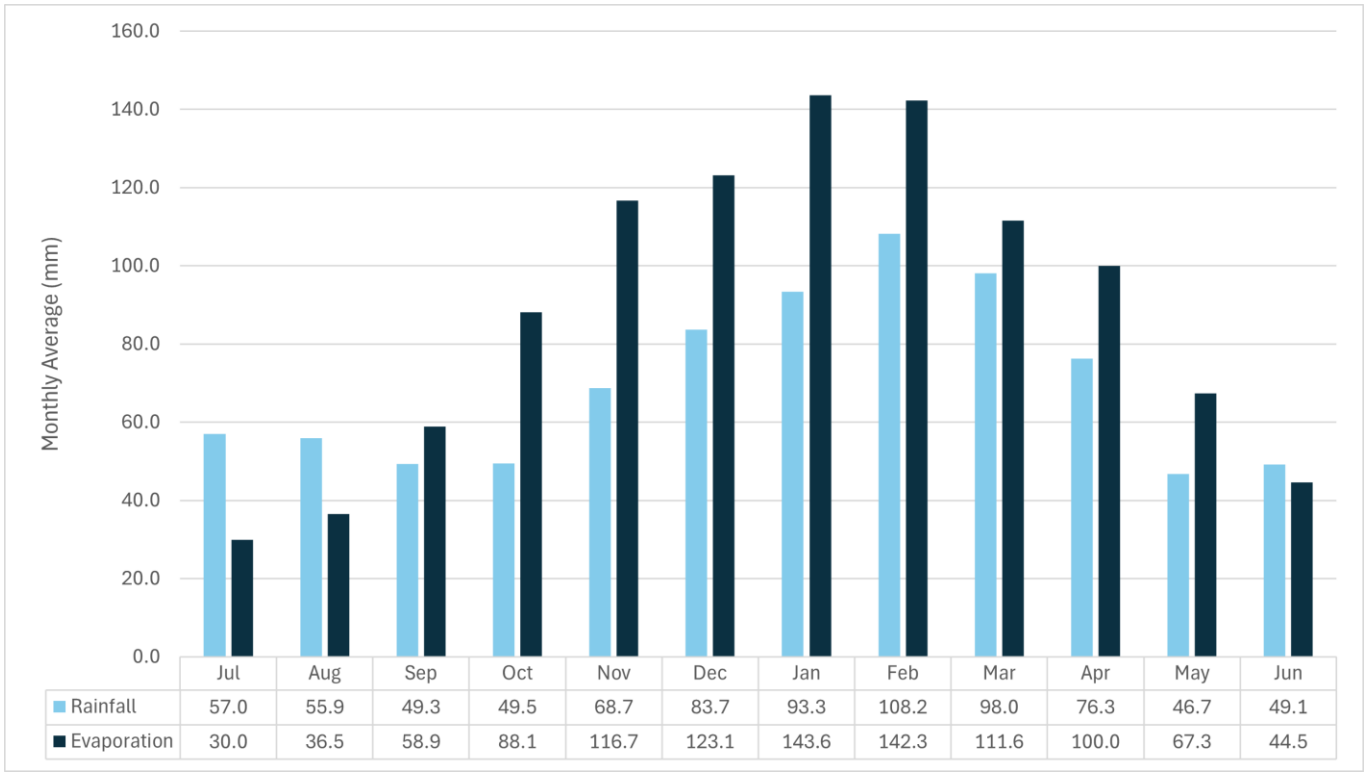
## 2.4 Climate

To understand the rainfall patterns within the Project Area, climate data was obtained from Queensland Government's SILO point climate database from 1889 to present. Figure 2.3, Figure 2.4 and Figure 2.5 present monthly rainfall and evaporation data for the Project Area at grid coordinates -30.90 latitude, 151.80 longitude .

Rainfall and evaporation characteristics relevant to the Project Area can be summarised as follows:

- The average rainfall and evaporation for the Project Area are typically higher in the summer months and lower in the winter months.

- The total monthly evaporation is generally greater than rainfall with the exception of June, July, and August.
- Monthly average rainfall is greatest in February (108.2 mm) and lowest in May (46.7 mm).
- The annual average rainfall for the Project Area is 836 mm.




| | Jul | Aug | Sep | Oct | Nov | Dec | Jan | Feb | Mar | Apr | May | Jun |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Rainfall | 57.0 | 55.9 | 49.3 | 49.5 | 68.7 | 83.7 | 93.3 | 108.2 | 98.0 | 76.3 | 46.7 | 49.1 |
| Evaporation | 30.0 | 36.5 | 58.9 | 88.1 | 116.7 | 123.1 | 143.6 | 142.3 | 111.6 | 100.0 | 67.3 | 44.5 |

**FIGURE 2.3: MONTHLY AVERAGE RAINFALL AND EVAPORATION**

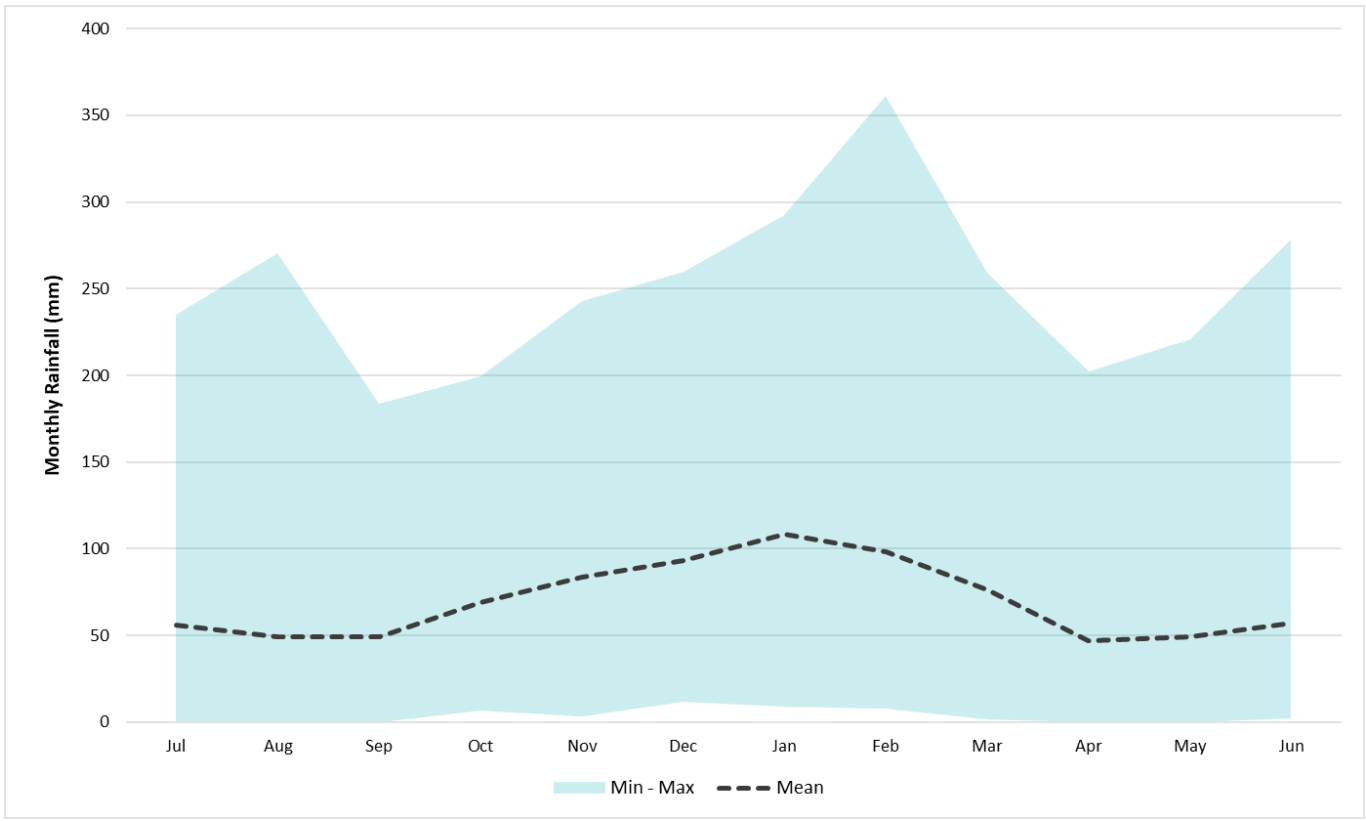



**FIGURE 2.4: MONTHLY RAINFALL RANGE**

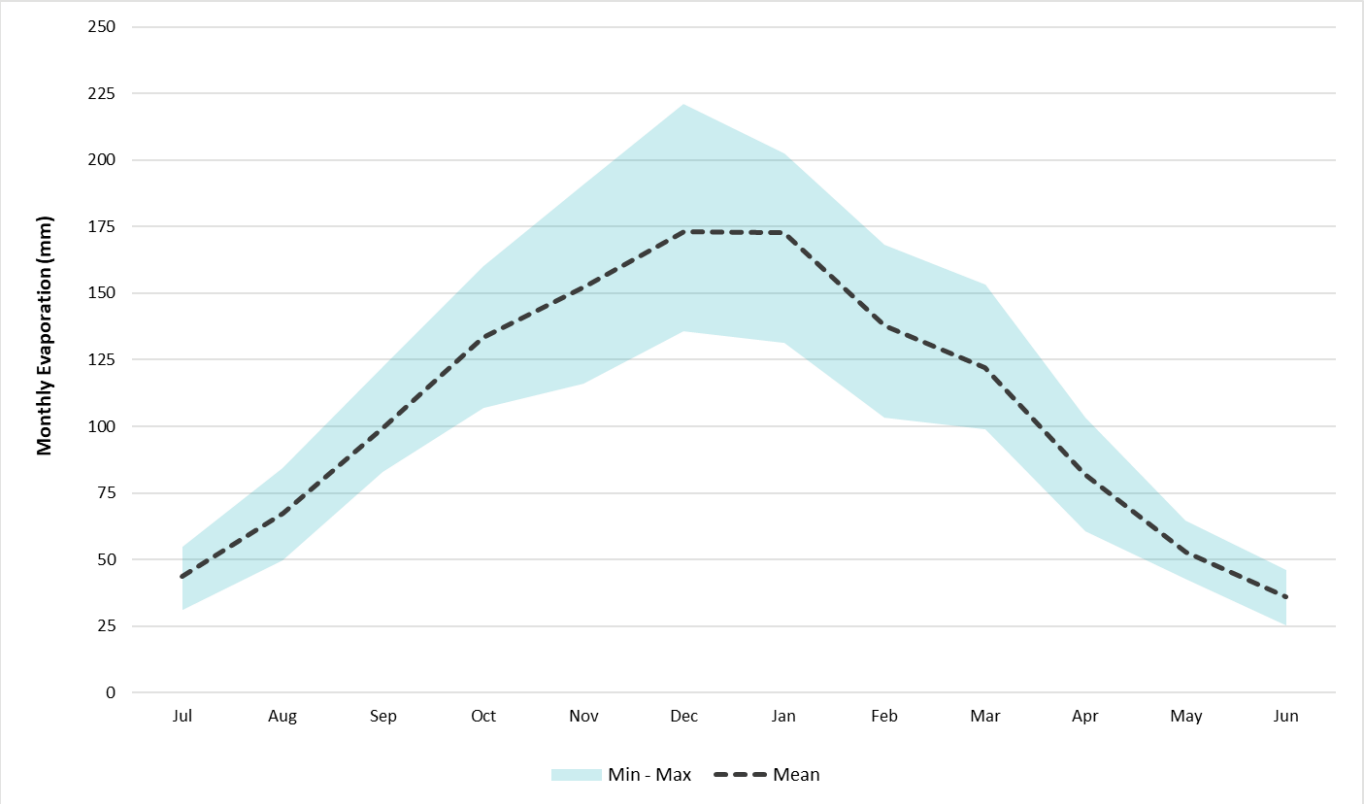



**FIGURE 2.5: MONTHLY EVAPORATION RANGE**

# 2.5 Water Quality

## 2.5.1 NSW Water Quality Objectives

NSW Water Quality Objectives (WQO) have been developed to guide plans and actions to achieve healthy waterways. The WQOs are based on measurable environmental values (EVs) for protecting aquatic ecosystems, recreation, primary industries, drinking water and industrial water (ANZECC & ARMCANZ, 2000). The aquatic ecosystem WQOs for the Macleay River Catchment that are considered relevant to the Project are presented in Table 2.4 below.

Given the agricultural land use surround the Project Area and the potentially impacted farm dam located immediately downstream of the Project Area, livestock water supply guidelines are also considered relevant. Relevant livestock NSW WQOs for livestock drinking water are provided in Volume 3 of the Australian and New Zealand Guidelines for Fresh and Marine Water Quality (Australian and New Zealand Environment and Conservation Council (ANZECC), 2000) (ANZECC 2000) and include total dissolved solids (TDS) and nitrate which are also presented in Table 2.4. Comparison of the aquatic ecosystem and livestock water supply WQOs shows that the guideline values for oxides of nitrogen (NOx) (noting that the livestock water supply guidelines have separate Nitrate and Nitrite guideline values) and total dissolved solids (TDS)/electrical conductivity (EC) (noting that EC is indicative of TDS) for livestock water supply are several orders of magnitude higher than those for protection of aquatic ecosystems.

**TABLE 2.4: WATER QUALITY OBJECTIVES – UPLAND RIVER**

| Parameter | Environmental Value | Units | Water Quality Objective Range |
|---|---|---|---|
| pH | Aquatic Ecosystems | pH units | 6.5 - 8.0 |
| Electrical Conductivity | Aquatic Ecosystems | µS/cm | 30 - 350 |
| Turbidity | Aquatic Ecosystems | NTU | 2 - 25 |

| Parameter | Environmental Value | Units | Water Quality Objective Range |
|---|---|---|---|
| Nitrite plus Nitrate as N (NOx) | Aquatic Ecosystems | mg/L | 0.25 |
| Total Dissolved Solids | Livestock Water Supply | mg/L | 0 – 4000 for beef cattle and sheep<br>0 – 2400 for dairy cattle |
| Nitrate as N | Livestock Water Supply | mg/L | 400 |
| Nitrite as N | Livestock Water Supply | mg/L | 30 |

## 2.5.2 Baseline Water Quality

ARDG completed baseline water quality monitoring at one surface water (SW01) and two groundwater monitoring locations (GW01 and GW02) in the vicinity of the Project on 26 June 2024. The monitoring locations are shown in Figure 2.6 and water quality monitoring results for key physiochemical parameters and nutrients are tabulated Table 2.5. Water quality monitoring data can be summarised as follows:

- At SW01, values for pH, EC and TDS were within the WQO range. The NOx (and Nitrate) result at SW01 (0.99 mg/L) exceeded WQO of 0.25 mg/L for aquatic ecosystems but was less than the Nitrate WQO of 400 mg/L for livestock drinking water. Results for nitrite and total oil and grease were below the limit of detection.
- Groundwater quality at GW01 and GW02 indicates close to neutral pH groundwater with low electrical conductivity and TDS concentrations. All results for nitrate, nitrate, NOx and total oil and grease were below the limit of detection at GW01 and GW02.

The full suite of water quality results inclusive of major cations and metals is provided in Appendix A.

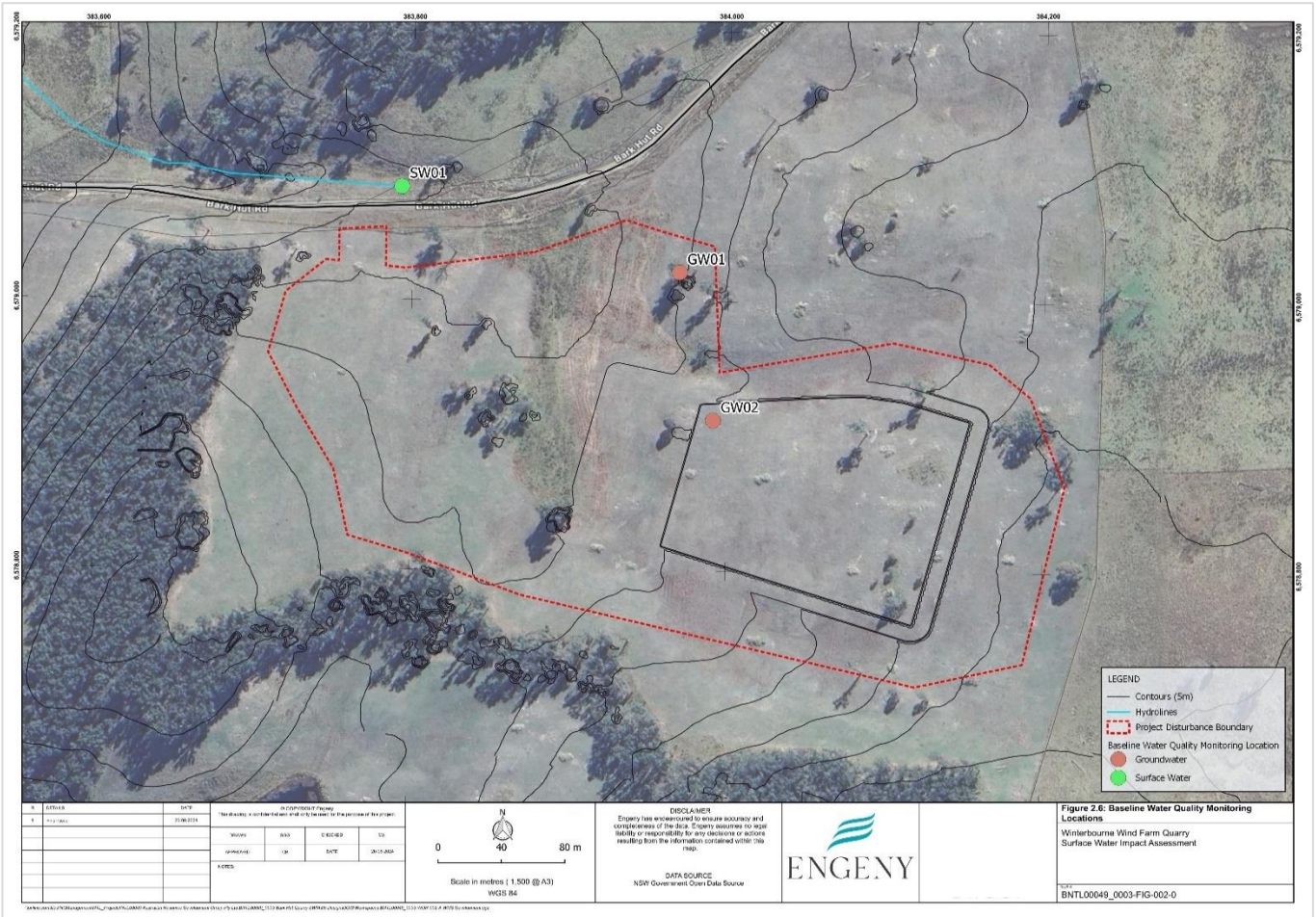



**FIGURE 2.6: BASELINE WATER QUALITY MONITORING LOCATIONS**

**TABLE 2.5: BASELINE WATER QUALITY DATA**

| Analyte | Unit | Limit of Reporting (LoR) | SW01 | GW01 | GW02 |
|---|---|---|---|---|---|
| pH | pH Unit | 0.01 | 6.51 | 6.84 | 6.50 |
| Electrical Conductivity | µS/cm | 1 | 121 | 566 | 523 |
| Total Dissolved Solids | mg/L | 10 | 116 | 336 | 359 |
| Nitrite as N | mg/L | 0.01 | <0.01 | <0.01 | <0.01 |
| Nitrate as N | mg/L | 0.01 | 0.99 | <0.01 | <0.01 |
| Nitrite plus Nitrate as N (NOx) | mg/L | 0.01 | 0.99 | <0.01 | <0.01 |

## 2.6 Water Extraction

Water Sharing Plans (WSPs) have been developed under the Water Management Act 2000 to protect the environmental health of water sources, whilst securing sustainable access to water for all users. The WSPs specify maximum water extractions and allocations and provide licensed and unlicensed water users with a clear picture of when and how water will be available for extraction. The Project Area is located within the Macleay Unregulated and Alluvial Water Sources (2016) WSP area and in the Apsley River Water Source.

Operational water requirements for the Quarry (materials processing and general site dust suppression) are proposed to be supplied via water captured via onsite water storages. A groundwater bore is proposed to be constructed within the Project area adjacent to the Pit to supply materials processing and dust suppression demands that are not met by water captured on site. The proponent will seek to acquire the appropriate licenses for the proposed groundwater bore during the construction phase of the Project. ARDG has undertaken pump testing and confirmed the adequacy of the groundwater supply. Further details relating to groundwater extraction are provided in the groundwater impact assessment component of the Amendment Report.

## 2.7 Surface Water Users

Licensed surface water users potentially impacted by the Project are located within the Apsley River Water Source. A search of the NSW Water Register for the 2024/2025 financial year revealed that there are 3 WALs with a total of 336-unit shares within the Apsley River Water Source. WALs are predominantly held for domestic and stock related uses associated with the agricultural land-use located throughout the catchments.

Groundwater sources relevant to the Project Area and groundwater users are detailed in the *Winterbourne Wind Farm Quarry Groundwater Impact Assessment* as part of the Amendment Report.

# 3. PROJECT WATER MANAGEMENT SYSTEM

The purpose of this section of the report is to describe the water management system and infrastructure for the project.

## 3.1 Types of Water

Types of water generated by the project are defined based on their source and quality. There are two types of water that will be associated with the project: clean water and sediment water. Characteristics of these water types are summarised in Table 3.1. Each of the water types will require different management strategies, as discussed in subsequent sections.

**TABLE 3.1: WATER TYPES**

| Type of Water | Definition |
|---|---|
| Sediment Water | Runoff from disturbed areas that are expected to contain increased levels of sediment. Sediment water is associated with runoff from disturbed catchments including the Pit, stockpiles and materials processing areas. Sediment water is managed through the use of erosion and sediment controls (refer to Section 3.3) |
| Clean Water | Natural rainfall and runoff from existing undisturbed catchment areas. Clean water is generally diverted away from the disturbed catchments within the Project Area through use of bund and drains to minimise the likelihood of clean water contamination. |

## 3.2 Water Management Infrastructure

The Project water management system (WMS) will be comprised of one sediment dam and a series of drains and bunds to contain sediment water on the site and divert runoff from upstream clean water catchment areas, and a groundwater bore. Details of the WMS features are provided in Section 3.2.2 to 3.2.5. An overview of the water management infrastructure is provided in Figure 3.1. The WMS features described in the following sections can be considered operational phase infrastructure. During the construction phase, erosion and sediment controls (ESCs) will be used to minimise erosion and reduce the risk of sediment laden runoff reporting off-site. Construction phase ESCs will be designed and implemented generally in accordance with requirements outlined in *Managing Urban Stormwater: Soils and Construction Volume 1* (Landcom, 2004) and *Volume 2E – Mines and quarries* (DECC, 2008) (the 'Blue Book').

### 3.2.1 Drains and Bund

During the operational phase, perimeter drains will be used to divert clean water runoff around the site. Drains will be used to divert water around the Pit and towards the sediment basin. These features will be designed and constructed to meet the requirements outlined in the 'Blue Book'.

### 3.2.2 Sediment Basin

There is one proposed sediment basin that will be used to capture and contain runoff from disturbed areas within the Project Area. The catchment area that will report to the sediment basin has been derived from the proposed disturbance boundary and LiDAR for the site. It is assumed that the entirety of the land contained within the disturbance boundary will be disturbed and report to the sediment basin (with the exception of the Pit). The sediment basin has been sized based on this basis in accordance with requirements outlined in the 'Blue Book'.

### 3.2.2.1 Sediment Dam Design Standard

An assessment of the Quarry site was undertaken in accordance with the 'Blue Book' to design the Sediment Basin component of a Water Management System (WMS) for the site. The assessment determined that based on the soil types on site a type-D sediment basin would be required. Relevant parameters used to calculate the sediment basin sediment storage capacity and water storage capacity (i.e., settling zone) are tabulated in Table 3.2.

Based on these calculations the required design Sediment Basin volume is 4.6 ML. This volume is inclusive of the calculated settling zone of operational volume (2,936 $m^3$) and the sediment storage capacity (1,622 $m^3$). It should be noted that required design Sediment Basin volume is exclusive of water storage allowances. Because the Sediment Basin is to be used to meet site water demands (for processing and dust suppression), additional capacity in excess of the calculated required design volume will be required to store this water.

A fixed staff gauge will be used to indicate the maximum sediment storage level (top of the sediment storage zone) and maximum operating level (top of the operational water storage zone). The volume above the maximum operating volume will include the settling volume and any required additional freeboard to be determined during detailed design. The Sediment Basin is to be managed to maintain the availability of the settling zone storage (as per requirements outlined in the Blue Book (Landcom, 2004 and DECC, 2008) so that the basin can contain the rainfall and runoff inflows during the design rainfall event.

These volumes have been considered during water balance modelling of the WMS (refer to Section 4).

**TABLE 3.2: SEDIMENT BASIN SIZING CALCULATIONS**

| Parameter | Design Values | Notes and Blue Book References |
|---|---|---|
| Total catchment area (ha) | 7.5 | The entirety of the catchment area is disturbed. The catchment area does not include the Pit catchment. |
| Soil Texture Group | D | See Section 6.3.3(e) of the 'Blue Book'. |
| **Rainfall Data** | | |
| Design rainfall event | 5 day, 95th percentile | See Section 6.3.4 and, particularly, Table 6.3 on pages 6-24 and 6-25 of the 'Blue Book'. The 5-day 90$^{th}$ percentile event rainfall depth (50.7 mm) for Armidale (the closest town listed in Table 6.3 of the 'Blue Book') was selected for the purpose of the assessment. |
| 5-day, 90th percentile rainfall event (mm) | 52.9 | |
| **Revised Universal Soil Loss Equation Values** | | |
| R-factor (rainfall erosivity) | 1400 | See Appendix A2 of the 'Blue Book'. |
| K-Factor (soil erodibility) | 0.05 | See Section 6.1 on page 32 of the 'Blue Book' Volume 2E. |
| LS Factor (slope length / gradient factor) | 3.1 | See Appendix A4 of the 'Blue Book'. Calculated using a slope length of 80m and a slope gradient of 8.2%. |
| P-Factor (erosion control practice factor) | 1.3 | See Appendix A5 of the 'Blue Book'. |
| C-Factor (ground cover and management factor) | 1 | See Appendix A6 of the 'Blue Book'. |

| Parameter | Design Values | Notes and Blue Book References |
|---|---|---|
| **Sediment and Settling Zone Sizing Parameters** | | |
| Sediment Zone Design Number of Months | 12 | Assumes the Sediment Basin will be desilted every 12 months. |
| Cv (Volumetric runoff coefficient) | 0.74 | See Table F2, page F-4 in Appendix F of the 'Blue Book'. |
| **Calculated Sediment Basin Size** | | |
| Sediment Basin Storage (soil) Volume ($m^3$) | 1,622 | See Sections 6.3.4(i) of 'Blue Book' for equations used to calculate this volume. |
| Sediment Basin Settling (water) Volume ($m^3$) | 2,936 | See Sections 6.3.4(i) of 'Blue Book' for equations used to calculate this volume. |
| Sediment Basin Total Volume ($m^3$) | 4,558 | Total required volume of the Sediment Basin calculated in accordance with the Blue Book us the Revised Universal Soil Loss Equation (RUSLE). It should be noted that this volume does not include any operational water storage allowances. |

### 3.2.3 Pumps and Pipelines

Pumps will be used to dewater the Pit via a pipeline to the Sediment Basin when the basin has available storage capacity above the required settling zone capacity (refer to Section 3.2.2.1). The Sediment Basin will dewater to the Pit sump as required to ensure that the required settling zone capacity is available to contain runoff from the design storm event (refer to Section 3.2.2.1).

### 3.2.4 Controlled Release Infrastructure

Controlled releases are not expected to be required. Water captured on site will be used to meet operational demands and will be stored in Pit as needed to maintain Sediment Basin freeboard requirements. Should controlled releases be required due to excessive accumulation of the sediment water impeding operations, ARDG will apply for a licensed discharge point to be added to the site EPL with appropriate discharge criteria.

### 3.2.5 Potable Water Supply and Wastewater Management

Potable water for amenities will be supplied to the site by water tanker. Wastewater from amenities will be collected in a tank and removed from site by a licensed waste contractor as required.

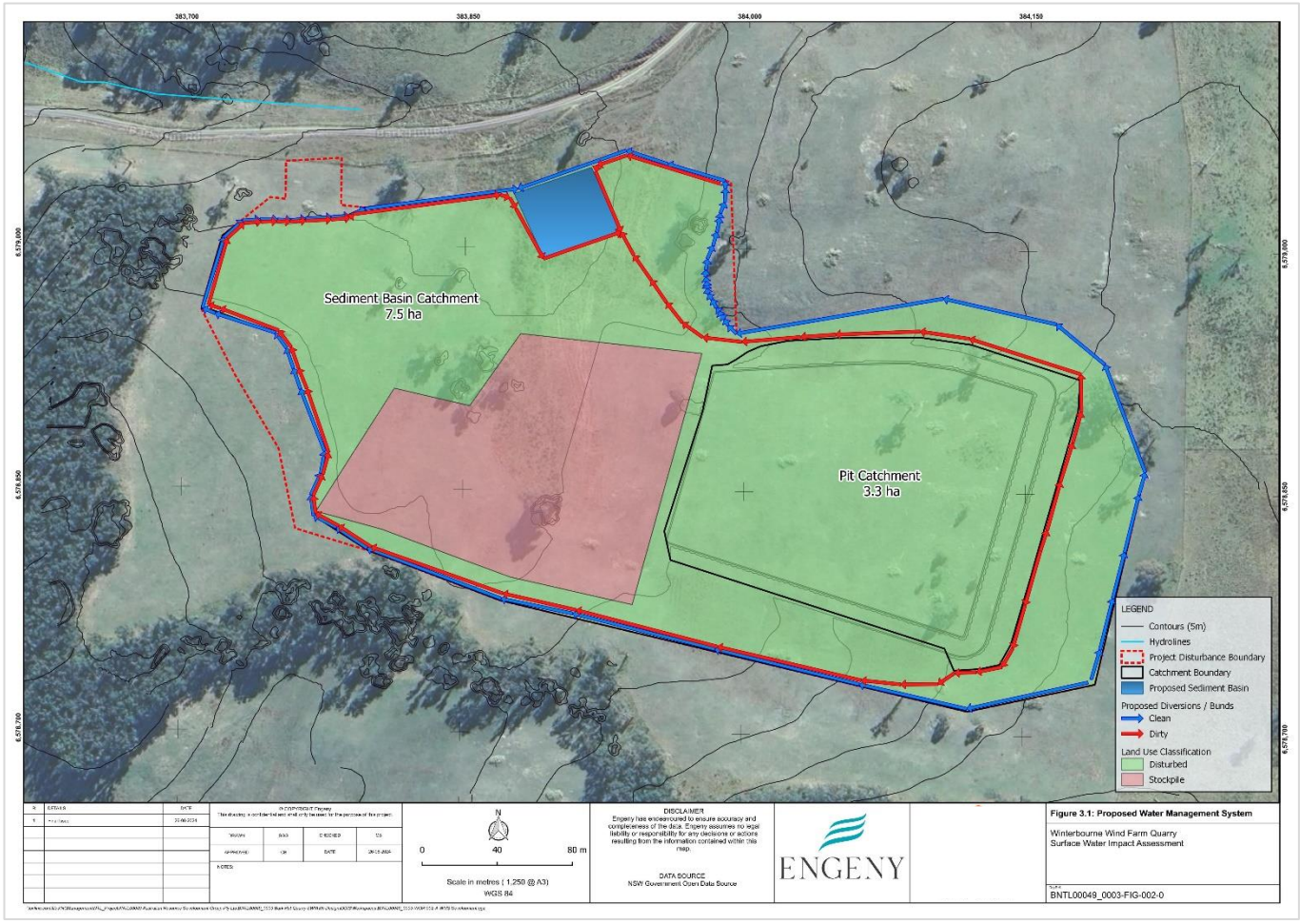



**FIGURE 3.1: PROPOSED WATER MANAGEMENT SYSTEM**

## 3.3 Water Management System Inflows, Outflows and Internal Transfers

Water management system inflows, outflows and internal transfers associated with the Project are tabulated in Table 3.3. The WMS is schematically represented in Figure 3.2.

**TABLE 3.3: WATER MANAGEMENT SYSTEM INFLOW AND OUTFLOWS**

| Type | Description |
|---|---|
| **Inflows** | |
| Rainfall and Runoff | Rainfall and runoff captured by the WMS. |
| Groundwater Inflows | Incidental groundwater inflows to the Pit. |
| Groundwater from Bores | Groundwater extracted from bores to be used as a supplementary water source for dust suppression and process demands if these demands cannot be met by the Sediment Basin. |
| Potable Water Supply | Potable water supplied via tanker truck. |

| Type | Description |
|---|---|
| **Outflows** | |
| Evaporation | Evaporative losses from the water storage surfaces (including water stored in-pit). |
| Dust Suppression | Water applied to roads and disturbed areas (including stockpiles) within the Project Area. This water will be supplied from the Sediment Basin and supplemented with water extracted from groundwater bores as required. |
| Process Water Demands | Water used for production of quarry products. This water will be supplied from the Sediment Basin and supplemented with water extracted from a groundwater bore as required. |
| **Internal Transfers** | |
| Pit Dewatering | The Pit will be dewatered to the Sediment Basin when the basin has available storage capacity above the required settling zone capacity (refer to Section 3.2.2.1) |
| Sediment Basin Dewatering | The Sediment Basin will dewater to the Pit as required to maintain adequate freeboard. |

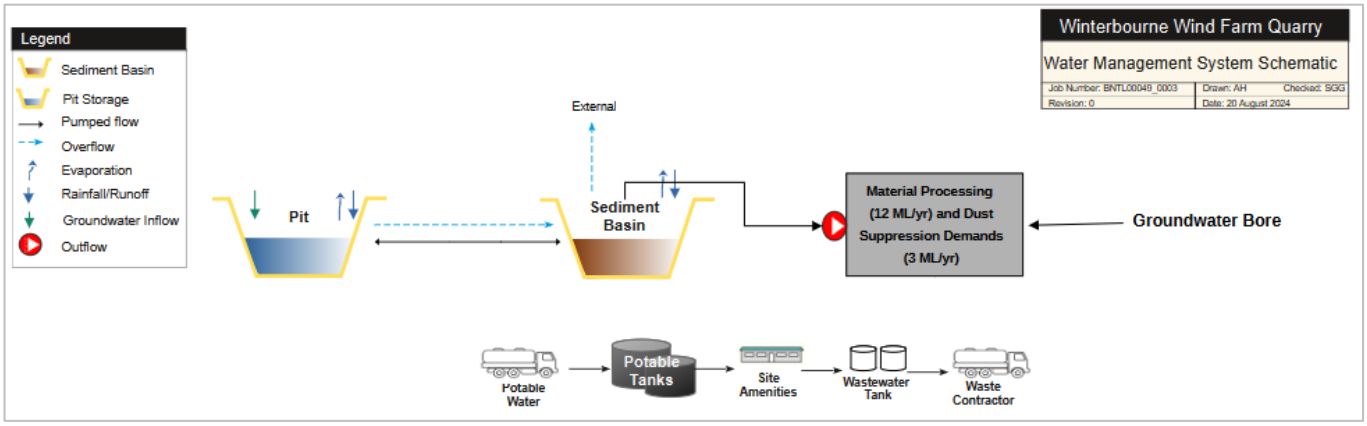



**FIGURE 3.2: WATER MANAGEMENT SYSTEM SCHEMATIC**

# 4. WATER BALANCE MODEL

A water balance model (WBM) representative of the proposed WMS was developed using the GoldSim software platform. The model simulates inflows from rainfall and runoff (including direct rainfall on water surfaces), outflows for dust suppression and process demands, and evaporative losses to assess future inventories and the frequency and volume of uncontrolled releases from the site. Sections 4.1 and 4.2 detail the development of the WBM and the WBM results, respectively.

## 4.1 Model Development

### 4.1.1 Dam Characteristics

For the assessment, the quarry Pit has been modelled as a water storage so that intercepted rainfall and runoff can be tracked and managed. Storage characteristics for the Sediment Basin and the Pit are provided in Table 4.1. The Project design digital elevation models (DEMs) were used to establish storage characteristics for the Pit.

Storage characteristics for the Sediment Basin were developed based on the dam sizing requirements described in Section 3.2.2.1. A conceptual storage curve was generated with assumed internal batters of 3:1. The depth and capacity of the dam was refined using preliminary WBM results to limit the estimated frequency of overflow events to 1 – 2 spills per year in accordance with the Blue Book (Table 6.2 of Volume 2E) while maintaining some inventory to supply operational demands.

It should be noted that modelled Sediment Basin capacity does not include the sediment storage volume (1.6 ML, refer to Section 3.2.2). The modelled Sediment Basin volume (4.9 ML) is inclusive of the operational water storage and settling storage zones only.

**TABLE 4.1: STORAGE CHARACTERISTICS**

| Storage | Capacity (ML) | Surface Area at Spill Level ($m^2$) | Depth (m) |
|---|---|---|---|
| Sediment Basin | 4.9 | 2,274 | 3.4 |
| Pit | 328.5 | 24,025 | 14.0 |

### 4.1.2 Catchment Area, Land Use and Runoff

Catchments draining to the water storages was assigned a land use classification based on the proposed Project layout. Two discrete land use classes are represented in the model, including:

- **Stockpile** – Soil and material stockpile areas.
- **Disturbed –** Disturbed land such as pits, roads and dam floors.

The catchment areas reporting to each of the storages for each land use type are provided in Table 4.2 and shown in Figure 3.1. Australian Water Balance Model (AWBM) (an antecedent rainfall runoff model) parameters have been adopted for each land use type, as described in Section 4.1.4.

**TABLE 4.2: CATCHMENT LAND USE BREAKDOWN**

| Storage | Stockpile (ha) | Disturbed (ha) | Total (ha) |
|---|---|---|---|
| Sediment Basin | 2.1 | 5.4 | 7.5 |
| Pit | 0.0 | 3.3 | 3.3 |
| | | **Total:** | **10.8** |

### 4.1.3 Climate Data

Climate data inputs to the water balance model include site specific daily rainfall, evapotranspiration (Mortons Potential) and lake evaporation (Mortons Lake) for a 133-year period sourced from the SILO climate database. Climate characteristics for the site are further detailed in Section 2.2.

### 4.1.4 AWBM Runoff Model

The AWBM was used to simulate catchment runoff based on the relationship between rainfall, evapotranspiration, storage catchment area and land use classification. The model represents each land use classification using three surface storage capacities which determine how much rainfall is stored and how much becomes runoff to each site storage.

A description and breakdown of adopted AWBM parameters is shown in Table 4.3. These parameters were adopted based on an EIS completed for the East Guyong Quarry in NSW (Hanson Heidelberg Cement Group, 2009). The AWBM parameters adopted for the East Guyong Quarry are considered typical for disturbed and stockpile land use types and suitable to represent the Winterbourne Wind Farm Quarry site in absence of catchment specific monitoring data that could be used to calibrate the runoff model.

**TABLE 4.3: AWBM RUNOFF PARAMETERS**

| Parameter | Description | Disturbed | Stockpile |
|---|---|---|---|
| Soil Store 1 (C1) (mm) | The capacity of surface storages. | 0.185 | 0.185 |
| Soil Store 2 (C2) (mm) | | 0.43 | 0.43 |
| Soil Store 3 (C3) (mm) | | 0.385 | 0.385 |
| Partial Area 1 (A1) | The partial area ratio of the overall catchment contributing to storages. | 5 | 20 |
| Partial Area 2 (A2) | | 30 | 50 |
| Partial Area 3 (A3) | | 50 | 100 |
| Base Flow Index (BFI) | Baseflow Index – The proportion of excess rainfall flowing to the baseflow store (remainder in surface store). | 0.05 | 0.05 |
| Baseflow Recession Constant (Kb Day-1) | Baseflow Recession Constant – The proportion of volume in the baseflow store remaining at the end of each day. | 0 | 0 |
| Surface Flow Recession Constant (Ks day-1) | Surface Recession Constant – The proportion of volume in the surface store remaining at the end of each day. | 0.985 | 0.985 |
| Average Long-Term Runoff Coefficients (%) | | 23% | 12% |

### 4.1.5 Groundwater Inflows

Groundwater inflows to the Pit have been estimated via groundwater modelling (GHD, 2024). The peak volume of groundwater inflow to the Pit is estimated to be 13,266 L/day. It is assumed that 50% of this water will be lost to evaporation and the 50% will accumulate in the Pit requiring management in the WMS. Modelled groundwater inflow parameters are tabulated in Table 4.4.

**TABLE 4.4: MODELLED GROUNDWATER INFLOWS TO THE PIT**

| Peak Groundwater Inflow (L/day) (GHD, 2024) | Assumed Percent of Inflow Lost to Evaporation (%) | Net Peak Groundwater Inflow (L/day) | Net Peak Groundwater Inflow (ML/year) |
|---|---|---|---|
| 13,266 | 50% | 6,633 | 2.4 |

### 4.1.6 Modelled Transfers and Operating Logic

Table 4.5 describes how outflows and internal transfer are modelled based on operating rules and adopted rates.

**TABLE 4.5: MODEL TRANSFER LOGIC AND RATES**

| Category | Transferred From | Transferred To | Description | Operating Rules | Rate |
|---|---|---|---|---|---|
| Internal Transfer | Pit | Sediment Basin | Rainfall, runoff and groundwater intercepted by the Pit will be dewatered to the Sediment Basin. | • The Pit can be completely dewatered.<br>• The Sediment Basin can receive transferred inflows until the storage reaches its maximum operating volume (2 ML). | Assumed maximum transfer rate of 20 L/s. |
| Internal Transfer | Sediment Basin | Pit | The Sediment Basin will dewater to the Pit to maintain adequate freeboard. | • The Pit can receive transferred inflows if the volume stored is less than 10 ML.<br>• The Sediment Basin will begin dewatering if the volume stored exceeds the maximum operating volume (2 ML) and the Pit has capacity (i.e. contains less than 10 ML). | Assumed maximum transfer rate of 20 L/s. |
| Outflow | Sediment Basin | Demands | Water stored in the Sediment Basin will be used to meet dust suppression and process demands. | • The Sediment Basin can dewater until it is empty. | 15 ML/year demand (12 ML/year for dust suppression and 3 ML/year for process demands). |

### 4.1.7 Assumptions and Limitations

Assumptions made during the development of the WBM, and limitations of the model include:

- It is assumed that any demand shortfalls can be adequately met by water extracted from groundwater bores and that the volumes extracted will be less than the groundwater WAL shares held by the site.
- As the project involves development of a new quarry there is no historical operational data to use for calibration of the WBM, i.e. the WBM has not been calibrated.

## 4.2 Water Balance Model Results

The WBM was simulated for 133 climate realisations to conduct a probabilistic Monte Carlo assessment using historic climate data. Each WBM realisation was simulated for a four year period, representative of the estimated life of quarry (3 – 4 years). Each modelled realisation uses four years of actual historic data, cycling through the historic dataset. Each realisation is time shifted from the start of the climate series (1889) by the realisation number (i.e., realisation 1 uses data from 1889 to 1892, realisation 2 uses data from 1890 to 1893 etc.) so that the model results cover the full range of consecutive four-year scenarios within the modelled climate dataset. Key results are presented in Section 4.2.1 and Section 4.2.2.

### 4.2.1 Overflow Assessment and Required Sediment Basin Size

The likelihood and frequency of overflow events occurring (as indicated by WBM results) is presented in Table 4.6. It should be noted that all modelled overflows are from the Sediment Basin and that the Pit does not overflow in any of the modelled realisations. Model results indicate that there is an approximately 85% chance that an overflow from the Sediment Basin will occur during the modelled life of quarry (four years). The average number of modelled overflow events per year is 1.5. This is consistent with the 1 – 2 spills per year indicated in Volume 2E of the 'Blue Book' as being typical of sediment basins sized to contain runoff from a 5 day 95$^{th}$ percentile rainfall event.

**TABLE 4.6: OVERFLOW ASSESSMENT – SEDIMENT BASIN**

| Parameter | Units | Result |
|---|---|---|
| Percent Chance of an Overflow Occurring During the Modelled Life of the Quarry (4 years) | % | 89% |
| Average Number of Overflow Events During the Modelled Life of the Quarry (4 years) | Count | 6.0 |
| Average Number of Overflow Events Per Year | Count | 1.5 |
| Average Total Overflow Volume During the Life of the Modelled Quarry (4 years) | ML | 7.5 |
| Average Overflow Volume Per Year | ML | 1.9 |

### 4.2.2 Shortfall

The total site water demand is estimated to be 15 ML per year. This volume is inclusive of 12 ML that is intended to be used for dust suppression and 3 ML that will be used to meet process demands. These demands will be met by:

(1) Surface water runoff captured by the WMS, and

(2) Bore sourced groundwater as required if water demands cannot be met by the rainfall runoff captured within the WMS.

Results presented in Table 4.7 indicate site water demands that cannot be met by the captured rainfall runoff during the life of quarry. These results are indicative of the volume of groundwater that may need to be acquired for the operation. Model results indicate an average yearly shortfall of 2.3 ML and a maximum yearly shortfall of 11.6 ML. This indicates that up to approximately 11.6 ML is likely to be required to ensure site water demands can be met during dry climatic periods. This groundwater would be acquired as detailed in in Section 2.6.

**TABLE 4.7: SEDIMENT BASIN PROCESSING AND DUST SUPPRESSION SHORTFALLS**

| Parameter | Units | Result |
|---|---|---|
| Max Shortfall During the Modelled Life of the Quarry (4 years) | ML | 25.3 |
| Max Shortfall Per Year | ML | 11.6 |
| Average Total Shortfall During the Modelled Life of the Quarry (4 years) | ML | 9.4 |
| Average Shortfall per Year | ML | 2.3 |

# 5. LICENSING, MONITORING, AND REPORTING

## 5.1 Licensing

### 5.1.1 Environmental Protection Licence

The quarry will be required to hold an EPL as it will be carrying out a premises-based activity listed in Schedule 1 of the Protection of the Environment Operations Act 1997 (POEO Act), i.e., Activity 19 Extractive activities, >30,000 tonnes/year. At this stage, the inclusion of a licensed discharge point on the EPL to permit controlled discharges from the WMS is not considered to be required.

### 5.1.2 Surface Water

All surface water runoff captured by the WMS will be to prevent the contamination of a water source. As such, all Project water storages are considered as excluded works under Schedule 1 of the Water Management (General) Regulation 2018 and therefore, exempt from requiring a WAL under Schedule 4 Clause 12 of the Water Management (General) Regulation 2018.

There will be no harvestable rights dams constructed as part of the proposed development. Surface water take associated with any final voids and/or other water storages that will remain after quarry closure will be licensed as required with consideration of the harvestable rights entitlement for the landholding. These licensing requirements will be communicated to any future landholders.

### 5.1.3 Groundwater

The project is located within the New England Fold Belt Coast Groundwater Source which is managed by the WSP for the North Coast Fractured and Porous Rock Groundwater Sources. Any interference or extraction of groundwater at the project requires a WAL under the Water Management Act (2000). The proponent plans to source groundwater (refer Section 2.6) to provide additional water to meet processing and dust suppression demands. Incidental groundwater inflows to the Pit are also have been predicted as part of a Groundwater Impact Assessment (GWIA) prepared for the Project (GHD, 2024).

The proponent will obtain a WAL and sufficient entitlement to cover the maximum groundwater take associated with groundwater bores constructed to supply operational demands. Recent trades (between 2021 and 2024), water made available and water usage statistics for recent water years (2023/2024, 2022/2023) indicate there is sufficient market depth for sufficient WAL entitlements to be obtained. Groundwater inflows are expected to continue for a period of time post closure until water levels within the Pit have recovered above the pre-quarry groundwater levels. A WAL will therefore still be required in the post closure phase of the project.

Details of groundwater licensing requirements, including licensing requirements for incidental groundwater inflows to the Pit, are address in the Project GWIA (GHD, 2024).

## 5.2 Monitoring

### 5.2.1 Surface Water

Table 5.1 and Table 5.2 presents the proposed surface water quality and quantity monitoring program for the Project. Proposed surface water monitoring locations are shown in Figure 5.1. The Farm Dam has been selected as a proposed surface water monitoring site given an overflow event from the Sediment Basin would report to this dam. The SW01 monitoring location has been selected for comparison to baseline water quality monitoring data (refer to Section 2.5.2). Impact assessment criteria for receiving water quality downstream of the quarry will be developed in accordance with the Australian and New Zealand Guidelines for Fresh and Marine Water Quality (ANZG 2018).

**TABLE 5.1: PRELIMINARY SURFACE WATER QUALITY MONITORING PROGRAM**

| Location | | Units | Frequency | Methodology |
|---|---|---|---|---|
| Sediment Basin<br>Farm Dam<br>SW01 | pH<br>EC<br>TSS<br>Turbidity<br>Nitrate<br>Nitrite<br>Oxides of Nitrogen (NOx)<br>Oil and Grease | -<br>µS/cm<br>mg/L<br>NTU<br>mg/L<br>mg/L<br>mg/L<br>mg/L | Monthly and during uncontrolled discharge (or following if uncontrolled discharge occurs when site unattended) | Water quality meter (pH, EC, Turbidity)<br>Grab sample<br>(All parameters) |

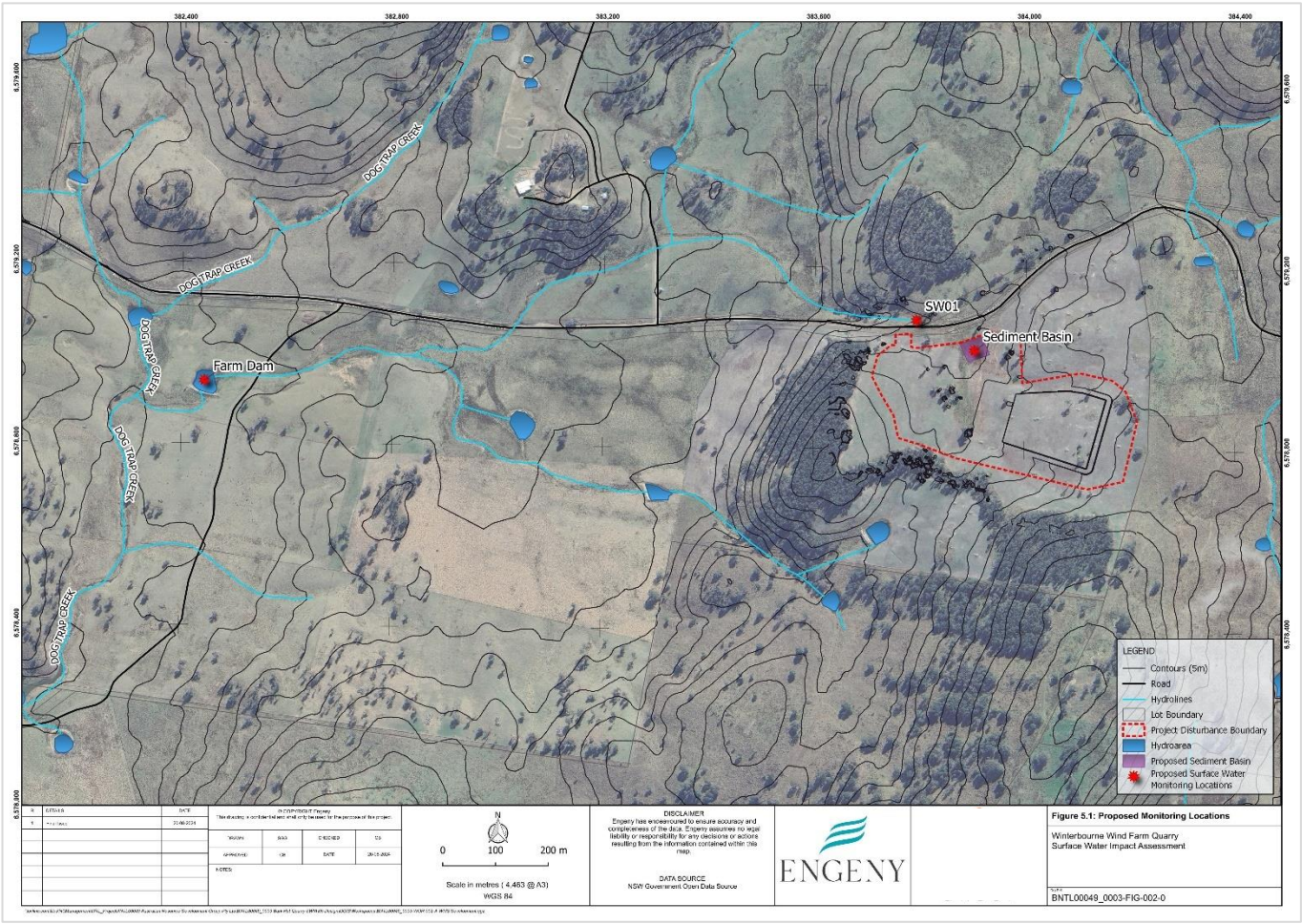



**FIGURE 5.1: PROPOSED SURFACE WATER MONITORING LOCATIONS**

**TABLE 5.2: PRELIMINARY SURFACE WATER QUANTITY MONITORING PROGRAM**

| Location | Units | Frequency | Methodology |
|---|---|---|---|
| Sediment Basin Volume | ML | Monthly and prior to the onset of significant rainfall. | Fixed staff gauge and Sediment Basin stage storage relationship. |
| Pit Volume | ML | Monthly | Survey |
| Dust Suppression | ML | Continuous during use | Totalising flow meter or number of water cart fills. |
| Process Water | ML | Continuous during use | Totalising flow meter |

### 5.2.2 Stream Stability

Given the net catchment reporting to the downstream environment will be reduced as a result of the Project and there are no proposed controlled discharges, impacts to stream stability are considered unlikely.

### 5.2.3 Amenities Potable Water

The proponent will implement an inspection and water quality testing program for potable water stored in tanks on site (delivered by water tanker) to ensure amenities water quality meets the Australian Drinking Water Guidelines – Version 3.5 (ADWG) (National Health and Medical Research Council, 2011).

## 5.3 Reporting

### 5.3.1 Environment Protection Licence

The proponent will be required to complete and submit an Annual Return to the NSW Environment Protection Authority (EPA) that it is anticipated to include a summary of an uncontrolled water discharges, monitoring, any complaints and a statement of compliance with EPL conditions. In the event that an incident occurs that threatens or causes environmental harm such as the contamination of water that does not meet EPL criteria, the proponent will notify the EPA immediately after becoming aware of the incident. The proponent will also provide a written report to the EPA within seven days of the date of becoming aware of the incident.

### 5.3.2 Annual Review and Incidents

The proponent will submit an Annual Review to DPHI that will include a summary of the quarry WMS performance. It is anticipated that the Annual Review will include the annual site water balance results, water quality monitoring results and details of any incidents or complaints. If an environmental incident involving surface water occurs the relevant authorities (including DPHI and the EPA) will be notified and reports provided as required.

# 6. CONCLUSION

An assessment of the potential impacts on surface water resources associated with the Project was undertaken and the following conclusions have been drawn from the assessment outcomes:

- The Project will have an adequate and reliable water source (i.e., captured rainfall runoff, passive groundwater inflows and groundwater bore) to support the required construction and civil aspects of the Project.
- The potential for adverse water quality impacts on downstream receiving waters during construction and closure phases of the Project can be satisfactorily mitigated by the implementation of ESCs in general accordance with the Blue Book.
- The potential for adverse water quality impacts on downstream receiving waters during the operational phases are considered negligible.
- Reductions in rainfall runoff volumes reporting to downstream users due to the Project WMS catchment area are considered negligible.

# 7. QUALIFICATIONS

(a) In preparing this document, including all relevant calculation and modelling, Engeny Australia Pty Ltd (Engeny) has exercised the degree of skill, care and diligence normally exercised by members of the engineering profession and has acted in accordance with accepted practices of engineering principles.

(b) Engeny has used reasonable endeavours to inform itself of the parameters and requirements of the project and has taken reasonable steps to ensure that the works and document is as accurate and comprehensive as possible given the information upon which it has been based including information that may have been provided or obtained by any third party or external sources which has not been independently verified.

(c) Engeny reserves the right to review and amend any aspect of the works performed including any opinions and recommendations from the works included or referred to in the works if:

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(g) This Report does not provide legal advice.

# APPENDIX A : BASELINE WATER QUALITY RESULTS

| Analyte | Unit | Limit of reporting | SW03 | GW01 | GW02 |
|---|---|---|---|---|---|
| pH Value | pH Unit | 0.01 | 6.51 | 6.84 | 6.50 |
| Electrical Conductivity @ 25°C | µS/cm | 1 | 121 | 566 | 523 |
| Total Dissolved Solids @180°C | mg/L | 10 | 116 | 336 | 359 |
| Total Dissolved Solids (Calc.) | mg/L | 1 | 79 | 368 | 340 |
| Sugar | - | - | Not Detected | Not Detected | Not Detected |
| Hydroxide Alkalinity as $CaCO_3$ | mg/L | 1 | <1 | <1 | <1 |
| Carbonate Alkalinity as $CaCO_3$ | mg/L | 1 | <1 | <1 | <1 |
| Bicarbonate Alkalinity as $CaCO_3$ | mg/L | 1 | 18 | 222 | 164 |
| Total Alkalinity as $CaCO_3$ | mg/L | 1 | 18 | 222 | 164 |
| Sulfate as $SO_4$ - Turbidimetric | mg/L | 1 | 13 | 13 | 16 |
| Chloride | mg/L | 1 | 15 | 29 | 44 |
| Calcium | mg/L | 1 | 2 | 65 | 47 |
| Magnesium | mg/L | 1 | 2 | 9 | 15 |
| Sodium | mg/L | 1 | 16 | 35 | 41 |
| Potassium | mg/L | 1 | 1 | 2 | 1 |
| Antimony | mg/L | 0.001 | <0.001 | <0.001 | <0.001 |
| Arsenic | mg/L | 0.001 | <0.001 | <0.001 | <0.001 |
| Barium | mg/L | 0.001 | 0.030 | 0.032 | 0.035 |
| Cadmium | mg/L | 0.0001 | <0.0001 | <0.0001 | <0.0001 |
| Chromium | mg/L | 0.001 | <0.001 | <0.001 | <0.001 |
| Copper | mg/L | 0.001 | 0.001 | <0.001 | <0.001 |
| Lead | mg/L | 0.001 | <0.001 | <0.001 | 0.002 |
| Manganese | mg/L | 0.001 | 0.035 | 0.213 | 0.248 |
| Molybdenum | mg/L | 0.001 | <0.001 | <0.001 | <0.001 |
| Nickel | mg/L | 0.001 | <0.001 | <0.001 | <0.001 |
| Selenium | mg/L | 0.01 | <0.01 | <0.01 | <0.01 |
| Silver | mg/L | 0.001 | <0.001 | <0.001 | <0.001 |
| Boron | mg/L | 0.05 | <0.05 | <0.05 | <0.05 |
| Mercury | mg/L | 0.0001 | <0.0001 | <0.0001 | <0.0001 |

| Analyte | Unit | Limit of reporting | SW03 | GW01 | GW02 |
|---|---|---|---|---|---|
| Total Cyanide | mg/L | 0.004 | <0.004 | <0.004 | <0.004 |
| Fluoride | mg/L | 0.1 | <0.1 | 0.4 | 0.5 |
| Nitrite as N | mg/L | 0.01 | <0.01 | <0.01 | <0.01 |
| Nitrate as N | mg/L | 0.01 | 0.99 | <0.01 | <0.01 |
| Nitrite + Nitrate as N | mg/L | 0.01 | 0.99 | <0.01 | <0.01 |
| Total Anions | meq/L | 0.01 | 1.05 | 5.52 | 4.85 |
| Total Cations | meq/L | 0.01 | 0.98 | 5.56 | 5.39 |
| Ionic Balance | % | 0.01 | ---- | 0.30 | 5.25 |
| Total Oil and Grease | mg/L | 2 | <2 | <2 | <2 |

# Appendix 2

## Groundwater Impact Assessment

Prepared by GHD Pty Ltd

# Groundwater Impact Assessment

## Winterbourne Windfarm Quarry

Australian Resource Development Group

22 August 2024

The Power of Commitment

| | | | | | | | |
|---|---|---|---|---|---|---|---|
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| **Document title** | | Groundwater Impact Assessment \| Winterbourne Windfarm Quarry | | | | | |
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**GHD Pty Ltd | ABN 39 008 488 373**
Contact: Malinda Kay, Senior Hydrogeologist | GHD
270 Summer Street,
Orange, New South Wales 2800, Australia
**T** +61 2 6393 6400 | **F** +61 2 9475 0725 | **E** oagmail@ghd.com | **ghd.com**

# Executive Summary

Australian Resource Development Group Pty Limited (ARDG) engaged GHD Pty Ltd (GHD) to prepare a Groundwater Impact Assessment (GIA) for a proposed hard rock quarry known as Winterbourne Windfarm Quarry (the project) and associated potential production bore. The project is located 20 km north-east of Walcha, in the Walcha Shire, in the northern tablelands of New South Wales (NSW). The project is seeking to access a high quality, hard rock resource to support the Winterbourne Windfarm Project (WWF). The production bore would be utilised by the project and the WWF for dust suppression associated with quarry operations and earthworks associated with the WWF.

This GIA has been undertaken with reference to the Groundwater Assessment Toolbox for Major Projects in NSW (DPE 2022) and to address the SEARs relating to groundwater (specific to the WWF only), dated 17 September 2020.

A conceptual groundwater model was developed for the duration of both the quarry operations and the WWF construction period (up to three years). The conceptual model is based on drilling and groundwater monitoring data, pump testing results, lithology logs and core photographs provided by ARDG and interpreted geology. The groundwater flow system occurs in a confined fractured rock aquifer within the Lochaber Greywacke. The fractured rock aquifer is confined by a clay/saprolite aquitard. Groundwater is recharged by rainfall infiltration and subsequent leakage through the clay aquitard, and by direct rainfall recharge outside of the project area where the fractured rock outcrops. Groundwater quality at the project is good, with circumneutral pH (6.5 – 6.84) and relatively low electrical conductivity (523 – 566 µS/cm). Total metal concentrations are low and are largely below laboratory detection limits.

The nearest high priority Groundwater Dependent Ecosystems (GDEs) are located near the Macleay River to the east, approximately 70 km from the project and associated production bore. The GDEs are classified as karst springs. With reference to the *Probable Vegetation Groundwater Dependent Ecosystems – Northern Rivers and Namoi* datasets (DPE Water 2022), high probability GDEs are associated with Dog Trap Creek and Snake Creek, located to the south west of the project, and Oxley Wild Rivers Nature Reserve to the east. Only low probability GDEs were identified within the project disturbance boundary. Eleven registered bores are located within an eight-kilometre radius of the project.

The project area is located within the New England Fold Belt Coast Groundwater Source which is managed by the Water Sharing Plan for the North Coast Fractured and Porous Rock Groundwater Sources. Any take of groundwater associated with the project or production bore (through passive inflow or direct take through extraction for operational purposes) will require a Water Access Licence (WAL) under the Water Management Act 2000 (WM Act). Quarry operations would require a direct take of 9.5 ML/year to 15.8 ML/year for a production bore located at the project. There is sufficient market depth for a licence for 9.5 ML/year to 15.8 ML/year.

Considering that the distances to the few registered landholder bores and highly probable vegetation GDEs are greater than two kilometres and the confined nature of the aquifer with a depth to groundwater exceeding 12 metres, which would not support GDEs, it is considered that the risk to identified groundwater receptors due to the project and associated production bore is low. Therefore, the level of complexity of analytical equations is appropriate to assess this risk.

To determine the extent of drawdown associated with a potential production bore pumping continuously at rates of 0.3 L/s to 0.5 L/s, an analytical model developed by GHD was used. For a production bore, with similar specifics to ARDG-PGW01, and a pumping rate of 0.5 L/s, the radius of influence is approximately 4.7 kilometres after three years (upper limit of expected WWF construction timeframe and therefore groundwater use). Drawdowns greater than 1.5 metres are not expected to occur at distances exceeding 1.5 kilometres from the production bore after three years continuous pumping at 0.5 L/s.

It has been assumed that the potential production bore will be used to supply the WWF for the duration of the construction period. Therefore, the initial groundwater level for the pit inflow modelling has been reduced by the average drawdown expected to be caused by the production bore throughout the pit area.

For the quarry pit, quantification of likely groundwater inflow rates and the radius of drawdown was undertaken using a steady-state analytical model. The interpreted hydraulic conductivity value obtained from pump testing production bore ARDG-PGW01 was assumed to represent the expected hydraulic conductivity in the confined aquifer ($K_1$ = 4.94 x $10^{-2}$ m/day). A lower hydraulic conductivity value was assumed for the confined aquifer below the base of the pit ($K_2$ = 2.47 x $10^{-2}$ m/day). Using these hydraulic conductivity estimates, groundwater inflows into the pit were predicted to range from 4.8 ML/year to 10.6 ML/year, and the radius of drawdown was predicted to be between 242 m and 378 m from the centre of the pit.

The requirement for a WAL for passive take will not arise until the pit floor of the quarry progresses below the top of the confined aquifer. An additional WAL for approximately 4.8 ML/year to 10.6 ML/year would be required. There is sufficient market depth for ARDG to obtain a licence for 4.8 ML/year to 10.6 ML/year.

The most conservative predicted radius of drawdown (378 m) from the centre of the pit was used to assess the groundwater impact of the pit on existing groundwater users. Landholder bores are well outside the quarry pit's radius of drawdown. No drawdown is therefore expected to occur at any of the landholder bores. Therefore, landholder bores will not be impacted by any drawdown associated with the pit and the impact of the quarry pit meets the NSW Aquifer Interference Policy (AIP) Level 1 Minimal Impact Considerations for Landholder Bores.

For a potential production bore pumping rate of 0.5 L/s, drawdowns exceeding 1.5 metres are not expected to occur at distances beyond 1.5 km, after three years continuous pumping. Given that the nearest registered bore (GW307759) is located approximately 2.7 km from ARDG-PGW02 (the location of the potential production bore), the impact of the production bore therefore meets the NSW Aquifer Interference Policy (AIP) Level 1 Minimal Impact Considerations for Landholder Bores.

The most conservative predicted radius of drawdown (378 m) was used to assess the impact of the quarry pit on GDEs. High priority GDEs identified in Section 3.6.1 are well outside the quarry pit's radius of drawdown. The highly probable vegetation GDEs associated with Snake Creek are located approximately 4.7 km to the south west of a potential production bore. Based on a continuous pumping rate of 0.5 L/s for three years, no drawdown is predicted to occur at the highly probable GDEs. The impacts of the quarry pit and potential production bore therefore meet the NSW Aquifer Interference Policy (AIP) Level 1 Minimal Impact Considerations for GDEs.

The quarry pit or a potential production bore are not expected to cause any significant change in groundwater quality or in the beneficial use of the groundwater. The increased groundwater recharge in the post closure phase may also result in a localised improvement in groundwater quality.

Cumulative impacts have been assessed. Drawdowns greater than 0.46 m are not expected to occur at any of the registered bores, after three years continuous pumping. No drawdown is expected to occur at any of the highly probable GDEs. The cumulative impact of the project and associated production bore therefore meets the NSW AIP Level 1 Minimal Impact Considerations for GDEs and Landholder Bores.

The project is expected be completed after three years. With time, groundwater levels in the aquifer surrounding the project will recover until equilibrium within the system occurs, and a pit lake forms within the final voids. The pit lake is likely to be an area of enhanced recharge for the confined aquifer. Once the system is in equilibrium, the flux of water within the pit lake will only be from rainfall and evaporation. During the recovery stage however, groundwater inflows will occur, and a WAL will still be required in the initial post closure phase of the project. Any enhanced recharge that occurs as a result of the quarry in the post closure phase would reduce the time required for groundwater levels to recover.

It is recommended that the existing groundwater monitoring program be continued. It is recommended that groundwater be monitored to:

– Measure dewatering performance.
– Assess potential impacts to groundwater levels and quality on other groundwater users in the vicinity.
– Identify groundwater issues such as potential large drawdowns at receptors as early as possible.
– Provide data which can be used to calibrate the analytical models and update the groundwater inflow predictions.
– Measure groundwater level recovery post closure and provide data which can be used to predict how long a WAL may be required after the project is completed.

It is recommended that the existing monitoring program be extended to include an additional, deeper monitoring bore near ARDG-BHPZ03, which targets the fractured rock aquifer. A second additional monitoring bore should be installed between ARDG-BHPZ04 and registered bore GW307759, to the north east of the project. Groundwater level data at this bore can be used to determine whether or not the radius of drawdown is extending further than predicted.

The groundwater monitoring program should also include pit inflow monitoring. It is recommended that the groundwater monitoring program be reviewed every year.

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# Appendices

# 1. Introduction

## 1.1 Background

Australian Resource Development Group Pty Limited (ARDG) engaged GHD Pty Ltd (GHD) to prepare a Groundwater Impact Assessment (GIA) for a proposed hard rock quarry known as Winterbourne Windfarm Quarry (the project) and associated production bore. The project is located near Walcha, Uralla Shire, in the northern tablelands of New South Wales (NSW). The project is within the boundary of the proposed Winterbourne Windfarm Project (WWF). The project is seeking to access a high quality, hard rock resource to support the WWF.

## 1.2 Purpose of this report

The purpose of this report is to prepare a GIA for the Winterbourne Windfarm Quarry to inform the preparation of an Amendment Report for the WWF.

## 1.3 Scope

The scope of the GIA is as follows:

- Review available information and data, including groundwater level data, geological and exploration data, and available groundwater reports for adjacent sites (Winterbourne Windfarm site area).
- Undertake searches of the registered groundwater bore and Groundwater Dependent Ecosystem (GDE) online databases and identify groundwater receptors (including basic landholder rights bores).
- Undertake a data gap analysis and identify additional monitoring and testing requirements (if any).
- Provide a description of the existing groundwater environment, including a summary of available monitoring data from site bores and adjacent quarries.
- Develop a conceptual groundwater model identifying inputs and outputs, groundwater flow systems and groundwater receptors.
- Review of relevant Water Sharing Plans (WSPs) and classification of the groundwater source under the NSW Aquifer Interference Policy.
- Review and analyse the results of the pump test using a commercial software package (e.g., Aqtesolv) to calculate aquifer transmissivity and storativity.
- Review and address the SEARS for the WWF relating to groundwater and issues of concern identified though agency consultation.
- Assess the rate of groundwater inflow and radius of drawdown due to the proposed operations (both quarry pit and production bore) using appropriate analytical methods.
- Assess potential impacts (quantity and quality) on identified groundwater receptors including assessment of impacts against the groundwater level and quality criteria in the NSW Aquifer Interference Policy (AIP) and Water Quality Objectives.
- Assess cumulative impacts of the project for the quarry pit and one production bore.
- Identify groundwater licensing requirements under the relevant WSPs, including an assessment of market depth should a Water Access Licence (WAL) be required.
- Identify ongoing groundwater monitoring requirements.
- Recommend mitigation measures to minimise potential groundwater impacts.
- Document the findings of the above in this GIA report.

## 1.4 Limitations

This report has been prepared by GHD for Australian Resource Development Group and may only be used and relied on by Australian Resource Development Group for the purpose agreed between GHD and Australian Resource Development Group as set out in Section 1.2 of this report.

GHD otherwise disclaims responsibility to any person other than Australian Resource Development Group arising in connection with this report. GHD also excludes implied warranties and conditions, to the extent legally permissible.

The services undertaken by GHD in connection with preparing this report were limited to those specifically detailed in the report and are subject to the scope limitations set out in the report.

GHD has prepared this report on the basis of information provided by Australian Resource Development Group and others who provided information to GHD (including Government authorities), which GHD has not independently verified or checked beyond the agreed scope of work. GHD does not accept liability in connection with such unverified information, including errors and omissions in the report which were caused by errors or omissions in that information.

The opinions, conclusions and any recommendations in this report are based on conditions encountered and information reviewed at the date of preparation of the report. GHD has no responsibility or obligation to update this report to account for events or changes occurring subsequent to the date that the report was prepared.

The opinions, conclusions and any recommendations in this report are based on assumptions made by GHD described in this report. GHD disclaims liability arising from any of the assumptions being incorrect.

# 2. Regulatory context

## 2.1 Legislation and policy

### 2.1.1 Environmental Planning and Assessment (EP&A) Act 1979

The EP&A Act is the core legislation relating to planning and development activities in NSW and provides the statutory framework under which development proposals are assessed. The EP&A Act aims to encourage the proper management, development and conservation of resources, environmental protection and ecologically sustainable development.

### 2.1.2 Water Management Act 2000

The aim of the *Water Management Act 2000* (WM Act) is to ensure that water resources are conserved and properly managed for sustainable use benefiting both present and future generations. It is also intended to provide formal means for the protection and enhancement of the environmental qualities of waterways and in-stream uses as well as to provide for protection of catchment conditions.

Certain licences and approvals, including WALs, water use approvals and water supply work approvals are issued under the WM Act.

A WAL is generally required to extract water from rivers or aquifers. The WM Act governs the issue of WALs for water sources in NSW where water sharing plans have commenced. A WAL entitles the holder to:

– Specified shares in the available water within a particular water management area or water source (the share component).
– Take water at specified times, rates or circumstances from specified areas or locations (the extraction component.

A water use approval confers a right on its holder to use water for a particular purpose at a particular location. A water supply work approval, as a specific type of water management work approval, authorises its holder to construct and use a specified water supply work at a specified location.

Landholders can take water under basic landholder rights without a water licence or approval under certain circumstances, including domestic and stock rights, native title and harvestable rights.

The WM Act defines the various offences for taking and using water from water source other than in accordance with the relevant approvals.

#### 2.1.2.1 Water sharing plans

Fresh water sources throughout NSW are managed via WSPs under the WM Act. Provisions within WSPs provide water to support the ecological processes and environmental needs of GDEs and waterways. WSPs also regulate how the water available for extraction is shared between the environment, basic landholder rights, town water supplies and commercial uses. Key rules within the WSPs specify when licence holders can access water and how water can be traded.

The project area is located within the New England Fold Belt Coast Groundwater Source which is managed by the Water Sharing Plan for the North Coast Fractured and Porous Rock Groundwater Sources. Therefore, the interference and extraction of groundwater at the project site will require a WAL under the WM Act.

### 2.1.3 NSW Aquifer Interference Policy

The NSW Aquifer Interference Policy (AIP) was finalised in September 2012 and clarifies water licensing and approval requirements for aquifer interference activities in NSW, including the taking of water from an aquifer while carrying out mining. Aquifer interference activities may take water from the water source in which they exist as well as connected groundwater and surface water sources.

The Policy outlines the water licensing requirements under the WM Act. A water licence is required whether water is taken for consumptive use or whether it is taken incidentally by the aquifer interference activity (such as groundwater filling a void), even where that water is not being used consumptively as part of the activity's operation. Under the WM Act, a water licence gives its holder a share of the total entitlement available for extraction from the groundwater source. The WAL must always hold sufficient share component and water allocation to account for the take of water from the relevant water source.

Sufficient access licences must be held to account for all water taken from a groundwater or surface water source resulting from aquifer interference activity, both for the life of the activity and after the activity has ceased. This also includes passive take from connected groundwater and surface water sources. The NSW AIP requires that potential impacts on groundwater sources, including users and GDEs, be assessed against minimal impact considerations, outlined in Table 1 of the Policy. If the predicted impacts meet the Level 1 minimal impact considerations, then these impacts will be considered as acceptable. The adopted Level 1 minimal impact considerations for the project and associated production bore are discussed in Section 6.6.

Aquifer interference approval requirements for the project or associated production bore have not commenced.

### 2.1.4 NSW Groundwater Strategy

The objective of the NSW Groundwater Strategy (December 2022) is to manage the State's groundwater resources so that they can sustain environmental, social, and economic uses for the people of NSW. The NSW Groundwater Strategy has three strategic priorities:

– Protect groundwater resources and the ecosystems that depend on them
– Build community and industry resilience through sustainable groundwater use
– Improve groundwater information and knowledge

### 2.1.5 Guide to Groundwater Management in NSW

The Guide to Groundwater Management in NSW (February 2023) provides details regarding the framework and regulatory context for groundwater management, as described throughout this section of this report. The Guide to Groundwater Management in NSW describes responsibilities of groundwater users, government agencies and development proponents for groundwater management using practical examples.

The Guide to Groundwater Management in NSW describes policies for groundwater management in NSW including:

– Draft NSW Groundwater Quantity Management Policy
– NSW Groundwater Quality Protection Policy
– NSW Groundwater Dependent Ecosystems Policy

#### Draft NSW Groundwater Quantity Management Policy

The principles of this policy include:

– Maintain total groundwater use within the sustainable yield of the aquifer from which it is withdrawn
– Groundwater extraction shall be managed to prevent unacceptable local impacts
– Provide opportunities for sustainable development that provide cultural, social, or economic benefits
– Increase community understanding of groundwater management measures

#### NSW Groundwater Quality Protection Policy (1998)

The objective of this policy is the ecologically sustainable management of the State's groundwater resources so as to:

– Slow, halt or reverse any degradation in groundwater resources
– Direct potentially polluting activities to the most appropriate local geological setting so as to minimise the risk to groundwater

### NSW Groundwater Dependent Ecosystems Policy (2002)

This policy was designed to protect ecosystems that are dependent on groundwater as a primary water source so that the ecological processes and biodiversity of these ecosystems are maintained or restored for the benefit of present and future generations. It provides guidance on how to protect and manage groundwater dependent ecosystems in a practical sense.

## 2.2 Secretary's Environmental Assessment Requirements (SEARs)

SEARs identify key issues for consideration in the EIS. The SEARs for the WWF (dated 17 September 2020) relating to groundwater, and where they are addressed in this report, are shown in Table 2.1.

***Table 2.1 SEARs***

| Requirement | Comment |
|---|---|
| Quantify water demand, identify water sources (surface and groundwater), including any licensing requirements, and determine whether an adequate and secure water supply is available for the development. | Water demand and surface water licensing requirements are addressed in the Surface Water Impact Assessment for the project.<br>Groundwater sources and licensing requirements are addressed in Section 2.1 and Section 6.5. |
| Assess potential impacts on the quantity and quality of surface and groundwater resources, including impacts on the other water users and watercourses. | Potential impacts on surface water resources are addressed the Surface Water Impact Assessment for the project.<br>Potential impacts on groundwater resources are addressed in Section 6.6. |
| Where the project involves works within 40 metres of the high bank of any river, lake or wetlands (collectively waterfront land), identify likely impacts to the waterfront land, and how the activities are to be designed and implemented in accordance with the DPI *Guidelines for Controlled Activities on Waterfront Land* (2018) and (if necessary) *Why Do Fish Need to Cross the Road? Fish Passage Requirements for Waterway Crossings* (DPI, 2003); and *Policy & Guidelines for Fish Habitat Conservation & Management* (DPI, 2013). | Impacts to waterfront land are addressed in the Surface Water Impact Assessment for the project. |
| Describe the measures to minimise surface and groundwater impacts, including how works on steep gradient land or erodible soil types would be managed and any contingency requirements to address residual impacts. | Mitigation measures relating to groundwater impacts are addressed in Section 7. |
| A detailed description of the proposed water management system (including sewage), water monitoring program and other measures to mitigate groundwater impacts, including how works on steep gradient land or erodible soil types would be managed and any contingency requirements to address residual impacts. | Groundwater monitoring and mitigation are addressed in Section 7.<br>Surface water monitoring, including the proposed water management system are addressed in the Surface Water Impact Assessment for the project. |

# 3. Regional environment

## 3.1 Topography and land use

The project area is located along the eastern slopes of the Great Dividing Range. The area is characterised by hills and ridgelines of the Walcha Plateau. The area varies in altitude with a range between 1,100 m and 1,200 m. The project is mostly surrounded by rural properties and is generally zoned as primary production grazing land with the exception of the Oxley Wild Rivers Nature Reserve to the east. The township of Walcha is located approximately 20 km to the south west of the project.

The topography of the project area is shown in Figure 3.1.

## 3.2 Hydrology

The project area is within the Northern Tablelands Land Services area and Macleay River catchment covering 11,450 square-kilometres. The catchment is bound by the Clarence, Bellinger, Coffs Harbour and Nambucca catchments in the north and by the Williams, Karuah and Great Lakes catchments in the south.

Major surface water features in the vicinity of the project include the Macleay River, located approximately 20 km to the north east of the project, and the Apsley River, located approximately 11 km to the south west. Other smaller surface water features include Dog Trap Creek located approximately seven kilometres to the south west of the project area and connects to various small dams and tributaries which are assumed to be dry for much of the year, depending on rainfall. No permanent or ephemeral drainage features are located on the project site, however when soils are saturated, overland flow is directed to the north via a culvert to an incised gully located on the north side of Bark Hut Road.

The hydrology of the project area is shown in Figure 3.1.


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0 0.3 0.6 0.9 1.2

Kilometres

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Map Projection: Transverse Mercator
Horizontal Datum: GDA2020
Grid: GDA2020 MGA Zone 56

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**Groundwater Impact Assessment**

## Topography and hydrology in the vicinity of the project

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Date **19/08/2024**

# FIGURE 3-1

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Data source: LPI: DTDB / DCDB, 2024; World Imagery: Maxar. Created by: schen4

# 3.3 Climate

Climate data were obtained as SILO Patched Point Data from the Science Division of the Queensland Government's Department of Environment and Science. SILO Patched Point Data are based on historical data from a particular Bureau of Meteorology station with missing data "patched in" by interpolating with data from nearby stations. For this assessment SILO data were obtained from Walcha (Emu Creek, station number 56010). The station was chosen based on the length and quality of the data record, and proximity to the project (approximately 10 km). The monitoring period selected was from January 1958 to 1 March 2024.

## 3.3.1 Rainfall

Annual totals are shown in Figure 3.2 and rainfall statistics are summarised below:

– Minimum annual rainfall – 316 mm in 2019
– Maximum annual rainfall – 1,071.6 mm in 1984
– Average annual rainfall – 718.0 mm
– Median annual rainfall – 704.6 mm

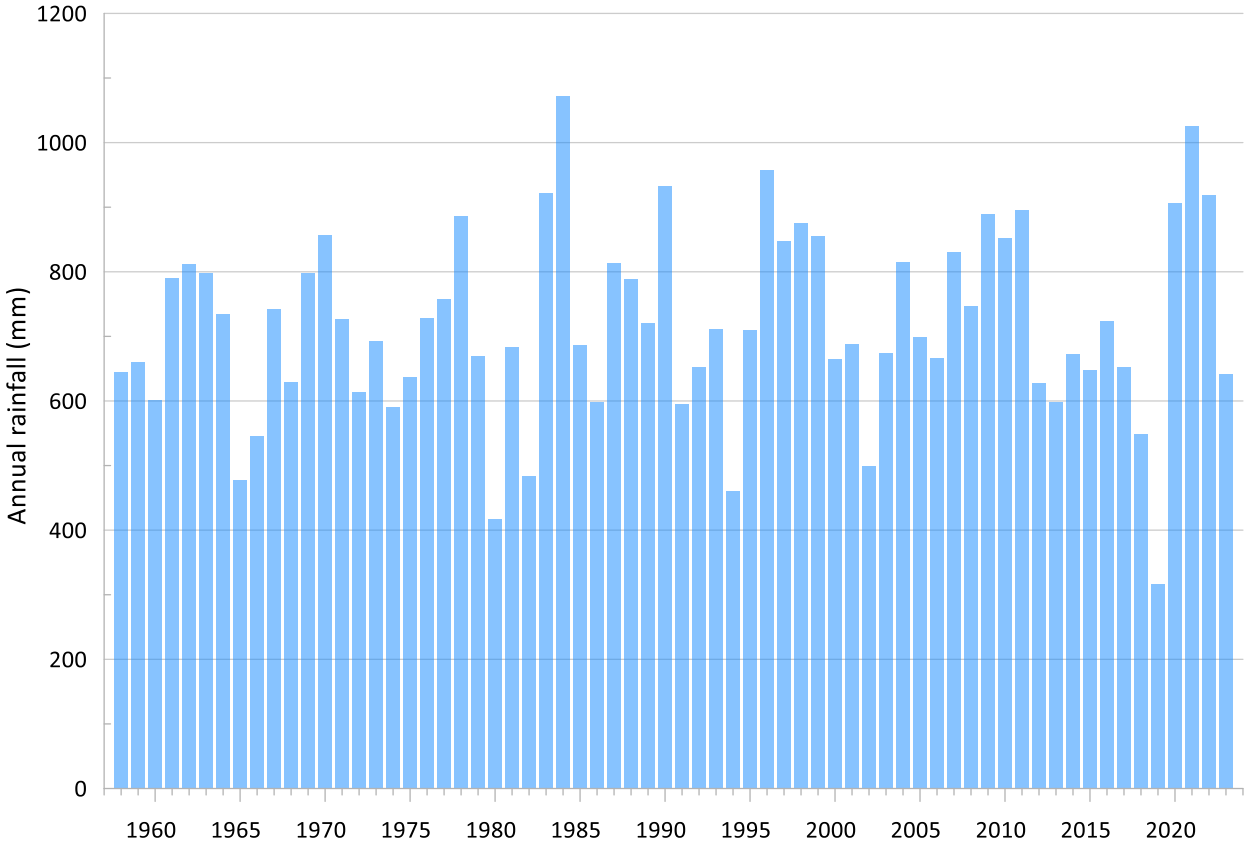



*Figure 3.2 Annual rainfall at Walcha (Emu Creek, station number 56010)*

Rainfall is variable throughout the year, with the highest rainfall occurring between November and February, as shown in Figure 3.3.

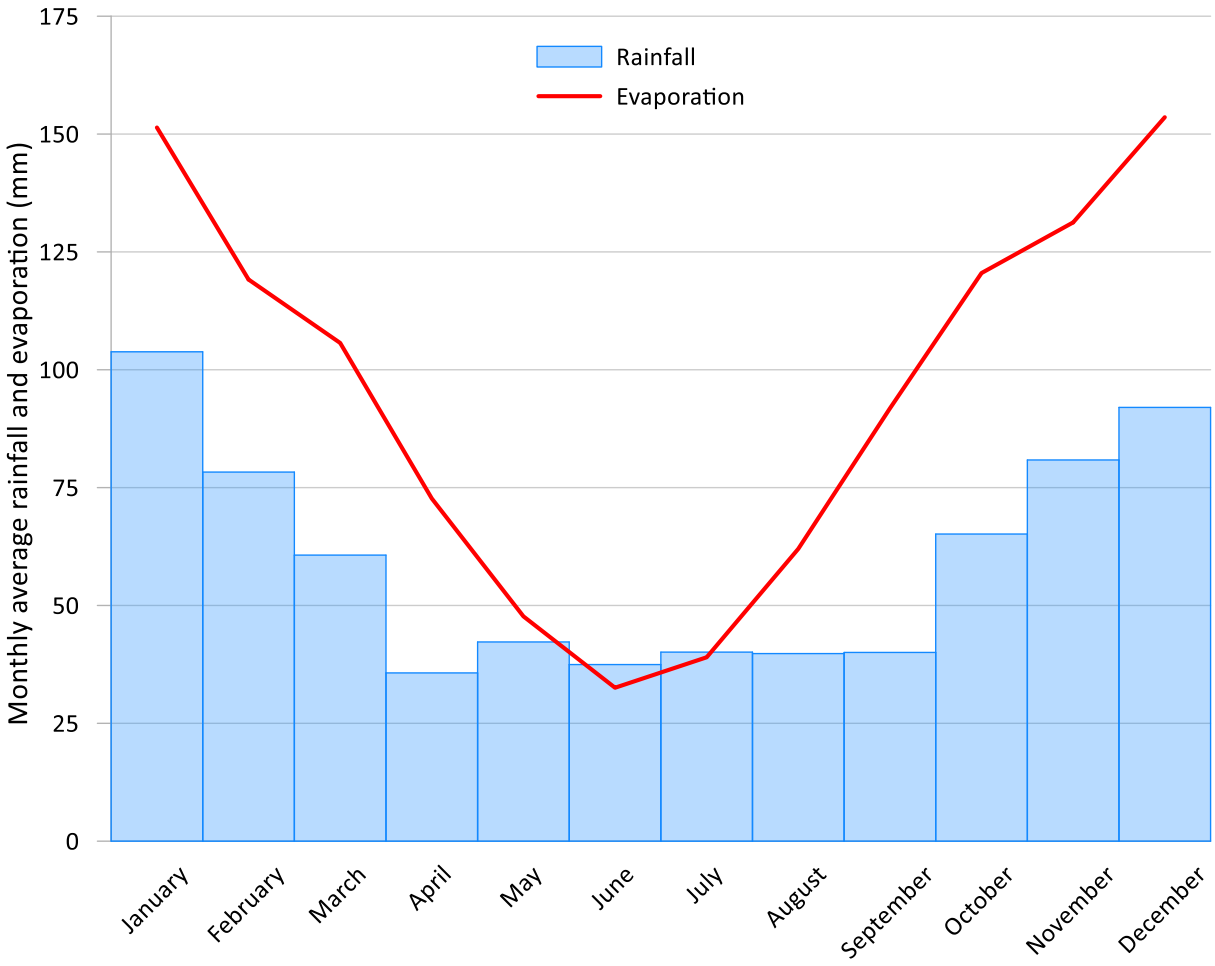



*Figure 3.3 Monthly average rainfall and evaporation at Walcha (Emu Creek, station number 56010)*

The SILO dataset was used to generate a Cumulative Rainfall Departure (CRD) curve (accumulative monthly residual rainfall). CRD is the monthly accumulation of the difference between the observed monthly rainfall and the long-term average monthly rainfall. Any increase in the CRD reflects above average rainfall while a decrease in CRD reflects below average rainfall. The CRD curve only deviates from zero due to atypical (above and below average) rainfall. The CRD over the period 1958 to March 2024 is shown in Figure 3.4. Between December 2019 and March 2023, the CRD shows an overall increasing trend, indicating above average rainfall conditions. From March 2023, the CRD shows an overall declining trend, reflecting mostly below average rainfall conditions. Monthly rainfall was above average however in November 2023 and February 2024.

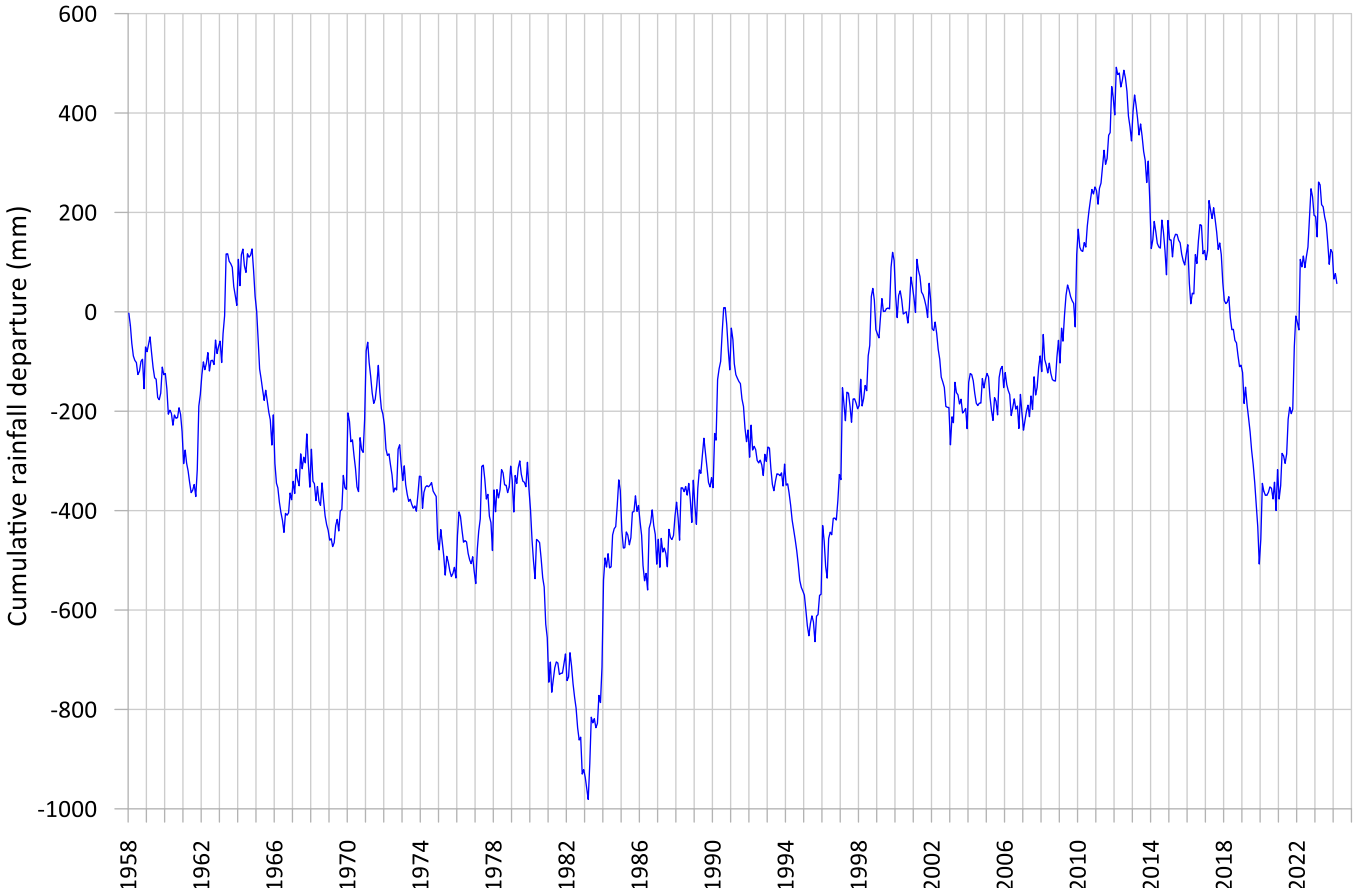



*Figure 3.4 Cumulative Rainfall Departure curve for Walcha (Emu Creek, station number 56010)*

### 3.3.2 Evaporation

Average annual evaporation is 1,129 mm. Average monthly evaporation varies between 33 mm in June to 154 mm in December. Evaporation exceeds rainfall for all months of the year except for June and July, as shown in Figure 3.3.

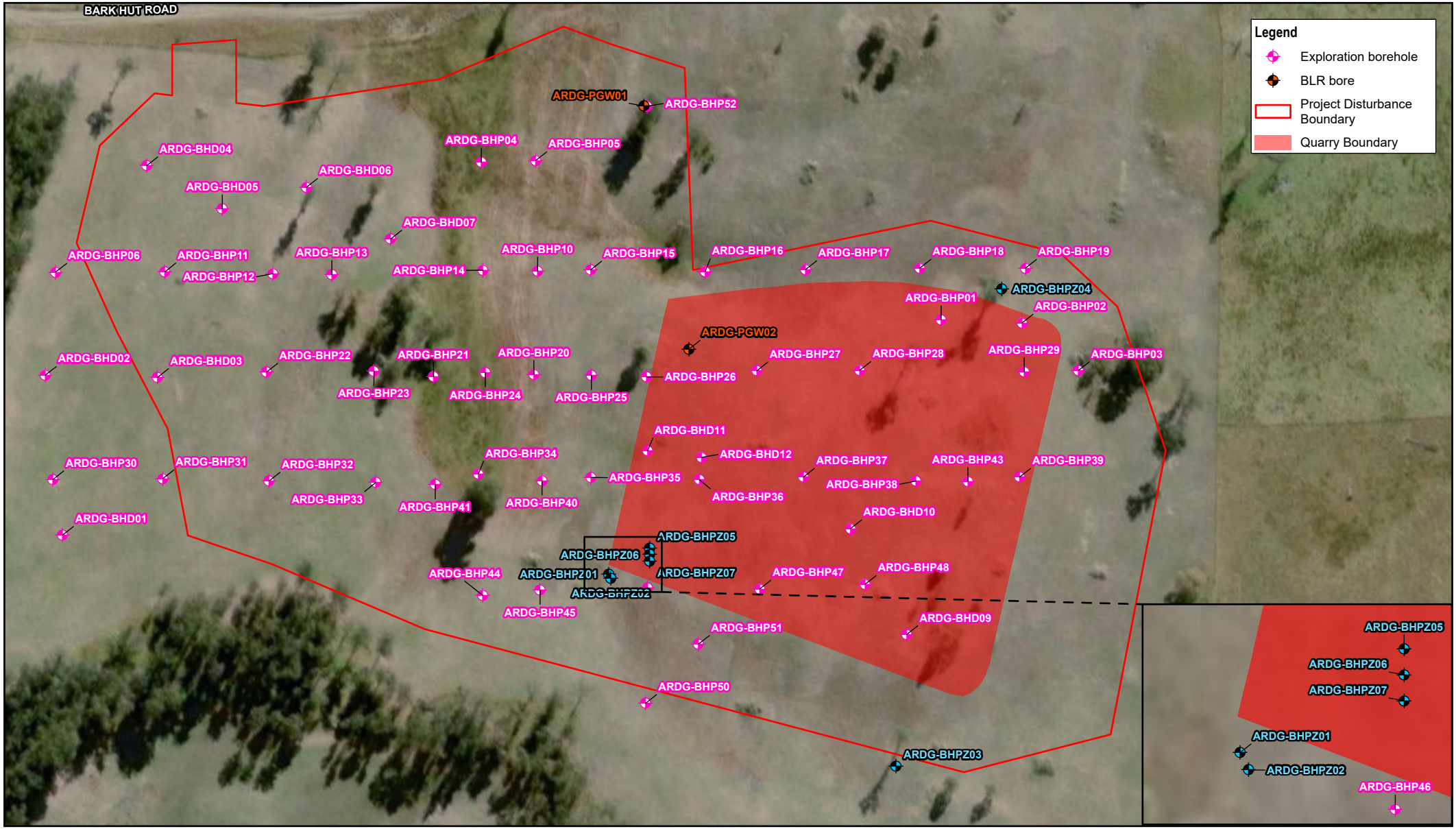
## 3.4 Geology

The project is within the New England Orogen Tectonic Province. NSW Surface Geology mapping (Minview) indicates that the project is underlain by lithic wacke, slate, minor chert, jasper and rare meta basalt of the Lochaber Greywacke unit.

ARDG investigated the subsurface and groundwater conditions as part of an extensive exploration program carried out in 2023 and early 2024. The exploration program involved drilling 58 bore holes across the project (11 diamond and 47 percussion). Two Basic Landholder Rights (BLR) bores and four monitoring bores were also installed as part of the exploration program. An additional three monitoring bores were later installed as part of the groundwater monitoring program. Monitoring and BLR bores are further discussed in Section 4.1. Drilled boreholes within the project area are shown in Figure 3.5.

The wider project area can be divided into a mega-argillite domain and meta-greywacke domain. The proposed quarry pit is located within the meta-greywacke domain. The wider project area is characterised by deeply weathered gullies and areas of outcropping fractured rock.

The weathering profile is on average 16 m deep, however, weathering extends to different depths depending on location. Deep and shallow weathering profiles are observed running at an approximate north-south strike. For example, in the western area of the pit, ARDG-BHD12 was logged as moderately weathered to 7.2 m depth, ARDG-BHD11 was logged as moderately weathered to 11 m depth and ARDG-BHP36 was logged as highly weathered to 6.5 m depth. In the eastern area of the pit, the weathering profile is deeper. For example, ARDG-BHD10 was logged as moderately weathered to 14.9 m depth, ARDG-BHP19 was logged as extremely weathered to 15.0 m depth and ARDG-BHP02 was logged as moderately to highly weathered between 13 and 16 m depth. Lithology at ARDG-BHP19 was logged as clay/saprolite to 15 m depth.

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Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA2020
Grid: GDA2020 MGA Zone 56

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## Drilling investigations

# FIGURE 3-5

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Data source: LPI: DTDB / DCDB, 2024; World Imagery: Source: Esri, Maxar, Earthstar Geographics, and the GIS User Community. Created by: schen4

# 3.5 Hydrogeology

The project is located within the New England Fold Belt Coast Groundwater Source which is a fractured aquifer system with groundwater contained within and moving through fractures in the rock that have occurred due to folding and faulting of the rock formations (NSW DPI 2016a).

Yields within the groundwater source are generally low, around 1 L/s, however, yields up to 10 L/s may be obtained from highly fractured fault systems (NSW DPI 2016a). Groundwater is typically recharged by direct rainfall infiltration which, combined with mineral leaching, has resulted in good quality water over time (NSW DPI 2016a).

At the project, groundwater observations during drilling, monitoring and pump testing indicate a confined fractured rock aquifer which is overlain by a clay/saprolite aquitard which allows for some vertical leakage. Groundwater monitoring, pump testing, and groundwater observations during drilling are further discussed in Section 4.

The hydrostratigraphy of the project area consists of:

– Clay/saprolite aquitard (and weathered profile), average thickness 16 m, overlying
– Confined fractured rock aquifer, up to 50 m thick, from 13 m to 17 m below ground level

# 3.6 Environmental values of groundwater

## 3.6.1 Groundwater dependent ecosystems

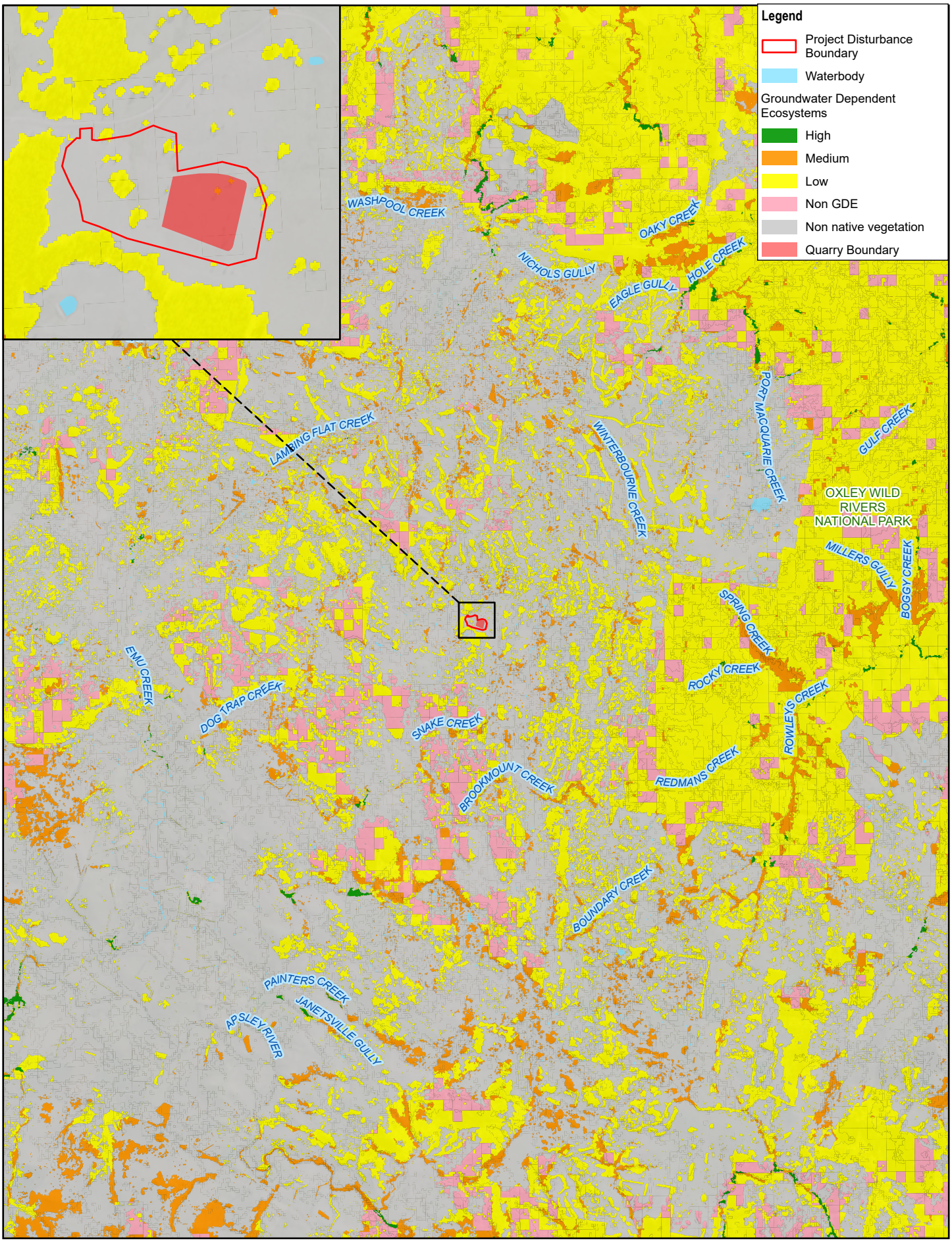
The *Probable Vegetation Groundwater Dependent Ecosystems – Northern Rivers and Namoi* datasets (DPE Water 2022) was reviewed to identify highly probable GDEs in the vicinity of the project site. The dataset developed by DPE Water identifies vegetation communities that have a low, medium and high probability of being a GDE within NSW. The dataset has been divided into catchment management areas. For this project, both the Northern and Namoi River's datasets was used.

The dataset indicates there are areas of low to high probability GDEs within 10 km of the project, as shown in Figure 3.6. Only low probability GDEs were identified with the project disturbance boundary.

High probability GDEs are associated with:

– Dog Trap Creek (approximately 7 km to the south west)
– Snake Creek (approximately 4.5 km to the south west) and
  Oxley Wild Rivers Nature Reserve (approximately 6 km to the east)

The background document for the WSP for the North Coast Fractured and Porous Rock Groundwater Sources 2016 (DPI 2016a) refers to the High Priority Groundwater Dependent Ecosystem Map (DPI 2016b) which was reviewed to identify any high priority GDEs within the New England Fold Belt Coast Groundwater Source. The nearest high priority GDEs are located near the Macleay River to the east, approximately 70 km from the project and associated production bore. The GDEs are classified as karst springs.




Paper Size ISO A4

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Kilometres

Map Projection: Transverse Mercator
Horizontal Datum: GDA2020
Grid: GDA2020 MGA Zone 56

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## Groundwater dependent ecosystems within 10 km of the project

Project No. **12627449**
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# FIGURE 3-6

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Data source: BOM: GDEs, 2024; LPI: DTDB / DCDB, 2024; World Imagery: Earthstar Geographics
World Imagery: Maxar. Created by: schen4

## 3.6.2 Landholder bores

A search of the Australian Groundwater Explorer (BOM 2024) and Water NSW (2024) was undertaken to identify registered bores in the vicinity of the project. The search identified 11 bores within an approximate eight-kilometre radius. Nine bores were reported to be water supply bores (stock and domestic) and are likely to be BLR bores. The purpose of two bores was unknown.

Reported yields range from 0.2 L/s to 3.8 L/s. Standing water levels (SWL) recorded at the time of drilling vary between 1.0 and 15.0 m depth. The nearest BLR bore (GW307759) is located approximately 2.5 km from the project.

Registered bore details are summarised in Table 3.1.

***Table 3.1 Registered private landholder bores within approximately eight kilometres of the project***

| Bore ID | Depth (m) | Purpose | Drilled date | Screened intervals (m depth) | Screened lithology | Yield (L/s) | SWL[1] (m) |
|---|---|---|---|---|---|---|---|
| GW018784 | 23.5 | Unknown | 1/08/1960 | Unknown | Unknown | Unknown | Unknown |
| GW023388 | 30.5 | Stock and Domestic | 1/12/1965 | 12.2 - 24.4 | Shale | 0.38 | 6.1 |
| GW303480 | 53.4 | Stock and Domestic | 14/12/2002 | 24.4 - 28.7, 47.3 - 51.8 | Basalt | 1.3 | 6.1 |
| GW303788 | 80.5 | Stock and Domestic | 15/12/2002 | 48.8 - 53.4, 73.2 - 76.8 | Basalt | 1.3 | 10.7 |
| GW307466 | 103.7 | Stock and Domestic | 1/02/2014 | 12.2 - 36.6, 1.5 - 97.6 | Basalt | 1.3 | 6.1 |
| GW307759 | 70.1 | Stock and Domestic | 21/05/2014 | 24.4 - 27.4, 62.5 - 70.1 | Basalt | 3.8 | 6.4 |
| GW307923 | 51.8 | Unknown | 12/05/2016 | Unknown | Unknown | Unknown | Unknown |
| GW308010 | 36.5 | Stock and Domestic | 1/11/2016 | 25.0 - 30.0 | Shale | 0.2 | 15.0 |
| GW901292 | 11.0 | Stock and Domestic | 14/11/1995 | 5.0 - 7.0 | Basalt | 1.3 | 5.0 |
| GW901293 | 16.0 | Stock and Domestic | 13/11/1994 | 11.0 - 13.0 | Basalt | 1.5 | 1.0 |
| GW901294 | 27.0 | Stock and Domestic | 12/11/1994 | 22.0 - 25.0 | Basalt | 1.6 | 1.4 |

1 Standing water level recorded at the time of drilling.

Registered bore locations are shown in Figure 3.7 and are summarised in Table 3.2, including the approximate distance from the bore to the centre of the project area.

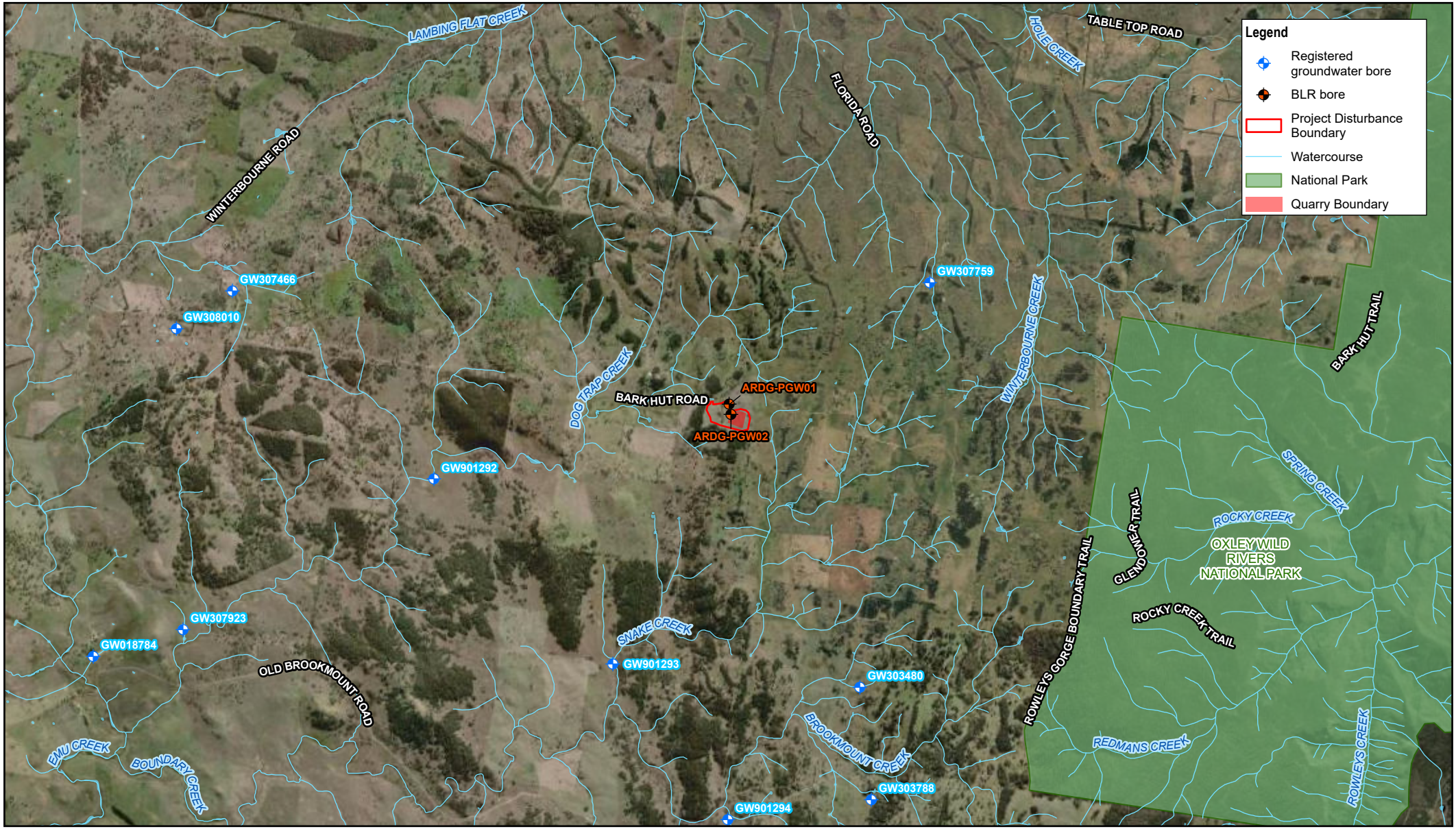
***Table 3.2 Registered bore locations and distance from the project***

| Bore ID | Easting (MGA Zone 56) | Northing (MGA Zone 56) | Distance from the project (m)[1] |
|---|---|---|---|
| GW018784 | 376610 | 6576108 | 7,967 |
| GW023388 | 390646 | 6581649 | 7,124 |
| GW303480 | 385486 | 6575749 | 3,486 |
| GW303788 | 385617 | 6574449 | 4,750 |
| GW307466 | 378220 | 6580335 | 6,011 |
| GW307759 | 386295 | 6580435 | 2,697 |
| GW307923 | 377649 | 6576421 | 6,885 |
| GW308010 | 377572 | 6579903 | 6,563 |

| Bore ID | Easting (MGA Zone 56) | Northing (MGA Zone 56) | Distance from the project (m)[1] |
|---|---|---|---|
| GW901292 | 380554 | 6578160 | 3,590 |
| GW901293 | 382625 | 6576018 | 3,250 |
| GW901294 | 383956 | 6574220 | 4,721 |

1 Approximate distance from the centre of the project area

A total dissolved solids (TDS) concentration of 500 mg/L was reported at GW303480 and a TDS of 335 mg/L was reported at GW303788, both at the time of drilling.

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Kilometres

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Map Projection: Transverse Mercator
Horizontal Datum: GDA2020
Grid: GDA2020 MGA Zone 56

GHD

**Australian Resource Development Group Pty Ltd**
**Winterbourne Windfarm Quarry**
**Groundwater Impact Assessment**

Project No. **12627449**
Revision No. **C**
Date **19/08/2024**

## Registered groundwater bores

# FIGURE 3-7

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Data source: BOM: Registered Bores, 2024; LPI: DTDB / DCDB, 2024; World Imagery: Earthstar Geographics. Created by: schen4

## 3.6.3 Macleay River Water Quality Objectives

The Macleay River Water Quality Objectives (WQO) resource (DPE 2006) identifies the environmental values that apply to groundwater use in the Macleay River Catchment. The environmental values identified for groundwater in 'uncontrolled streams' areas, such as Dog Trap Creek, are:

– Livestock water supply
– Irrigation water supply
– Homestead water supply
– Aquatic ecosystem health

The following subsections describe the relevance of the identified environmental values for groundwater.

### 3.6.3.1 Livestock and irrigation water supply

The WM Act recognises that landholders in NSW are entitled to take water from an aquifer which is underlying their land for domestic consumption and stock watering, without the need for a WAL or a water use approval (basic landholder right). Landholders in the vicinity of the project have this basic landholder right, which could reasonably include domestic scale irrigation of gardens and stock watering. Therefore, livestock and irrigation WQOs are relevant to this assessment.

### 3.6.3.2 Homestead water supply

This objective applies to all homesteads that draw water from groundwater for domestic needs, including drinking water. It is unknown whether groundwater in the vicinity of the project is used as a drinking water supply, however landholders is the vicinity of the project have basic landholder rights, which could reasonably include drinking water for human consumption. Therefore, health-based drinking water guidelines (Australian Drinking Water Guidelines (DWGs); NHMRC, NRMMC 2011) have been considered in identification of WQOs that could be potentially influenced by the project or associated production bore. However, DPE (2006) identifies that these DWGs are designed to be applied at the "point of use" and, therefore, the assessment of groundwater at the project's groundwater monitoring locations is not an appropriate measure for assessing human health risk for individual households.

### 3.6.3.3 Aquatic ecosystem health

The objective applies to all natural waterways and groundwater.

## 3.6.4 Water quality objectives

The WQOs that are relevant to each of the environmental values, as outlined in Section 3.6.3 are presented in Table 3.3. This includes WQOs applicable to:

– Aquatic ecosystem health – Toxicant default guideline values (DGVs) for freshwater in slightly to moderately disturbed systems (95% species protection) from ANZG (2018), and physical and chemical stressors for upland rivers from ANZECC (2000).
– Livestock water supply – Livestock drinking water quality guidelines from ANZECC (2000) Section 4.3.
– Irrigation water supply – Long-term and short-term irrigation trigger values from ANZECC (2000) (Table 4.2.10).
– Homestead water supply (drinking water) – Australian drinking water guidelines from NHMRC (2011) for health considerations.

The ANZG (2018) 95% species protection values are suitable for the groundwater environment due to rural land use (grazing) in the catchment (i.e. the catchment is consistent with a slightly to moderately disturbed system).

*Table 3.3 WQOs for groundwater*

| Analyte^ | ANZG (2018) DGVs | ANZECC (2000) | | | | Australia DWGs (NHMRC 2011) |
|---|---|---|---|---|---|---|
| | 95% species protection | Physical and chemical stressors | Livestock drinking water quality | Irrigation long-term trigger | Irrigation short-term trigger | Health |
| EC (µS/cm) | NA | 350 | 1600 | NA | NA | 1500 [3] |
| pH (pH unit) | NA | 6.5-8.0 | 6.5-8.5 | 6.0-9.0 | 6.0-9.0 | NA |
| DO (% saturation) | NA | 90-110 | NA | NA | NA | NA |
| Total dissolved solids | NA | NA | 2000 | NA | NA | NA |
| Turbidity (NTU) | NA | 25 | NA | NA | NA | NA |
| Aluminium | 0.055 | NA | 5 | 5 | 20 | NA |
| Antimony | NA | NA | NA | NA | NA | 0.003 |
| Arsenic | 0.013 | NA | 0.5 | 0.1 | 2 | 0.01 |
| Beryllium | NA | NA | NA | 0.1 | 0.5 | 0.06 |
| Boron | 0.94 | NA | 5 | 0.5 | NA | 4 |
| Cadmium | 0.0002 | NA | 0.01 | 0.01 | 0.05 | 0.002 |
| Chromium | 0.001 [2] | NA | 1 | 0.1 | 1 | 0.05 [2] |
| Cobalt | NA | NA | 1 | 0.05 | 0.1 | NA |
| Copper | 0.0014 | NA | 0.4 | 0.2 | 5 | 2 |
| Iron | NA | NA | NA | 0.2 | 10 | NA |
| Lead | 0.0034 | NA | 0.1 | 2 | 5 | 0.01 |
| Manganese | 1.9 | NA | NA | 0.2 | 10 | 0.5 |
| Mercury [1] | 0.00006 | NA | 0.002 | 0.002 | | 0.001 |
| Molybdenum | NA | NA | 0.15 | 0.01 | 0.05 | 0.05 |
| Nickel | 0.011 | NA | 1 | 0.2 | 2 | 0.02 |
| Selenium [1] | 0.005 | NA | 0.02 | 0.02 | 0.05 | 0.01 |
| Silver | 0.00005 | NA | NA | NA | NA | 0.1 |
| Strontium | NA | NA | NA | NA | NA | NA |
| Uranium | NA | NA | 0.2 | 0.01 | 0.1 | 0.02 |
| Zinc | 0.008 | NA | 20 | 2 | 5 | NA |
| Ammonia | 0.9 | NA | NA | NA | NA | NA |
| Nitrate | NA | NA | 400 | NA | NA | 50 |
| Nitrite | NA | NA | 30 | NA | NA | 3 |
| Total nitrogen | NA | 0.25 | NA | NA | NA | NA |
| Total phosphorus | NA | 0.02 | NA | NA | NA | NA |
| Reactive phosphorus | NA | 0.015 | NA | NA | NA | NA |
| Chloride | NA | NA | 1200 | NA | NA | NA |
| Fluoride | NA | NA | 2 | 1 | 2 | 1.5 |
| Sodium | NA | NA | NA | NA | NA | NA |
| Sulfate | NA | NA | 1000 | NA | NA | NA |

| Analyte^ | ANZG (2018) DGVs | ANZECC (2000) | | | | Australia DWGs (NHMRC 2011) |
|---|---|---|---|---|---|---|
| Water hardness | NA | NA | NA | NA | NA | NA |

^ All values in mg/L (unless otherwise specified)
1 99% species protection value for mercury and selenium is used for slightly to moderately disturbed systems (95% species protection) due to the bioaccumulating nature of these toxicants
2 As CrVI
3 From WQOs (DPE 2006)
NA No guideline value for this parameter
All metals are in the dissolved form

# 4. Groundwater management and monitoring

## 4.1 Groundwater monitoring network

Four groundwater monitoring bores and two BLR bores were installed at the project site in November 2023 as part of the exploration program. Three additional groundwater monitoring bores were installed in April 2024 to provide further detail on aquifer conceptualisation.

ARDG-BHPZ01 to ARDG-BHPZ04 were cased with 50 mm diameter threaded PVC, in 100 mm diameter drill holes. These bores were constructed with a 1.5 m sump, 3 m screen and blank casing to surface. The gravel pack extended from the base of the hole to 1.5 m depth. A bentonite seal was installed from 1.5 m depth to surface.

ARDG-BHPZ05 to ARDG-BHPZ07 were cased with 100 mm diameter threaded PVC, in 200 mm diameter drill holes. These bores were constructed with 3 m screen and blank casing to surface. ARDG-BHPZ05 was constructed with a 1 m sump. ARDG-BHPZ06 and ARDG-BHPZ07 were constructed without a sump. The gravel pack extended 0.5 m to 1 m above the top of the screen, followed by a 0.5 m to 1 m bentonite seal. Bores were cement-bentonite grouted to surface.

Production bores were cased with 150 mm diameter threaded PVC, in 200 mm diameter drill holes. Bores were screened from 1.5 m depth to the base of the hole. The gravel pack extended from the base of the hole to 1.5 m depth. A bentonite seal was installed from 1.5 m depth to surface.

Bore construction details are summarised in Table 4.1. Bore locations are summarised in Table 4.2 and are shown in Figure 4.1.

*Table 4.1 Groundwater bore construction details*

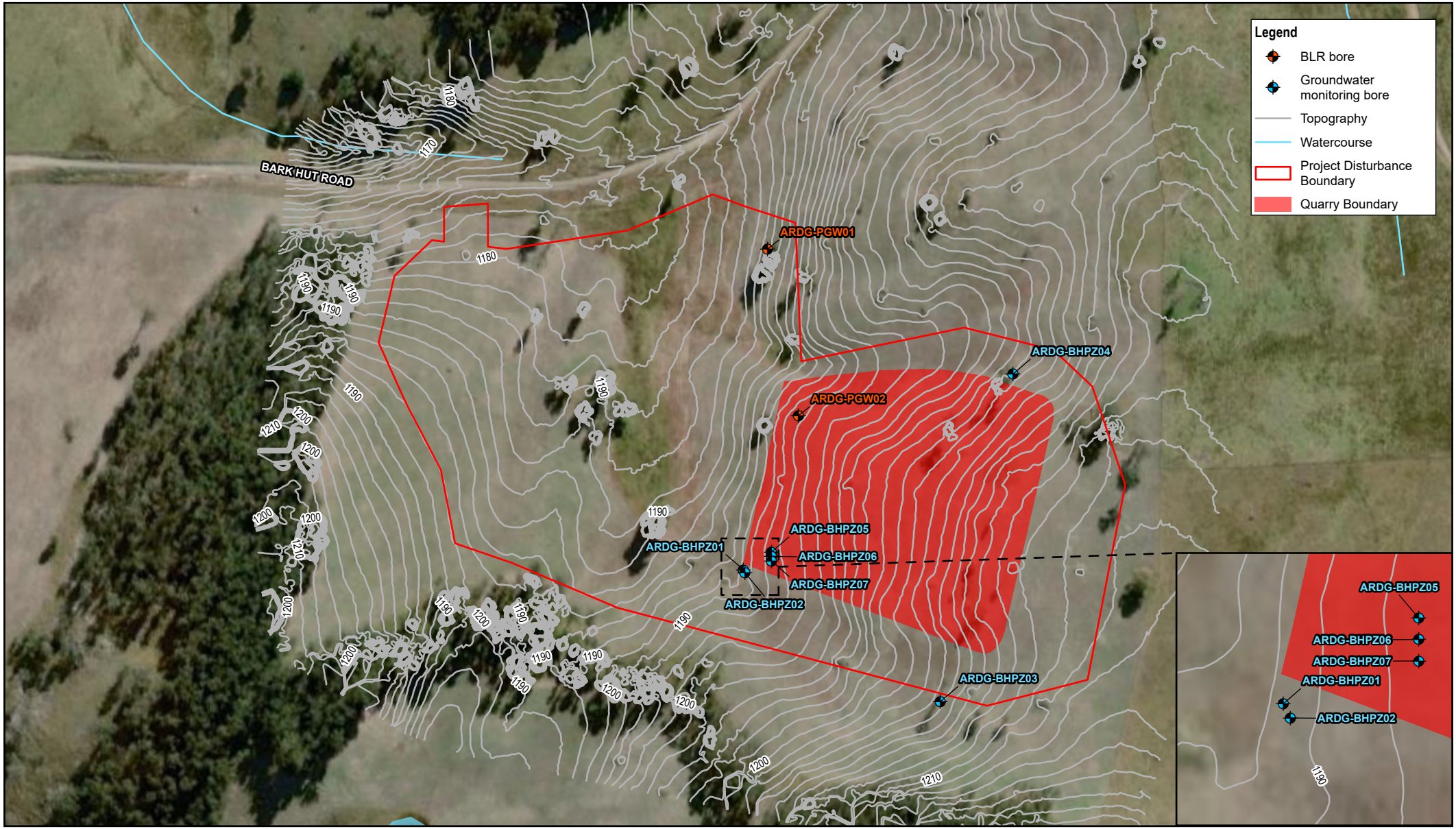
| Location ID | Type | Bore depth (m bgl[1]) | Screen depth (m bgl) | Ground elevation (m AHD[2]) | TOC[3] elevation (m AHD) | Screened hydrostratigraphic layer |
|---|---|---|---|---|---|---|
| ARDG-BHPZ01 | Monitoring | 7.0 | 2.5 – 5.5 | 1,189.4 | 1189.5 | Aquitard |
| ARDG-BHPZ02 | Monitoring | 13.2 | 8.8 – 11.8 | 1,189.6 | 1189.8 | Aquifer |
| ARDG-BHPZ03 | Monitoring | 17.3 | 12.8 – 15.8 | 1,203.9 | 1204.1 | Aquitard |
| ARDG-BHPZ04 | Monitoring | 17.3 | 12.8 – 15.8 | 1,200.1 | 1200.5 | Aquitard |
| ARDG-BHPZ05 | Monitoring | 20.6 | 16.6 –19.6 | 1,191.7 | 1192.1 | Aquifer |
| ARDG-BHPZ06 | Monitoring | 4.5 | 1.5 – 4.5 | 1,191.7 | 1192.5 | Aquitard |
| ARDG-BHPZ07 | Monitoring | 12.9 | 9.9 – 12.9 | 1,191.7 | 1192.1 | Aquifer |
| ARDG-PGW01 | Production | 67.0 | 1.5 – 66.0 | 1,184.2 | 1184.4 | Aquitard/aquifer |
| ARDG-PGW02 | Production | 20.0 | 1.5 – 17.0 | 1,191.5 | 1191.7 | Aquitard/aquifer |

Notes:
1) m bgl – m below ground level
2) m AHD – m Australian Height Datum
3) TOC – top of casing

*Table 4.2 Bore locations*

| Location ID | Easting MGA2020 Zone 56 | Northing MGA2020 Zone 56 | Ground elevation (m AHD) |
|---|---|---|---|
| ARDG-BHPZ01 | 383,956 | 6,578,807 | 1,189.4 |
| ARDG-BHPZ02 | 383,957 | 6,578,805 | 1,189.6 |
| ARDG-BHPZ03 | 384,089 | 6,578,718 | 1,203.9 |
| ARDG-BHPZ04 | 384,138 | 6,578,939 | 1,200.1 |
| ARDG-BHPZ05 | 383,975 | 6,578,819 | 1,191.7 |

| Location ID | Easting<br>MGA2020 Zone 56 | Northing<br>MGA2020 Zone 56 | Ground elevation<br>(m AHD) |
|---|---|---|---|
| ARDG-BHPZ06 | 383,975 | 6,578,816 | 1,191.7 |
| ARDG-BHPZ07 | 383,975 | 6,578,813 | 1,191.7 |
| ARDG-PGW01 | 383,969 | 6,579,022 | 1,184.2 |
| ARDG-PGW02 | 383,991 | 6,578,912 | 1,191.5 |

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Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA2020
Grid: GDA2020 MGA Zone 56

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**Australian Resource Development Group Pty Ltd**
**Winterbourne Windfarm Quarry**
**Groundwater Impact Assessment**

Project No. **12627449**
Revision No. **C**
Date **19/08/2024**

## Groundwater monitoring bore locations

# FIGURE 4-1

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Data source: LPI: DTDB / DCDB, 2024; World Imagery: Source: Esri, Maxar, Earthstar Geographics, and the GIS User Community
World Imagery: Maxar. Created by: schen4

## 4.2 Monitoring results

### 4.2.1 Groundwater levels

Groundwater levels at the project site have been monitored by ARDG since 23 January 2024. Groundwater levels are monitored by dataloggers at one-hour intervals.

Groundwater level hydrographs are shown in Figure 4.2 for data collected between 23 January 2024 and 24 April 2024. Individual groundwater level hydrographs are shown in Appendix A.

Since monitoring began, groundwater levels have remained relatively stable. Diurnal fluctuations (up to 0.06 m) are observed in all monitoring bores, which are consistent with phases of the moon.

There was a very limited observed response to rainfall recharge in ARDG-BHPZ03 and ARDG-BHPZ04. The decreasing trend in groundwater levels at ARDG-BHPZ03 and ARDG-BHPZ04 reflects the generally declining CRD curve (refer Section 3.3).

A groundwater level increase of less than 0.1 m was observed in ARDG-PGW02, ARDG-BHPZ01 and ARDG-BHPZ02 following rainfall events exceeding 25 mm. It is likely that this response is a result of leakage through the gravel pack (gravel pack extending almost to the surface), rather than it being the result direct recharge to the confined fractured rock aquifer because the response is almost immediate. Nested monitoring bores ARDG-BHPZ01 and ARDG-BHPZ02 suggest downward flow, however it is likely that these two monitoring bores were hydraulically connected during drilling due to the gravel pack being installed to a depth of 1.5 m below the surface.

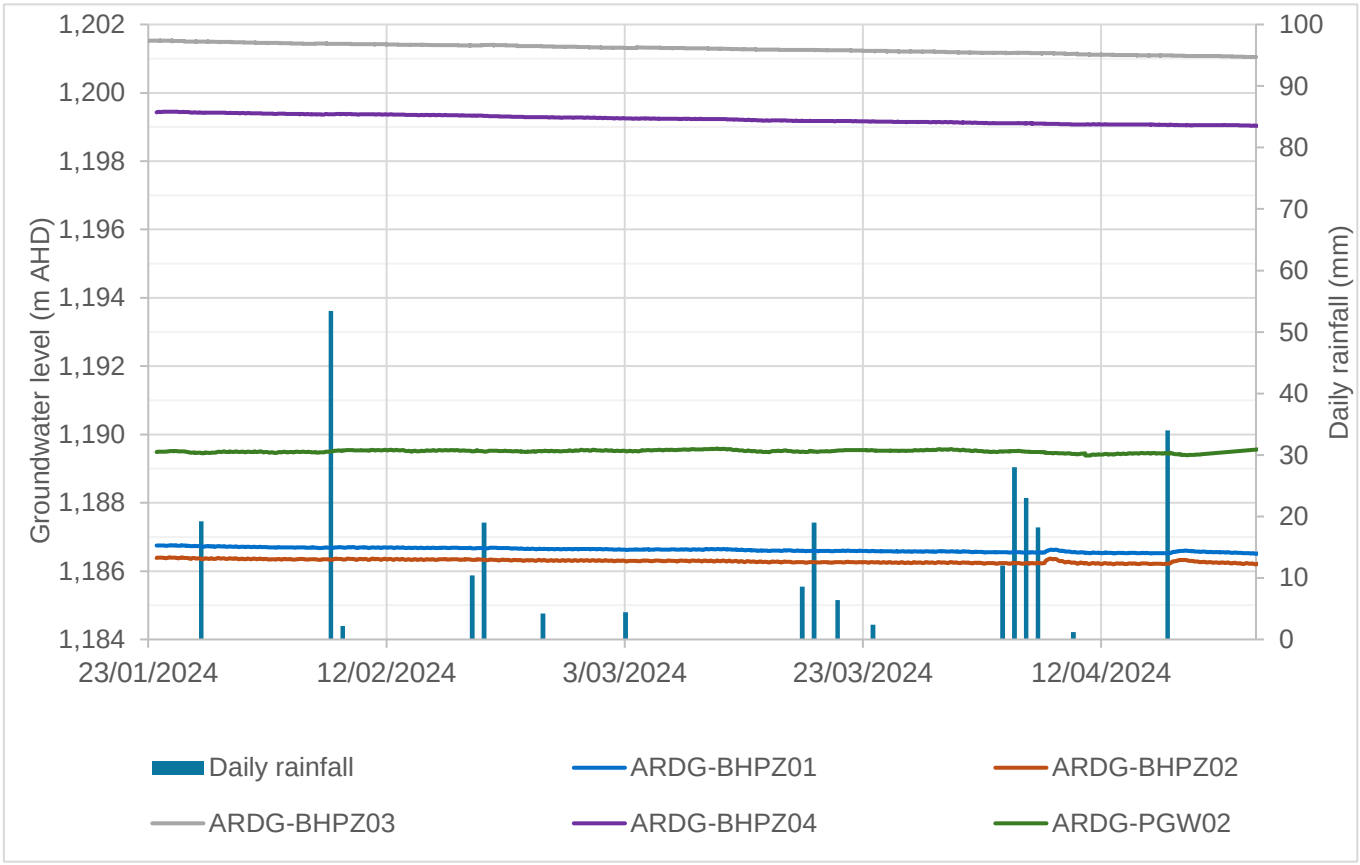



***Figure 4.2 Groundwater level hydrographs and daily rainfall***

Average groundwater level and ground surface elevations are summarised in Table 4.3. Average groundwater levels in the fractured rock aquifer range from 1,186.3 m AHD at ARDG-BHPZ02 to 1,189.5 m AHD at ARDG-PGW02.

The standing water level within the aquitard reflects soil saturation and infiltrating rainfall recharge. The water level within the aquitard does not represent a shallow groundwater system.

*Table 4.3 Monitoring bore and groundwater level elevation*

| Bore ID | Screened hydrostratigraphic layer | Ground surface elevation (m AHD) | Average groundwater level (m AHD) |
|---|---|---|---|
| ARDG-BHPZ01 | Aquifer | 1,189.38 | 1,186.62 |
| ARDG-BHPZ02 | Aquitard | 1,189.61 | 1,186.29 |
| ARDG-BHPZ03 | Aquitard | 1,203.87 | 1,201.29 |
| ARDG-BHPZ04 | Aquitard | 1,200.14 | 1,199.23 |
| ARDG-PGW02 | Aquifer | 1,191.45 | 1,189.51 |

The groundwater level monitoring data shown in Figure 4.2 and summarised in Table 4.3 were collected prior to pump testing investigations and groundwater sampling. This data is considered to be representative of baseline groundwater level data for the site. Monthly rainfall was above average in November 2023, February 2024 (refer Section 3.3.1) and April 2024. It is therefore likely that the dataset represents groundwater levels during average to above average rainfall conditions. During drier periods, groundwater levels at the project may be lower.

Between 25 April and June 2024, the groundwater level data is impacted by drawdown due to pumping tests and groundwater quality sampling. The elevation of some of the data loggers were also changed during this period. Data from this period have not been considered as part of the baseline dataset.

All groundwater level monitoring data collected to date are shown as individual groundwater level hydrographs in Appendix A. Pump testing and the interpretation of this data are discussed in Section 4.3.

Groundwater monitoring bores ARDG-BHPZ05, ARDG-BHPZ06 and ARDG-BHPZ07 were installed to further conceptualise the aquifer. These bores were installed in the same location, at different depths. The change in groundwater levels observed in these monitoring bores after drilling on the 23 April 2024 are summarised in Table 4.5 and shown in Figure 4.3.

*Table 4.4 Change in groundwater levels observed in ARDG-BHPZ05, ARDG-BHPZ06 and ARDG-BHPZ07*

| Date and time | Groundwater level (m bgl) | | | Groundwater level (m AHD) | | |
|---|---|---|---|---|---|---|
| | ARDG-BHPZ05 | ARDG-BHPZ06 | ARDG-BHPZ07 | ARDG-BHPZ05 | ARDG-BHPZ06 | ARDG-BHPZ07 |
| 23-Apr-24 9:30 | 3.54 | Dry | Dry | 1188.18 | Dry | Dry |
| 23-Apr-24 12:15 | 3.32 | Not measured | Not measured | 1188.40 | Not measured | Not measured |
| 26-Apr-24 9:05 | 2.73 | Dry | 12.01 | 1188.99 | Dry | 1179.73 |
| 13-May-24 15:50 | 5.05 | 0.77 | 7.09 | 1186.68 | 1190.97 | 1184.65 |
| 23-May-24 10:42 | 5.23 | 1.43 | 5.74 | 1186.49 | 1190.31 | 1186.00 |
| 13-Jun-24 10:15 | 4.74 | 1.01 | 4.32 | 1186.98 | 1190.73 | 1187.42 |

In the deeper monitoring bore ARDG-BHPZ05, the groundwater level immediately increased after drilling, before declining and stabilising. Intermediate depth ARDG-PZ07 was dry immediately after drilling however subsequent measurements showed an increase in groundwater level. From 23 May 2024, the groundwater levels in ARDG-BHPZ05 and ARDG-PZ07 are relatively similar, which suggests that these bores are both within the same hydrostratigraphic layer. Based on groundwater strike recorded during drilling (refer Section 4.2.2), these bores are screened within the fractured rock aquifer. The groundwater level at ARDG-PZ07 on 13 June 2024 is approximately 0.5 m higher than the deeper ARDG-BHPZ05, suggesting a component of downward flow within the fractured rock aquifer.

Shallow bore ARDG-PZ06 was dry during drilling and remained dry a few days later. There was a 19 mm rainfall event on 11 May (Walcha – Emu Creek Station) which was reflected by an increase in the water level in this bore on 13 May, followed by a decline. The water levels in ARDG-PZ06 do not reflect the fractured rock aquifer (represented by ARDG-BHPZ05 and ARDG-BHPZ07). It is likely that water levels in shallow bore ARDG-BHPZ06 reflect soil saturation levels, similarly to ARDG-BHPZ01, ARDG-BHPZ03 and ARDG-BHPZ04.

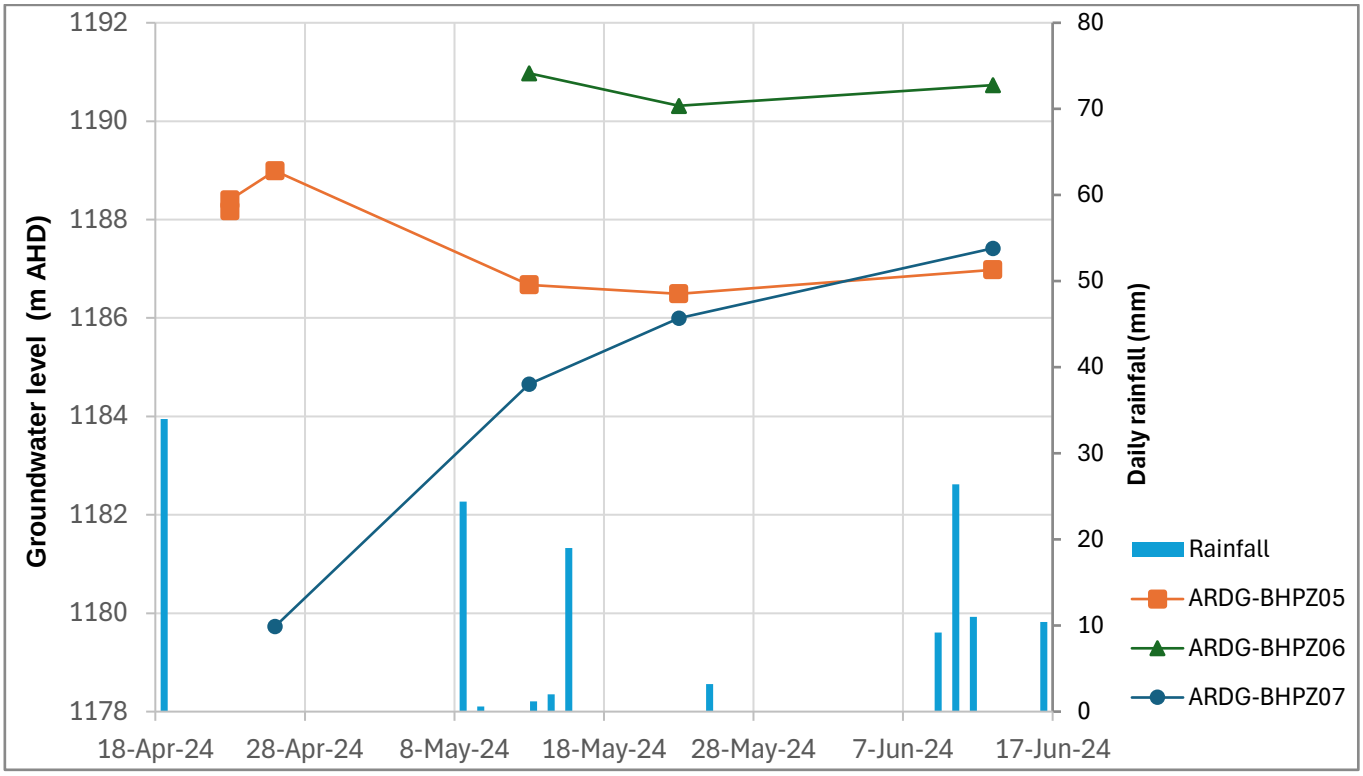



*Figure 4.3 Change in groundwater levels after drilling*

## 4.2.2 Groundwater strike

The depth to groundwater recorded during drilling, and the subsequent rise of the water level within the standpipe, is summarised in Table 4.5. The data obtained from drilling and monitoring suggests that the aquifer is confined. Note ARDG-BHPZ01 and ARDG-BHPZ06 are shallow monitoring bores and were dry when drilled. These bores do not extend into the confined, fractured rock aquifer. ARDG-BHPZ07 is discussed in Section 4.2.1.

ARDG-BHPZ03 and ARDG-BHPZ04 were initially assumed to be part of the fractured rock aquifer, due to groundwater inflow at approximately 16 m depth during drilling. However, the lack of response in these bores during pump testing (refer Section 4.3.2), the increased depth of weathering at the eastern area of the pit (refer Section 3.4), and the significantly higher standing water levels, suggests that is more likely that these bores are screened within the confining aquitard. Therefore, the groundwater strike shown in Table 4.5 for ARDG-BHPZ03 and ARDG-BHPZ04 does not represent depth groundwater within the fractured rock aquifer.

*Table 4.5 Groundwater strike during drilling (depth to groundwater)*

| Bore ID | Depth to groundwater strike (m) | Groundwater strike (m AHD) | Groundwater level (m AHD) |
|---|---|---|---|
| ARDG-BHPZ01 | Dry when drilled | - | - |
| ARDG-BHPZ02 | 12 | 1,177.61 | 1,186.40[2] |
| ARDG-BHPZ03 | 16 | 1,187.87[5] | 1,201.52[2] |
| ARDG-BHPZ04 | 16 | 1,184.14[5] | 1,199.43[2] |
| ARDG-PGW01 | 17[1] | 1,167.19 | 1,182.85[4] |
| ARDG-PGW02 | 13 | 1,178.45 | 1,189.49[2] |
| ARDG-BHPZ05 | 13 | 1,178.72 | 1,186.49[3] |
| ARDG-BHPZ06 | Dry when drilled | - | - |
| ARDG-BHPZ07 | Dry when drilled | - | 1186.00[3] |

Notes:
1 Initial groundwater strike, groundwater inflows were also observed at 42 m depth
2 measured approximately two months after drilling

3 measured approximately one month after drilling
4 measured approximately five months after drilling
5 strike does not represent depth groundwater within the fractured rock aquifer

During drilling, artesian conditions were observed at exploration drill hole ARDG-BHP16, which further supports the conceptualisation of aquifer confinement in the project area.

### 4.2.3 Groundwater quality

Groundwater was sampled by ARDG at bores ARDG-PGW01 and ARDG-PGW02 on 26 June 2024 and analysed for major ions, nutrients, total metals, pH, EC and oil and grease. Results are summarised in

Table 4.6.

The groundwater in both bores is similar and of good quality. pH is circumneutral and ranges from 6.5 to 6.84. pH is within the guideline range for all WQOs. EC is relatively fresh at 523 – 566 µS/cm, however it exceeds the guideline value of 350 µS/cm for aquatic ecosystem health. Total dissolved solids are well below the guideline value for livestock drinking water.

Total metal concentrations of antimony, arsenic, cadmium, chromium, copper, molybdenum, nickel, selenium, silver, boron and mercury are all below detection limits in both bores. Total cyanide concentrations are also below detection limits in both bores. Nitrate, nitrite and oil and grease concentrations are below detection limits.

Barium concentrations vary between 0.032 and 0.035 mg/L. There is no guideline value for barium. A lead concentration of 0.002 mg/L was observed in ARDG-PGW02. This is below the minimum guideline value of 0.0034 mg/L for aquatic ecosystem health. Fluoride concentrations vary between 0.4 and 0.5 mg/L, below the guideline values for all WQOs.

Manganese concentrations vary between 0.213 and 0.248 mg/L, which exceeds the guideline value of 0.2 mg/L for irrigation long-term, however it is noted that reported metal concentrations are total rather than dissolved, and dissolved concentrations of manganese may be lower.

***Table 4.6 Groundwater quality monitoring***

| Analyte | Unit | LOR | ARDG-PGW01 | ARDG-PGW02 |
|---|---|---|---|---|
| pH Value | pH Unit | 0.01 | 6.84 | 6.5 |
| Electrical Conductivity @ 25°C | µS/cm | 1 | 566 | 523 |
| Total Dissolved Solids @180°C | mg/L | 10 | 336 | 359 |
| Total Dissolved Solids (Calc.) | mg/L | 1 | 368 | 340 |
| Sugar | - | - | Not Detected | Not Detected |
| Hydroxide Alkalinity as CaCO3 | mg/L | 1 | <1 | <1 |
| Carbonate Alkalinity as CaCO3 | mg/L | 1 | <1 | <1 |
| Bicarbonate Alkalinity as CaCO3 | mg/L | 1 | 222 | 164 |
| Total Alkalinity as CaCO3 | mg/L | 1 | 222 | 164 |
| Sulfate as SO4 - Turbidimetric | mg/L | 1 | 13 | 16 |
| Chloride | mg/L | 1 | 29 | 44 |
| Calcium | mg/L | 1 | 65 | 47 |
| Magnesium | mg/L | 1 | 9 | 15 |
| Sodium | mg/L | 1 | 35 | 41 |
| Potassium | mg/L | 1 | 2 | 1 |
| Antimony* | mg/L | 0.001 | <0.001 | <0.001 |
| Arsenic* | mg/L | 0.001 | <0.001 | <0.001 |
| Barium* | mg/L | 0.001 | 0.032 | 0.035 |

| Analyte | Unit | LOR | ARDG-PGW01 | ARDG-PGW02 |
|---|---|---|---|---|
| Cadmium* | mg/L | 0.0001 | <0.0001 | <0.0001 |
| Chromium* | mg/L | 0.001 | <0.001 | <0.001 |
| Copper* | mg/L | 0.001 | <0.001 | <0.001 |
| Lead* | mg/L | 0.001 | <0.001 | 0.002 |
| Manganese* | mg/L | 0.001 | 0.213 | 0.248 |
| Molybdenum* | mg/L | 0.001 | <0.001 | <0.001 |
| Nickel* | mg/L | 0.001 | <0.001 | <0.001 |
| Selenium* | mg/L | 0.01 | <0.01 | <0.01 |
| Silver* | mg/L | 0.001 | <0.001 | <0.001 |
| Boron* | mg/L | 0.05 | <0.05 | <0.05 |
| Mercury* | mg/L | 0.0001 | <0.0001 | <0.0001 |
| Total Cyanide* | mg/L | 0.004 | <0.004 | <0.004 |
| Fluoride | mg/L | 0.1 | 0.4 | 0.5 |
| Nitrite as N | mg/L | 0.01 | <0.01 | <0.01 |
| Nitrate as N | mg/L | 0.01 | <0.01 | <0.01 |
| Nitrite + Nitrate as N | mg/L | 0.01 | <0.01 | <0.01 |
| Total Oil and Grease | mg/L | 2 | <2 | <2 |

Notes:
* Total metals
LOR – Limit of Reporting

### 4.2.4 Groundwater flow

Based on the groundwater bores which target the fractured rock aquifer, groundwater flow is controlled by topography.

Snake Creek and its tributaries to the east of the project have an elevation of approximately 1,240 m AHD to 1,260 m AHD and are therefore too high in elevation to be points of discharge for groundwater at the project. Dog Trap Creek and its tributaries to the west of the project have an elevation of approximately 1,160 m AHD to 1,180 m AHD and could potentially to be a point of discharge for the groundwater at the project. Dog Trap Creek and its tributaries however are dry for much of the year (refer Section 3.5), with flow depending on rainfall. It is therefore unlikely that these water courses are reliant on groundwater baseflow. The project is therefore unlikely to have an impact on aquatic GDEs or baseflow.

## 4.3 Pump testing

### 4.3.1 ARDG-PGW02 pump testing

ARDG conducted a short duration pump test on a shallow BLR bore ARDG-PGW02 on 6 December 2023. The bore was initially pumped at 1.72 L/s for 15 minutes, before dropping the water level below the pump intake. The bore was allowed to recharge for approximately 75 minutes before undertaking a reducing rate step test. The bore was pumped at reducing rates between 1.2 L/s and 0.66 L/s for approximately 130 minutes. The bore was allowed to recharge for approximately 915 minutes before undertaking another short duration constant rate pump test. This final test was pumped at a rate of 0.55 L/s for approximately 345 minutes. Water levels were subsequently recorded for a recharge period of approximately 167 minutes.

ARDG-PGW02 is screened between 0.00 m and 19.53 m depth. The pump inlet was set at 15.58 m depth.

Given that the pumping duration was relatively short (longest analysed pumping period was approximately six hours), it is likely that the aquifer was still having a confined response. An aquifer saturated thickness of 20 m was assumed.

Data was analysed using pumping test software Aqtesolv. Pump test results are summarised in Table 4.7 and Table 4.8 for pumping rates 1.72 L/s and 0.55 L/s, respectively. The best matches are highlighted in bold text. Plots are shown in Appendix B1 (confined model only).

No response was observed in the monitoring bores and therefore estimates of storativity could not be obtained from the pump test data.

*Table 4.7 Pump test results, Q = 1.72 L/s*

| Method | Model | T ($m^2$/day) | Comment |
|---|---|---|---|
| Theis/Hantush | Confined | 1.93 | Poor match residuals and early and late pumping time data. |
| **Theis (recovery)** | **Confined** | **1.86** | **Good match early to mid-time recovery data** |
| **Theis/Hantush (recovery data)** | **Confined** | **1.64** | **Good match recovery** |
| Cooper-Jacob | Confined | 2.23 | Reasonable match early to mid-time pumping data; poor match residuals |
| Theis/Hantush | Unconfined | 3.19 | Good match pumping data; reasonable match to residuals, poor match to recovery. |
| Cooper-Jacob | Unconfined | 3.91 | Reasonable match early to mid-time pumping data; poor match residuals |
| Neuman | Unconfined | 1.71 | Good match early to mid-time pumping data; good match to recovery, reasonable match to residuals; aquifer compressibility value does not make sense |

*Table 4.8 Pumping test results, Q = 0.55 L/s*

| Method | Model | T ($m^2$/day) | Comment |
|---|---|---|---|
| Theis/Hantush | Confined | 1.63 | Poor match residuals, reasonable match to mid to late-time pumping data and recovery |
| **Theis (recovery)** | **Confined** | **1.83** | **Good match early to mid-time recovery data** |
| **Theis/Hantush (recovery data)** | **Confined** | **1.71** | **Good match recovery** |
| Theis/Hantush | Unconfined | 2.08 | Good match to mid to late-time pumping data; poor match to residuals, good match to recovery. |
| Neuman | Unconfined | 1.54 | Reasonable match mid-time pumping data; poor match to residuals, good match to recovery. |

Averaged results (best matches only) suggest an aquifer transmissivity of 1.76 $m^2$/day. This equates to a hydraulic conductivity of 0.088 m/day ($1.0x10^{-6}$m/s), assuming at aquifer saturated thickness of 20 m. A hydraulic conductivity of $1.0x10^{-6}$ m/s is within the literature range for fractured igneous rock or metamorphic rock.

### 4.3.2 ARDG-PGW01 pump testing

ARDG conducted a 72-hour pump test on BLR bore ARDG-PGW01 between 25 April and 28 April 2024. Following cessation of pumping, groundwater levels continued to be monitored until 15 May 2024 (recovery period). Pump test details are summarised in Table 4.9.

***Table 4.9 ARDG-PGW01 pump testing***

| Detail | Value |
|---|---|
| Pump make | Lowara 16GS55/B |
| Pump depth | 62 m below ground level |
| Pump start time | 25/04/2024 11:16 AM |
| Pump end time | 28/04/2024 11:40 AM |
| Recharge period end time | 15/05/2024 4:29 PM |
| Initial standing water level | -1.565 m below top of casing |

ARDG-PGW01 is screened between 1.5 m and 66 m depth and was assumed to fully penetrate the fractured rock aquifer. An aquifer saturated thickness of 50 m was assumed. It should be noted that the groundwater level fell below the logger in the production bore during the pump test which resulted in an incomplete drawdown dataset for the ARDG-PGW01.

Monitoring bores ARDG-PZ01, ARDG-PZ02, ARDG-PZ05 and production bore ARDG-GW02 were monitored as observation bores during the pump test and a response was observed in all four bores. Monitoring bores ARDG-PZ03 (330 m away) and ARDG-PZ04 (200 m away) were also monitored during the pump test, however no drawdown was observed in either bore. ARDG-BHPZ04 is at a similar distance from the pumping bore compared with ARDG-BHPZ01.

Data were analysed using pumping test software Aqtesolv. Analysis of drawdown data indicated a confined aquifer response.

Pump test results are summarised in Table 4.10 based on an average pumping rate of 5.11 L/s. Note that the pumping rate is based on flow meter readings taken at the start and end of the pumping test, and therefore the pumping rate represents an average rate only. It is likely that fluctuations in the pumping rate occurred during the test, up to 6 L/s, however this cannot be quantified from the data available.

The range of transmissivity values obtained are likely due to aquifer heterogeneity and also potential leakage through the confining layer (and through the gravel pack between ARDG-BHPZ01 and ARDG-BHPZ02).

Plots are shown in Appendix B2.

***Table 4.10 Pump test results, Q = 5.11 L/s (average)***

| Data analysed ARDG- | Method | Model | T ($m^2$/day) | S (m/m) | Comment |
|---|---|---|---|---|---|
| PGW01 | Theis/Hantush | Confined | 2.74 | - | Reasonable match to late time pumping time data, reasonable match to early time recovery data. |
| PGW01 | Theis (recovery) | Confined | **2.40** | - | Good match to early recovery data. |
| PGW01 | Cooper-Jacob | Confined | 3.04 | - | Reasonable match to mid to late pumping data. |
| PGW01 | Papadopulos-Cooper | Confined | **2.54** | - | Good match to mid-late time pumping data and early time recovery data. |
| BHPZ01 | Cooper-Jacob | Confined | 16.59 | $4.0 \times 10^{-4}$ | Good match to later time pumping data, no recovery observations. |

| Data analysed ARDG- | Method | Model | T ($m^2$/day) | S (m/m) | Comment |
|---|---|---|---|---|---|
| BHPZ01 | Papadopulos-Cooper | Confined | 16.10 | $5.0 \times 10^{-4}$ | Good match to mid-late time pumping data, no recovery observations. |
| BHPZ02 | Cooper-Jacob | Confined | 17.89 | $1.8 \times 10^{-4}$ | Good match to late time pumping data. |
| BHPZ02 | Papadopulos-Cooper | Confined | 15.61 | $2.3 \times 10^{-4}$ | Good match to mid-late time pumping data, poor match to recovery. |
| BHPZ05 | Theis/Hantush | Confined | 4.01 | **$1.3 \times 10^{-3}$** | Good match late time pumping data, poor match to recovery. |
| BHPZ05 | Papadopulos-Cooper | Confined | 4.87 | **$1.3 \times 10^{-3}$** | Good match late time pumping data. Poor match to recovery. |
| PGW02 | Theis/Hantush | Confined | 8.32 | $5.5 \times 10^{-3}$ | Good match mid to late time pumping data. Poor match to recovery. |
| PGW02 | Papadopulos-Cooper | Confined | 8.14 | $5.7 \times 10^{-3}$ | Good match mid to late time pumping data. Poor match to recovery. |

ARDG-BHPZ02 is likely hydraulically connected with ARDG-BHPZ01, through bore construction, and therefore the initial standing water level in these bores may reflect soil saturation levels, rather than being representative of the groundwater level within the fractured rock aquifer. The results obtained from these bores have therefore not been used for further analysis in this assessment.

ARDG-PGW02 is screened through both the aquitard and fractured rock aquifer. The storativity value interpreted for this bore may be influenced by leakage from aquitard storage. It is possible that a storativity obtained from ARDG-PGW02 is higher than the actual storativity of the aquifer.

The type curves were a poor match to the recovery data obtained from both ARDG-BHPZ05 and ARDG-PGW02. Given that the pump rate was not constant, it is preferable to match to recovery data, which is not influenced by the pumping rate. Therefore, based on the best matches to the type curves, and weighting the analysis towards curve matching recovery data, the following range of parameters were obtained:

– Transmissivity: 2.40 to 2.54 $m^2$/day (range of ARDG-PGW01)
– Storativity: 1.3 $\times 10^{-3}$ m/m (average of ARDG-BHPZ05)

After two weeks of recovery, the groundwater levels in the pumping and monitoring bores had not fully recovered which indicates slow recharge to the confined aquifer system.

# 5. Conceptual hydrogeological model

The conceptual model is based on drilling and groundwater monitoring data, downhole logs and core photographs provided by ARDG and interpreted geology.

The groundwater flow system occurs in a confined fractured rock aquifer within the Lochaber Greywacke.

The hydrostratigraphy of the project area consists of two hydrostratigraphic layers:

– Clay/saprolite aquitard
– Confined fractured rock aquifer

Groundwater levels only have a minor response to rainfall recharge.

Groundwater is recharged by rainfall infiltration and subsequent leakage through the clay aquitard, and by direct rainfall recharge outside of the project area where the fractured rock outcrops.

Based on the groundwater bores which target the fractured rock aquifer, groundwater flow is controlled by topography.

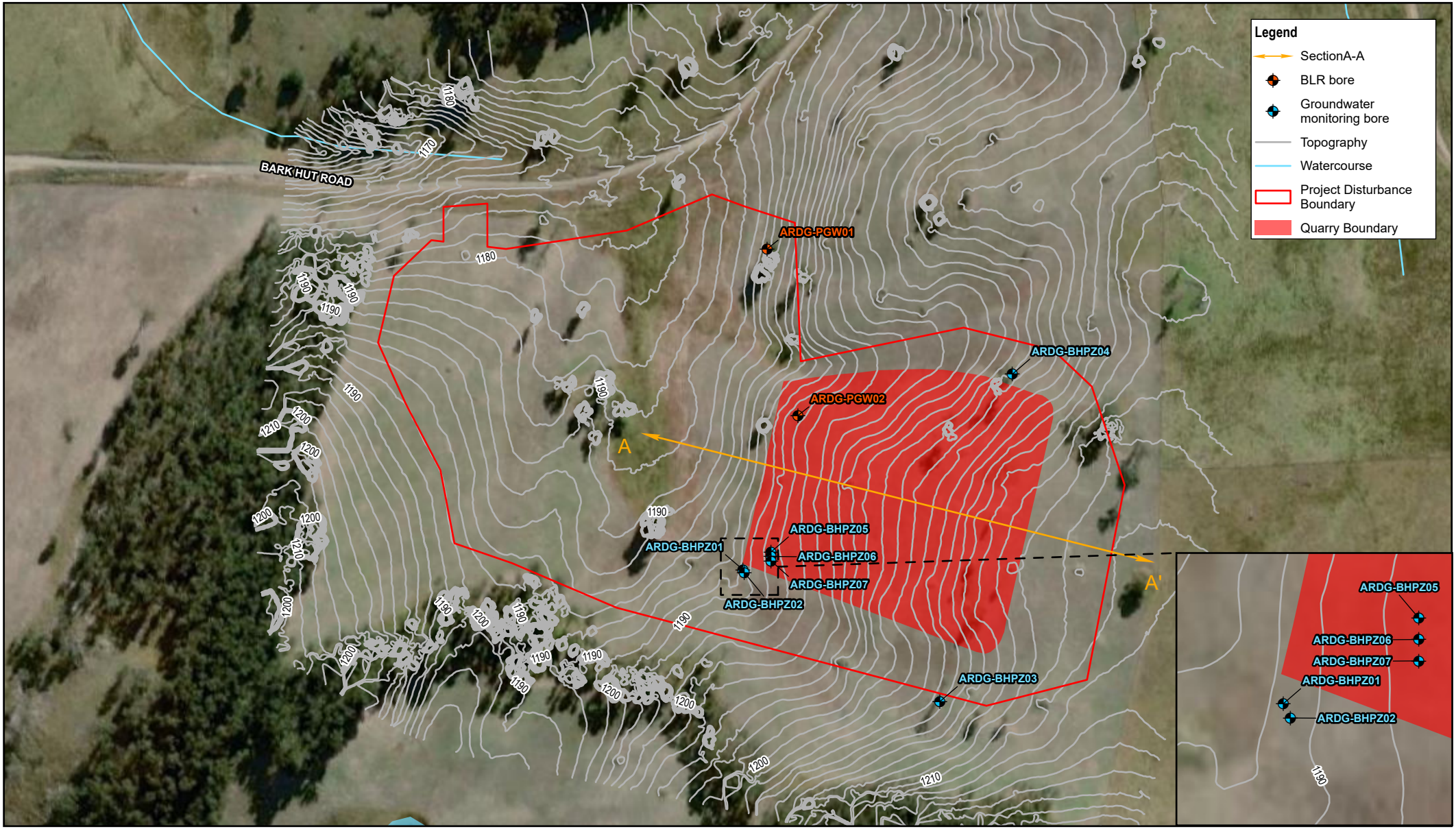
Groundwater within the fractured rock aquifer is unlikely to contribute to baseflow to the nearby ephemeral creeks.

Groundwater quality at the project is good, with circumneutral pH (6.5 – 6.84) and relatively low EC (523 – 566 µS/cm). Total metal concentrations are low and are largely below detection limits.

The conceptual hydrogeological model is shown as one cross section (A-A') through the project area. The cross-section location and the proposed quarry pit are shown in Figure 5.1. Cross section A-A trends northwest to southeast through the centre of the proposed pit. All monitoring and production bores have been offset onto the cross section.

The final quarry pit shell is shown in Figure 5.2. The groundwater level shown as a light-blue-dashed line in Figure 5.2 represents pre-quarrying and pre-pumping conditions and is based on average groundwater levels. The soil saturation/infiltrating rainfall level is shown as a dark-blue-dashed line in the figure. The top of the confined fractured rock aquifer is shown as a yellow-dashed line.

Pumping from the potential production bore will lower the groundwater level in the vicinity of the project (purple-dashed line, based on a pumping rate of 0.5 L/s, after three years continuous pumping). During development, groundwater inflow into the pit will cause additional groundwater drawdown in the vicinity of the project. The predicted drawdown impact from pit inflows is shown as a red-dashed line (based on a radius of influence of 378 m).




Paper Size ISO A4

0 25 50 75 100

Metres

Map Projection: Transverse Mercator
Horizontal Datum: GDA2020
Grid: GDA2020 MGA Zone 56

N

GHD

**Australian Resource Development Group Pty Ltd**
**Winterbourne Windfarm Quarry**
**Groundwater Impact Assessment**

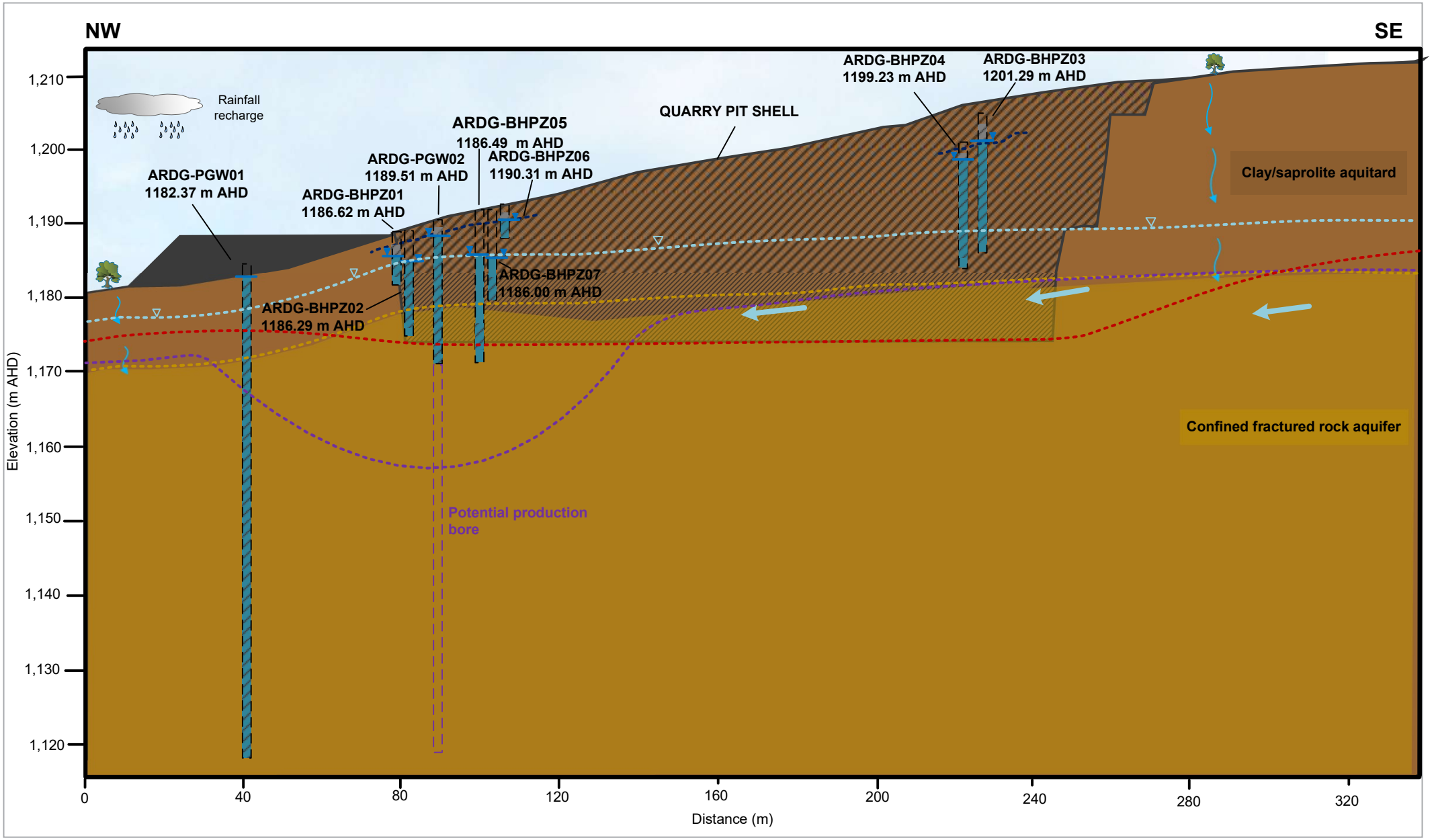
Project No. **12627449**
Revision No. **B**
Date **19/08/2024**

## Conceptual model cross section location

# FIGURE 5-1

\\ghdnet\ghd\AU\Orange\Projects\22\12627449\GIS\Maps\Deliverables\12627449_GWIA.aprx
Print date: 19 Aug 2024 - 15:54

Data source: LPI: DTDB / DCDB, 2024; World Imagery: Source: Esri, Maxar, Earthstar Geographics, and the GIS User Community
World Imagery: Maxar. Created by: schen4




Interpreted groundwater level
Measured groundwater level
Groundwater flow
Infiltration and leakage
Top of confined aquifer
Pumping impact groundwater level
Pit inflow impact groundwater level
Soil saturation level
Bore (offset onto the section)

Australia Resource Development Group Pty Ltd
Barry Hut Quarry
Groundwater Impact Assessment

**Conceptual cross section A - A**

Project No. 12627449
Revision No. 0
Date 21/08/2024

**FIGURE 5.2**

Created by: MJKay and MZhou

# 6. Impact assessment

Groundwater impacts have been assessed for the final depth of the quarry pit. Groundwater impacts from a potential production bore have also been assessed.

## 6.1 Justification for using analytical models

Considering that the distances to the few registered landholder bores and highly probable vegetation GDEs are greater than two kilometres and the confined nature of the aquifer with a depth to groundwater exceeding 12 metres, which would not support GDEs, it is considered that the risk to identified groundwater receptors due to the project and associated production bore is low. Therefore, the level of complexity of analytical equations is appropriate to assess this risk.

## 6.2 Prediction of drawdown for a production bore

To determine the extent of drawdown associated with a potential production bore (with similar specifications to ARDG-PGW01) pumping continuously at rates of 0.30 L/s and 0.5 L/s, an analytical model developed by GHD was used. This model is based on the non-equilibrium Theis (1936) solution to the well equation and assumes the following:

– Pumping bore penetrates the entire aquifer thickness.
– Discharge is instantaneous with decline in pressure.
– Flow is radial, horizontal and laminar.
– The aquifer is homogenous and isotropic.
– Aquifer thickness is uniform.
– The aquifer remains saturated during pumping.
– The aquifer is infinite (in areal extent, no areal boundaries).
– The aquifer is horizontal and bounded above and below by impermeable beds (the aquifer is confined).
– All storage of water within the aquifer comes from the cone of depression (the aquifer is isolated from overlying or underlying leaky aquifers, local recharge, precipitation, irrigation, rivers, lakes and wetlands).

Analytical inputs are summarised in Table 6.1.

***Table 6.1 Analytical inputs***

| Input | Value | Justification |
|---|---|---|
| Transmissivity ($m^2$/day) | 2.47 | Based on the pump test on ARDG-PGW01. The adopted transmissivity value is the average value obtained from interpreting the observations at ARDG-PGW01. |
| Storativity (m/m) | $1.3 \times 10^{-3}$ | Based on the pump test on ARDG-PGW01. The adopted storativity value is the average value obtained from interpreting the observations at ARDG-BHPZ05. |
| Pumping bore radius (m) | 0.1 | Hole diameter 200 mm |
| Pumping rate (L/s) | Q = 0.3 | Required take (minimum) |
| | Q = 0.5 | Required take (minimum) |
| Pump inlet depth (m) | 62 | Setting during pumping test |
| Standing water level (m bgl) | 1.34 | Initial groundwater level prior to pump test at ARDG-PGW01 |

Predicted drawdowns are summarised in Table 6.2.

*Table 6.2 Predicted drawdown*

| Radial distance from pumping bore (m) | Q = 0.3 L/s | | | Q = 0.5 L/s | | |
|---|---|---|---|---|---|---|
| | Drawdown after 1 year (m) | Drawdown after 2 years (m) | Drawdown after 3 years (m) | Drawdown after 1 year (m) | Drawdown after 2 years (m) | Drawdown after 3 years (m) |
| 0 | 15.75 | 16.33 | 16.67 | 26.25 | 27.22 | 27.78 |
| 50 | 5.37 | 5.95 | 6.29 | 8.96 | 9.92 | 10.49 |
| 100 | 4.22 | 4.80 | 5.13 | 7.03 | 7.99 | 8.56 |
| 150 | 3.55 | 4.12 | 4.46 | 5.91 | 6.87 | 7.43 |
| 200 | 3.07 | 3.64 | 3.98 | 5.12 | 6.07 | 6.63 |
| 250 | 2.70 | 3.27 | 3.61 | 4.51 | 5.46 | 6.02 |
| 300 | 2.41 | 2.97 | 3.31 | 4.01 | 4.96 | 5.51 |
| 400 | 1.95 | 2.50 | 2.83 | 3.25 | 4.17 | 4.72 |
| 500 | 1.60 | 2.14 | 2.47 | 2.67 | 3.57 | 4.12 |
| 1,000 | 0.65 | 1.09 | 1.38 | 1.08 | 1.82 | 2.31 |
| 1,500 | 0.25 | 0.58 | 0.82 | 0.42 | 0.96 | 1.37 |
| 2,000 | 0.09 | 0.30 | 0.49 | 0.15 | 0.50 | 0.81 |
| 2,500 | 0.02 | 0.15 | 0.28 | 0.04 | 0.25 | 0.47 |
| 3,000 | 0.00 | 0.07 | 0.16 | 0.00 | 0.12 | 0.27 |
| 3,500 | 0.00 | 0.03 | 0.09 | 0.00 | 0.04 | 0.14 |
| 4,000 | 0.00 | 0.00 | 0.04 | 0.00 | 0.00 | 0.07 |
| 4,500 | 0.00 | 0.00 | 0.01 | 0.00 | 0.00 | 0.02 |
| 4,700 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 5,000 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |

The radius of influence is approximately 4.7 kilometres after three years of continuous pumping at 0.5 L/s. Drawdowns greater than 1.5 metres are not expected to occur at distances exceeding 1.5 kilometres from the production bore after three years continuous pumping.

The radius of influence is approximately 4.7 kilometres after three years of continuous pumping at 0.3 L/s. Drawdowns greater than 1.5 metres are not expected to occur at distances exceeding one kilometre from the production bore after three years continuous pumping.

This method does not consider discontinuous pumping and groundwater level recovery. When operated, the production bore will only be pumped for 12 hours each day, which would allow for groundwater recovery, and a reduce the radius of influence. Therefore, the predicted drawdowns shown in Table 6.2 represent conservative estimates.

This method does not consider the presence of boundaries i.e. a zero-recharge aquifer boundary which would limit the radius of influence. The method does not consider leakage or local rainfall recharge which would also reduce the radius of influence.

# 6.3 Prediction of groundwater inflow and drawdown

## 6.3.1 Method

An assessment of likely groundwater inflow rates and the radius of drawdown was undertaken using the Marinelli and Niccoli (2000) steady-state analytical model. Groundwater inflows will occur from the fractured rock aquifer.

The initial groundwater level adopted for modelling is the average groundwater level elevation of ARDG-PGW02 and ARDG-BHPZ05 (23 May 2024 observation) minus the average drawdown impact from the production bore after one year.

Marinelli and Niccoli (2000) model calculates groundwater inflow to a mine pit excavated below the water table. The flow area is divided into two zones. Zone 1 represents flow to the pit wall and Zone 2 considers flow to the base of the pit. Groundwater inflows were calculated for Zone 1 and Zone 2 using the following equations:

$$Q_1 = W\pi(r_0^2 - r_p^2)$$

$$Q_2 = 4r_p\left(\frac{K_{h2}}{m_2}\right)(h_0 - D)$$

$$m_2 = \sqrt{\frac{K_{h2}}{K_{v2}}}$$

The radius of drawdown was determined via iteration of the following equation:

$$h_0 = \sqrt{h_p^2 + \frac{W}{K_{h1}}\left[r_0^2 ln\left(\frac{r_0}{r_p}\right) - \frac{\left(r_0^2 - r_p^2\right)}{2}\right]}$$

Where:

- Q1 inflow from the walls ($m^3$/day)
- Q2 inflow from the base ($m^3$/day)
- W distributed recharge flux
- $r_0$ radius of drawdown (m)
- $r_p$ effective pit radius (m)
- $K_{h1}$ horizontal hydraulic conductivity value for the aquifer in Zone 1
- $K_{h2}$ horizontal hydraulic conductivity value for the aquifer in Zone 2
- $K_{v2}$ vertical hydraulic conductivity value for the aquifer in Zone 2
- $h_0$ saturated thickness of the aquifer, based on the average groundwater level in the unconfined fractured rock aquifer
- $h_p$ saturated thickness above the base of Zone 1
- D depth of water in the base of the pit

The assumptions of the Marinelli and Niccoli (2000) analytical model include:

- The aquifer is unconfined
- Lowering of the water table reduces the saturated thickness of the surrounding aquifer
- Relative to seepage through pit walls, significant inflow occurs through the pit bottom
- There is no impermeable boundary at depth
- Steady state flow conditions exist near the pit

For Zone 1 the analytical solution considers steady-state, unconfined, horizontal radial flow with uniformly distributed recharge. The solution is also based on the following assumptions:

- Walls are approximated as a circular cylinder.
- Groundwater flow is horizontal and the Dupuit-Forchheimer approximation is used to account for changes in saturated thickness due to reduction of the water table.
- The static (pre-mining) water table is approximately horizontal.
- Uniform distributed recharge occurs across the site because of surface infiltration from rainfall and all recharge within the radius of drawdown of the pit is assumed to be captured by the excavation.
- Groundwater flow toward the pit is axially symmetric.

For Zone 2 the analytical solution is based on steady-state flow to one side of a circular disc sink of constant and uniform drawdown. The sink represents the bottom of the pit. The solution is also based on the following assumptions:

– Hydraulic head is initially uniform throughout Zone 2. Initial head is equal to the elevation of the initial water table in Zone 1.
– The disc sink has a constant hydraulic head equal to the elevation of the pit lake water surface. If the pit is completely dewatered the disk sink head is equal to the elevation of the pit bottom.
– Flow to the disc sink is three dimensional and axially symmetric.

The analytical model is illustrated in Figure 6.1.

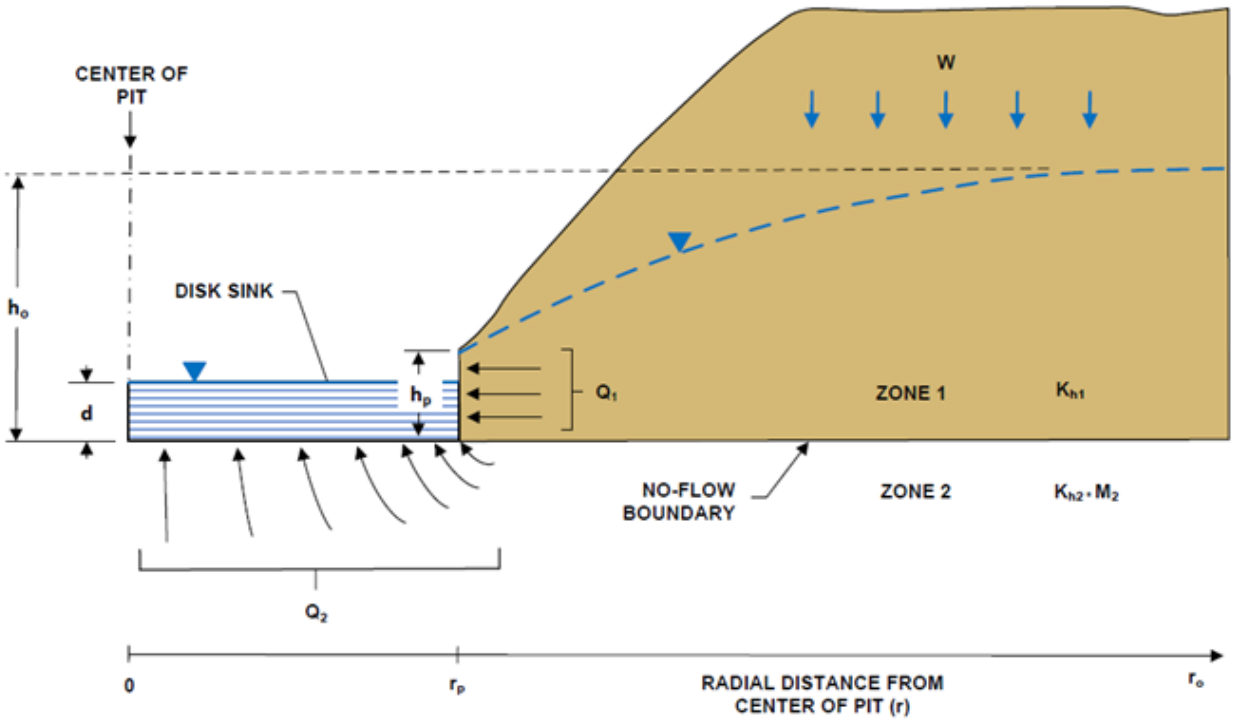



*Figure 6.1 Conceptual analytical model*

## 6.3.2 Analytical inputs

Analytical inputs are summarised in Table 6.3.

*Table 6.3 Analytical inputs*

| Input | Value | Justification |
|---|---|---|
| Horizontal hydraulic conductivity (m/day) - Zone 1 | $K_{h1}$ = 4.94 x $10^{-2}$ | Pump test on ARDG-PGW01 (transmissivity = 2.47 $m^2$/day and aquifer saturated thickness = 50 m) |
| Horizontal hydraulic conductivity (m/day) - Zone 2 | $K_{h2}$ = 2.47 x $10^{-2}$ | Value reflects a decrease in hydraulic conductivity with depth as overburden pressure increases and fracture frequency reduces. |
| Vertical hydraulic conductivity | 10% $K_{h2}$ | Assumed |
| Average groundwater level (m AHD) prior to pumping | 1,188.0 | Average groundwater level elevation of ARDG-PGW02 and ARDG-PZ05 (23 May 2024 observation) |
| Initial water level (m AHD) | 1,182.4 | Based on production bore pumping rate of 0.3 L/s<br>Approximate drawdown in pit^ = 3.1 m – 8.7 m<br>Average drawdown in pit = 5.6 m |

| Input | Value | Justification |
|---|---|---|
| | 1,178.6 | Based on production bore pumping rate of 0.5 L/s<br>Approximate drawdown in pit^ =5.1 m – 13.6 m<br>Average drawdown in pit = 9.4 m |
| Rainfall recharge (mm/year) | 7.18 | 1% average annual rainfall (AAR) |
| Effective pit radius (m) | 90.09 | Pit dimensions (length 170 m, width 150 m) – final bench dimensions<br>The majority of the intersected confined aquifer is within the final bench of the pit. |
| Base of pit (m AHD) | 1,175 | Final base of development |
| Initial saturated thickness (m) above base of pit floor | 7.4 | The aquifer has been represented as an unconfined aquifer, with a water table elevation of 1,182.4 m AHD |
| | 3.6 | The aquifer has been represented as an unconfined aquifer, with a water table elevation of 1,178.6 m AHD |

Note: ^ 365 days after pumping commences

The initial groundwater level adopted for modelling is the average groundwater level elevation of ARDG-PGW02 and ARDG-PZ05 (23 May 2024 observation) minus the average drawdown impact from the production bore after one-year continuous pumping.

Given the fractured rock aquifer does not outcrop in the immediate project area and is elevated and isolated at the top of a ridge, recharge would only occur by infiltration through the clay aquitard. Direct rainfall recharge in low permeability soils can be less than 1% of total rainfall (DPE 2023). Therefore, recharge equal to 1% AAR was assumed for the project.

To apply the Marinelli and Niccoli (2000) model to the quarry, the pit was represented as an open pit in the shape of a circular cylinder. The approximate pit area was then used to calculate an effective pit radius. The plan dimensions of the quarry are not symmetrical and therefore representing the quarry as a circular cylinder is a significant simplification. The majority of the intersected confined aquifer is within the final bench of the pit. Therefore, only pit dimensions for the final bench have been modelled.

We note that the fractured rock aquifer is confined, and the Marinelli and Niccoli (2000) model assumes unconfined conditions.

### 6.3.3 Results

Groundwater inflow and the radius of drawdown from the centre of the pit are shown in Table 6.4.

***Table 6.4 Groundwater inflow and radius of drawdown***

| Production bore pumping rate | 0.3 L/s (25,920 L/day) (9.5 ML/year) | 0.5 L/s (43,200 L/day) (15.8 ML/year) |
|---|---|---|
| Saturated thickness above base of pit floor | 7.4 m | 3.6 m |
| Total pit inflow | 10.6 ML/year (29,158 L/day) | 4.8 ML/year (13,266 L/day) |
| Radius of influence | 378 m | 242 m |

The Marinelli and Niccoli (2000) method assumes that the aquifer is laterally infinite, and drawdown will propagate until equilibrium is reached between discharged water and rainfall recharge. The method does not consider the presence of a zero-recharge aquifer boundary which would limit the radius of drawdown. If the radius of drawdown reaches a zero-recharge boundary close to the quarry pit, inflows would be significantly less.

The Marinelli and Niccoli (2000) method does not consider any increased recharge that may occur as a result of the quarry activities. During development, it has been assumed that any rainfall or runoff presenting to the pit would be removed via a stormwater collection and pumping system. Any enhanced recharge that occurs as a result of the quarry in the post closure phase would reduce the time required for groundwater levels to recover.

Note the radius of influence is for pit inflows only.

## 6.4 Prediction of cumulative drawdown

Cumulative impacts have been assessed. The total drawdown will be the drawdown impact from both pit inflows and pumping from the potential production bore.

To determine the extent and magnitude of drawdown associated with both direct and passive take of groundwater, an analytical model developed by GHD was used. This model is based on the non-equilibrium Theis (1936) solution to the well equation (refer Section 6.2).

The quarry inflows have been represented as a bore, located at the approximate centre of the pit, pumping at rates of 0.15 L/s (13,266 L/day) and 0.34 L/s (29,158 L/day) (refer Table 6.4). Cumulative drawdown after one to three years at each of the registered bores and highly probable GDEs are shown in Table 6.5.

***Table 6.5 Predicted cumulative drawdown***

| Bore ID | Distance from production bore (m) | Pit Q=0.15 L/s, Bore Q = 0.5 L/s | | | Pit Q=0.34L/s, Bore Q = 0.3 L/s | | |
|---|---|---|---|---|---|---|---|
| | | Drawdown after 1 year (m) | Drawdown after 2 years (m) | Drawdown after 3 years (m) | Drawdown after 1 year (m) | Drawdown after 2 years (m) | Drawdown after 3 years (m) |
| GW018784 | 7,896 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| GW023388 | 7,196 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| GW303480 | 3,499 | 0.00 | 0.06 | 0.19 | 0.00 | 0.06 | 0.20 |
| GW303788 | 4,750 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| GW307466 | 5,944 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| GW307759 | 2,762 | 0.00 | 0.22 | 0.46 | 0.00 | 0.22 | 0.46 |
| GW307923 | 6,814 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| GW308010 | 6,495 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| GW901292 | 3,518 | 0.00 | 0.05 | 0.18 | 0.00 | 0.05 | 0.17 |
| GW901293 | 3,200 | 0.00 | 0.11 | 0.27 | 0.00 | 0.11 | 0.27 |
| GW901294 | 4,692 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.01 |
| Oxley Wild | 5,815 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Snake Creek | 4,705 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| Dog Trap Creek | 6,991 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |

Drawdowns greater than 0.46 m are not expected to occur at any of the registered bores. No drawdowns are expected to occur at any of the highly probable GDEs.

Drawdown caused by the production bore will increase with time (assuming continuous use at these rates). Pit inflows will therefore reduce with time. For this assessment, pit inflows have been assumed to be constant, and therefore the drawdowns shown in Table 6.5 represent a conservative assessment.

## 6.5 Water sharing plan licensing requirements

The project and associated production bore is located within the New England Fold Belt Coast Groundwater Source which is managed by the WSP for the North Coast Fractured and Porous Rock Groundwater Sources. Any interference or extraction of groundwater at the project site requires a WAL under the WM Act.

A WAL would be required to obtain approximately 9.5 ML/year to 15.8 ML/year for direct take (production bore).

A WAL would be required to obtain approximately 4.8 ML/year to 10.6 ML/year for passive take (groundwater inflows into the pit).

Based on recent trades (between 2021 and 2024), water made available and water usage statistics for recent water years (2023/2024, 2022/2023), there is sufficient market depth for a licence of this magnitude.

Groundwater inflows are expected to continue for a period of time post closure until water levels within the pit have recovered above the pre-quarry groundwater levels. A WAL will therefore still be required in the post closure phase of the project. Impacts post closure are discussed further in Section 6.6.5.

## 6.6 Impact assessment

The potential impacts have been assessed in accordance with the NSW AIP. The AIP requires that potential impacts on groundwater sources, including their users and GDEs, be assessed against minimal impact considerations, outlined in Table 1 of the policy. If the predicted impacts meet the Level 1 Minimal Impact Considerations, then these impacts will be considered as acceptable.

The NSW AIP divides groundwater into “highly productive” and “less productive” groundwater sources. Highly productive groundwater is defined in this policy as having:

– Total dissolved solids of less than 1,500 mg/L
– Contains water supply works that can yield water at a rate greater than 5 L/sec

Based on the reported yields for the registered bores outlined in Section 3.6.2, groundwater yields within the fractured rock aquifer are less than 5 L/s, varying between 0.2 L/s to 3.8 L/s. Groundwater at the project site is therefore defined as “less productive” as per the NSW AIP.

Level 1 minimal impact considerations for Less Productive Groundwater Sources – Porous and Fractured Rock Water Sources have therefore been adopted for the GIA and are defined as follows:

– Water table:
    - Less than or equal to 10% cumulative variation in the water table, allowing for typical climatic ‘post-water sharing plan’ variations, at a distance of 40 m from any high priority GDE or high priority culturally significant site listed in the schedule of the relevant WSP. A maximum of a 2 m water table decline cumulatively at any water supply work.
    - If more than 10% cumulative variation in the water table, allowing for typical climatic ‘post-water sharing plan’ variations, 40 m from any high priority GDE; or high priority culturally significant site; listed in the schedule of the relevant WSP then appropriate studies will need to demonstrate to the Minister’s satisfaction that the variation will not prevent the long-term viability of the dependent ecosystem or significant site. If more than 2 m decline cumulatively at any water supply work, then make good provisions should apply.
– Water pressure:
    - A cumulative pressure head decline of not more than a 2 m decline at any water supply work.
    - If the predicted pressure head decline is greater than the requirement above, then appropriate studies are required to demonstrate to the Minister’s satisfaction that the decline will not prevent the long-term viability of the affected water supply works unless make good provisions apply.
– Water quality:
    - Any change in groundwater quality should not lower the beneficial use category of the groundwater source, beyond 40 m from the activity.

- If the above condition is not met then appropriate studies will need to demonstrate to the Minister's satisfaction that the change in groundwater quality will not prevent the long-term viability of the dependent ecosystem, significant site or affected water supply work.

## 6.6.1 Impact to existing groundwater users

### 6.6.1.1 Quarry pit

As the quarry pit floor deepens below the pre-quarry groundwater level and is dewatered, the pit will create a hydraulic gradient towards the pit. This will cause a decline in groundwater levels surrounding the quarry pit. The decline in groundwater levels is referred to as a cone of depression, and the extent to which the cone of depression extends is referred to as the radius of drawdown (or radius of influence). Drawdown will only occur once the pit floor is below the top of the confined aquifer. The lowest point of the cone of depression will be the ultimate floor level of the quarry or the level of water within the quarry (whichever is higher).

The radius of drawdown depends primarily on the nature of the aquifer and the floor level of the quarry or the level of water within the quarry (if the pit lake is not dewatered). For a fractured rock aquifer, it is likely that the drawdown will propagate in certain preferential directions, rather than in a circular shape.

The magnitude and extent of drawdown also depends on factors such as leakage between aquifers and aquitards, and the interaction with recharge or no flow boundaries. Where the hydrogeological systems become more complex, the accuracy of the drawdown predictions reduces.

The nearest BLR bore (GW307759) is located approximately 2.5 km from the centre of the pit. The most conservative predicted radius of drawdown from the centre of the quarry pit is 378 m. GW307759 is well outside the influence of the quarry pit's radius of drawdown and therefore no drawdown is expected to occur at any of the registered bores as a result of dewatering the quarry pit. The impact of the quarry pit therefore meets the NSW AIP Level 1 Minimal Impact Considerations for Landholder Bores.

### 6.6.1.2 Production bore

The nearest BLR bore (GW307759) is located approximately 2.7 km from the ARDG-PGW02. Based on a continuous pumping rate of 0.5 L/s, the predicted radius of drawdown for the production bore is five kilometres after three years. However, drawdowns greater than 1.5 metres are not expected to occur at distances exceeding 1.5 kilometres from the production bore after three years continuous pumping. The impact of the production bore therefore meets the NSW AIP Level 1 Minimal Impact Considerations for Landholder Bores.

## 6.6.2 Impact to GDEs

The nearest high priority GDEs are located near the approximately 70 km from the project and associated production bore. These GDEs are well outside the predicted radius of drawdown of the quarry pit and production bore and therefore will not be impacted by drawdown.

### 6.6.2.1 Quarry pit

No areas of probable vegetation GDEs within the most conservative predicted radius of drawdown (378 m) have been mapped as part of the *Probable Vegetation Groundwater Dependent Ecosystems — Northern Rivers and Namoi datasets (DPE Water 2022).* The impact of the quarry pit therefore meets the NSW AIP Level 1 Minimal Impact Considerations for GDEs.

### 6.6.2.2 Production bore

Highly probable vegetation GDEs associated with Snake Creek have been mapped as part of the Probable Vegetation Groundwater Dependent Ecosystems — Northern Rivers and Namoi datasets (DPE Water 2022) within the predicted radius of drawdown (4.7 km) of the production bore. The highly probable vegetation GDEs associated with Snake Creek are located approximately 4.7 km to the south west of a potential production bore and based on a continuous pumping rate of 0.5 L/s for three years, no drawdown is predicted to occur at the highly probable GDEs. The impact of the quarry pit therefore meets the NSW AIP Level 1 Minimal Impact Considerations for GDEs.

### 6.6.3 Impact to groundwater quality

The project and associated production bore are not expected to cause any significant change in groundwater quality or in the beneficial use of the groundwater. Major ion analysis of groundwater does not indicate any previous or potential oxidation of sulfide minerals. The project is not expected to result in the generation of acid groundwater. Additionally, no processing waste or tailings are to be produced or emplaced at the project site.

Quarrying activities may increase groundwater recharge in the post closure phase which may result in a localised improvement in groundwater quality.

### 6.6.4 Cumulative impacts

Cumulative impacts have been assessed. Drawdowns greater than 0.46 m are not expected to occur at any of the registered bores, and therefore the cumulative impact of the project and associated production bore meets the NSW AIP Level 1 Minimal Impact Considerations for Landholder Bores.

No drawdown is expected to occur at any of the highly probable GDEs and is therefore unlikely to impact any potential GDEs. The cumulative impact of the project and associated production bore therefore meets the NSW AIP Level 1 Minimal Impact Considerations for GDEs.

### 6.6.5 Impacts post closure

At the end of development, the groundwater table will be locally depressed to 1,175 m AHD. With time, groundwater levels in the aquifer surrounding the quarry pit will recover until equilibrium within the system occurs, and a pit lake forms within the final void. The pit lake is likely to be an area of enhanced recharge for the confined aquifer. Once the system is in equilibrium, the flux of water within the pit lake will only be from rainfall and evaporation. During the recovery stage however, groundwater inflows will occur, and a WAL will still be required in the initial post closure phase of the project.

Recovery of groundwater levels post closure has not been modelled in this assessment. Water level recovery in the final void however has been modelled in the Surface Water Impact Assessment for the project.

Any enhanced recharge that occurs as a result of the quarry in the post closure phase would reduce the time required for groundwater levels to recover. The increased groundwater recharge in the post closure phase may also result in a localised improvement in groundwater quality.

It is recommended that groundwater monitoring continues in the post closure period however, so that groundwater level recovery can be monitored, and predictions made regarding how long a WAL may be required after the project is completed. Groundwater monitoring is further discussed in Section 7.

# 7. Mitigation measures

## 7.1 Groundwater monitoring

It is recommended that the existing groundwater monitoring program be continued. It is recommended that groundwater be monitored to:

– Measure dewatering performance
– Assess potential impacts to groundwater levels and quality on other groundwater users in the vicinity
– Identify groundwater issues such as potential large drawdowns at receptors as early as possible
– Provide data which can be used to calibrate the analytical model and update the groundwater inflow predictions
– Measure groundwater level recovery post closure and provide data which can be used to predict how long a WAL may be required after the project is completed

It is recommended that the existing monitoring program be extended to include an additional, deeper monitoring bore near ARDG-BHPZ03 which targets the fractured rock aquifer. A second additional monitoring bore should be installed between ARDG-BHPZ04 and registered bore GW307759, to the north east of the project. Groundwater level data at this bore can be used to determine whether or not the radius of drawdown is extending further than predicted.  Monitoring program

The monitoring program should include regular monitoring of water levels and water quality. The monitoring program should be established prior to the commencement of the project or pumping from the associated production bore.

Bores ARDG-PGW01, ARDG-PGW02, ARDG-BHPZ01, ARDG-BHPZ02, ARDG-BHPZ05, ARDG-BHPZ06 and ARDG-BHPZ07 should continue to be monitored whilst they are not affected by the quarry operations. It is recommended that groundwater levels initially be monitored quarterly in these bores and the proposed. Once groundwater inflows occur, it is recommended that the monitoring frequency increase to monthly.

It is recommended that water quality be monitored quarterly in all monitoring bores for the first two years after the project commences (or until they are affected by quarry operations). Water quality samples should be analysed for pH, EC, nutrients, major ions and dissolved metals (aluminium, arsenic, cadmium, chromium, copper, iron, manganese, nickel, lead, zinc and mercury). Due to the low level of risk, after two years it is recommended that only EC and pH be monitored quarterly, with selected metals monitored annually. A TARP should be developed to monitor the full suite of parameters in the event of a significant departure from pH and EC triggers.

It is recommended that the monitoring program be reviewed every year to determine if monitoring results indicate that less frequent monitoring would still provide a reasonable level of data to enable the impacts to be reliably detected.

Once the quarry pit extends below the top of the confined aquifer, the monitoring program should also include monitoring of groundwater inflow into the quarry. Measuring groundwater take is a requirement from a licensing perspective and the measured inflows can also be used to calibrate the analytical model and provide updated predictions. Groundwater inflow rates should therefore be accurately recorded.

Groundwater quality monitoring requirements post closure should be reviewed as part of closure planning with a focus on understanding the impacts of groundwater recharge from a recovering pit lake on the local groundwater system. Groundwater levels should continue to be monitored in the post closure phase until groundwater levels stabilise and/or regulation requirements are met. Monitoring locations and frequency in the post closure period should be identified as part of the quarry closure planning process and be informed by monitoring undertaken during the life of project, updated predictions of pit lake recovery and likely water quality and risks presented from pit lake recovery.

The groundwater monitoring program will provide a safeguard against any impacts that have not been identified in this assessment. If unforeseen impacts are identified during monitoring ARDG will be able to amend the dewatering operation and/or the monitoring program to prevent further reductions in groundwater levels and/or quality.

# 8. Conclusions

For the project, an assessment of likely groundwater inflow rates and the radius of drawdown for the proposed quarry pit was undertaken using a steady-state analytical model. To determine the extent of drawdown associated with a potential production bore pumping continuously at rates of 0.3 L/s to 0.5 L/s, an analytical model developed by GHD was used.

Considering that the distances to the few registered landholder bores and highly probable vegetation GDEs are greater than two kilometres and the confined nature of the aquifer with a depth to groundwater exceeding 12 metres, which would not support GDEs, it was considered that the risk to identified groundwater receptors due to the project and associated production bore is low. Therefore, the level of complexity of analytical equations was appropriate to assess this risk.

For the quarry pit, quantification of likely groundwater inflow rates and the radius of drawdown was undertaken using a steady-state analytical model. The interpreted hydraulic conductivity value obtained from pump testing production bore ARDG-PGW01 was assumed to represent the expected hydraulic conductivity in the confined aquifer ($K_1$ = 4.94 x $10^{-2}$ m/day). A lower hydraulic conductivity value was assumed for the confined aquifer below the base of the pit ($K_2$ = 2.47 x $10^{-2}$ m/day). Using these hydraulic conductivity estimates, groundwater inflows into the pit were predicted to range from 4.8 ML/year to 10.6 ML/year, and the radius of drawdown was predicted to be between 242 m and 378 m from the centre of the pit.

The project area is located within the New England Fold Belt Coast Groundwater Source which is managed by the Water Sharing Plan for the North Coast Fractured and Porous Rock Groundwater Sources. Any take of groundwater associated with the project or production bore (through passive inflow or direct take through extraction for operational purposes) will require a WAL under the WM Act. Quarry operations would require a direct take of 9.5 ML/year to 15.8 ML/year for a production bore located at the project site. There is sufficient market depth for a licence for 9.5 ML/year to 15.8 ML/year.

The requirement for a WAL for passive take will not arise until the pit floor of the quarry progresses below the top of the confined aquifer. An additional WAL for approximately 4.8 ML/year to 10.6 ML/year would be required. There is sufficient market depth for ARDG to obtain a licence for 4.8 ML/year to 10.6 ML/year.

The most conservative predicted radius of drawdown (378 m) from the centre of the pit was used to assess the groundwater impact of the pit on existing groundwater users. Landholder bores are well outside the quarry pit's radius of drawdown. No drawdown is therefore expected to occur at any of the landholder bores. Therefore, landholder bores will not be impacted by any drawdown associated with the pit and the impact of the quarry pit meets the NSW Aquifer Interference Policy (AIP) Level 1 Minimal Impact Considerations for Landholder Bores.

For a potential production bore pumping rate of 0.5 L/s, drawdowns exceeding 1.5 metres are not expected to occur at distances beyond 1.5 km, after three years continuous pumping. Given that the nearest registered bore (GW307759) is located approximately 2.7 km from ARDG-PGW02 (the location of the potential production bore), the impact of the production bore therefore meets the NSW Aquifer Interference Policy (AIP) Level 1 Minimal Impact Considerations for Landholder Bores.

The most conservative predicted radius of drawdown (378 m) was used to assess the impact of the quarry pit on GDEs. High priority GDEs identified in Section 3.6.1 are well outside the quarry pit's radius of drawdown. The highly probable vegetation GDEs associated with Snake Creek are located approximately 4.7 km to the south west of a potential production bore. Based on a continuous pumping rate of 0.5 L/s for three years, no drawdown is predicted to occur at the highly probable GDEs. The impacts of the quarry pit and potential production bore therefore meet the NSW Aquifer Interference Policy (AIP) Level 1 Minimal Impact Considerations for GDEs.

The quarry pit or a potential production bore are not expected to cause any significant change in groundwater quality or in the beneficial use of the groundwater. The increased groundwater recharge in the post closure phase may also result in a localised improvement in groundwater quality.

Cumulative impacts have been assessed. Drawdowns greater than 0.46 m are not expected to occur at any of the registered bores, after three years continuous pumping. No drawdown is expected to occur at any of the highly probable GDEs. The cumulative impact of the project and associated production bore therefore meets the NSW AIP Level 1 Minimal Impact Considerations for GDEs and Landholder Bores.

The project is expected be completed after three years. With time, groundwater levels in the aquifer surrounding the project will recover until equilibrium within the system occurs, and a pit lake forms within the final voids. The pit lake is likely to be an area of enhanced recharge for the confined aquifer. Once the system is in equilibrium, the flux of water within the pit lake will only be from rainfall and evaporation. During the recovery stage however, groundwater inflows will occur, and a WAL will still be required in the initial post closure phase of the project. Any enhanced recharge that occurs as a result of the quarry in the post closure phase would reduce the time required for groundwater levels to recover.

# 9. References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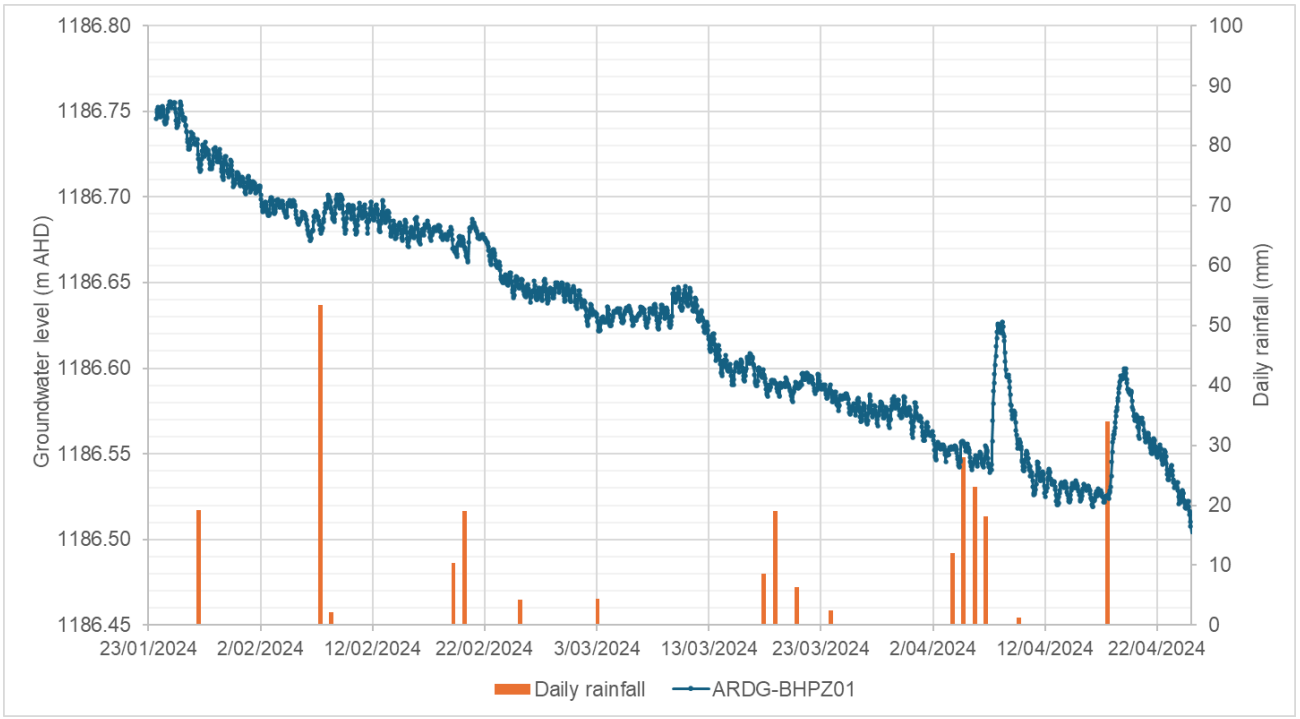
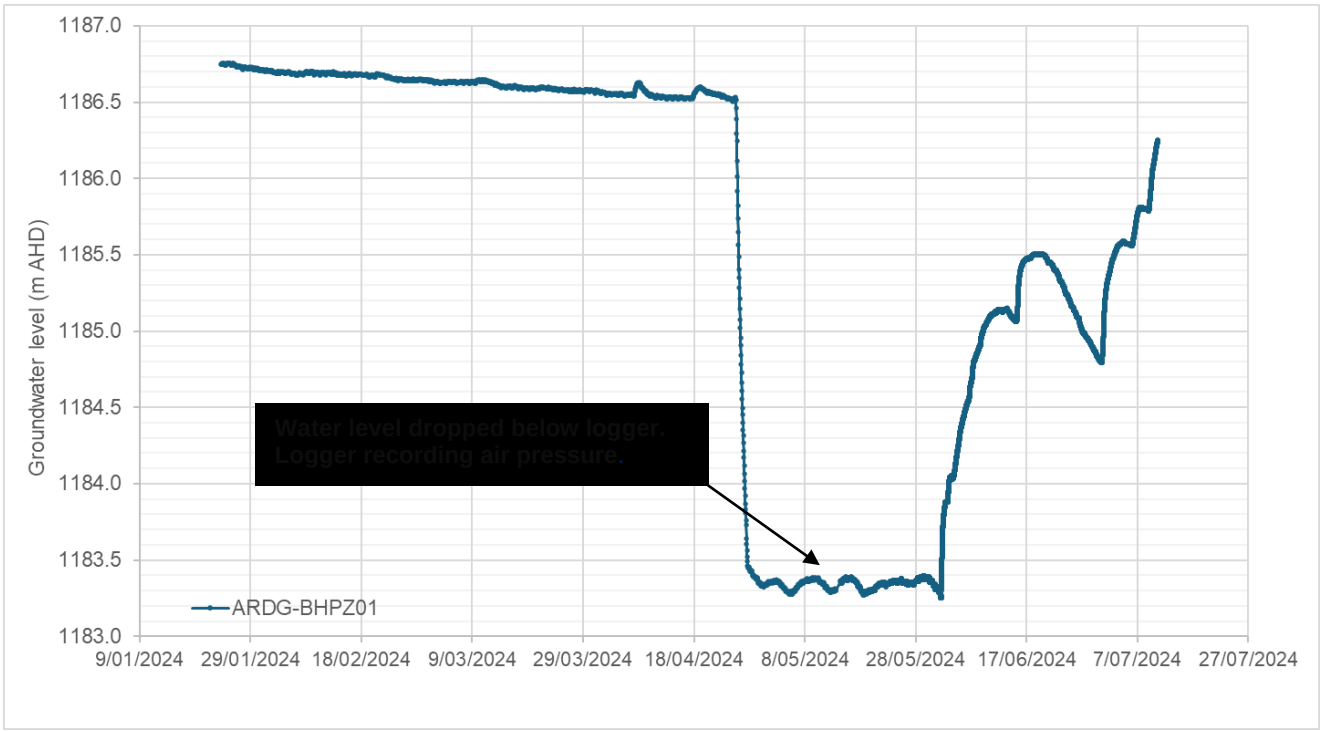
# Appendix A

## Groundwater level hydrographs

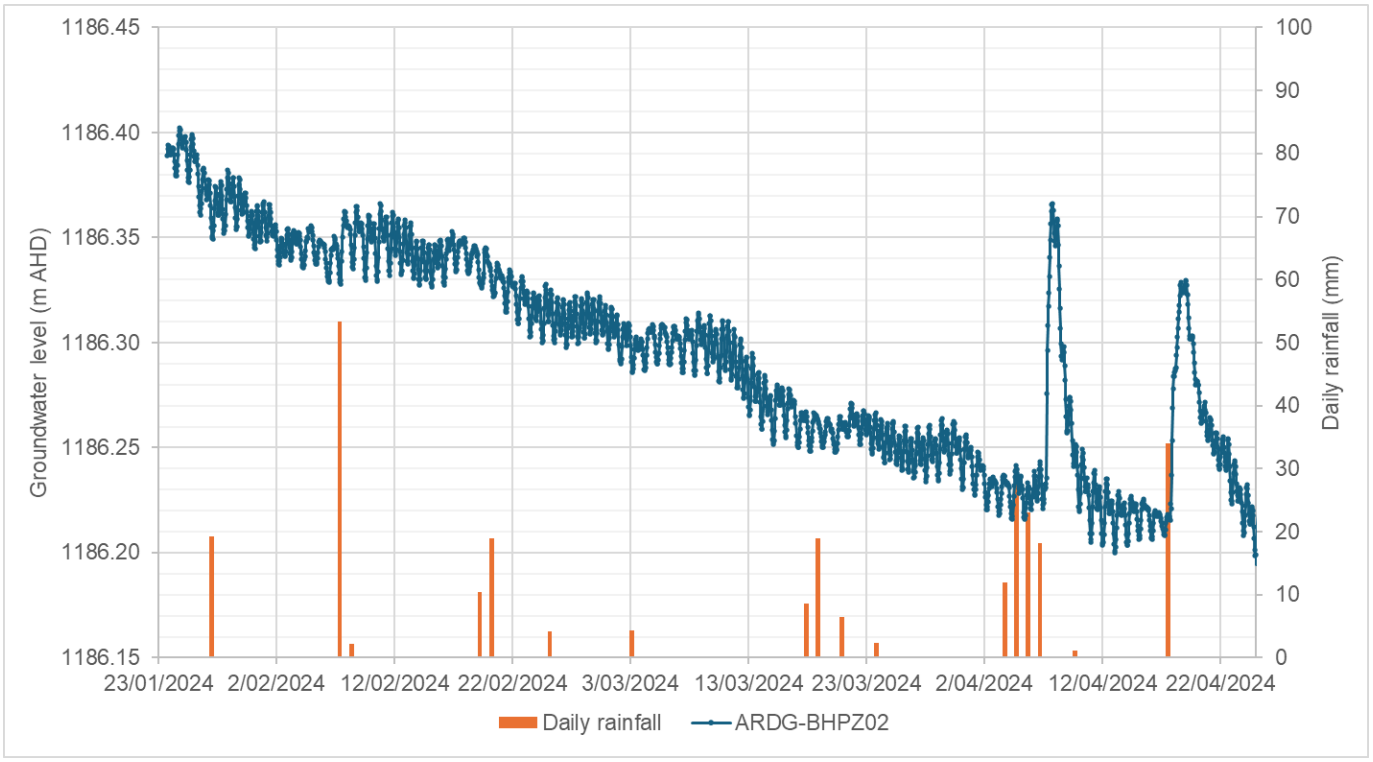
ARDG-BHPZ01 – baseline data and daily rainfall



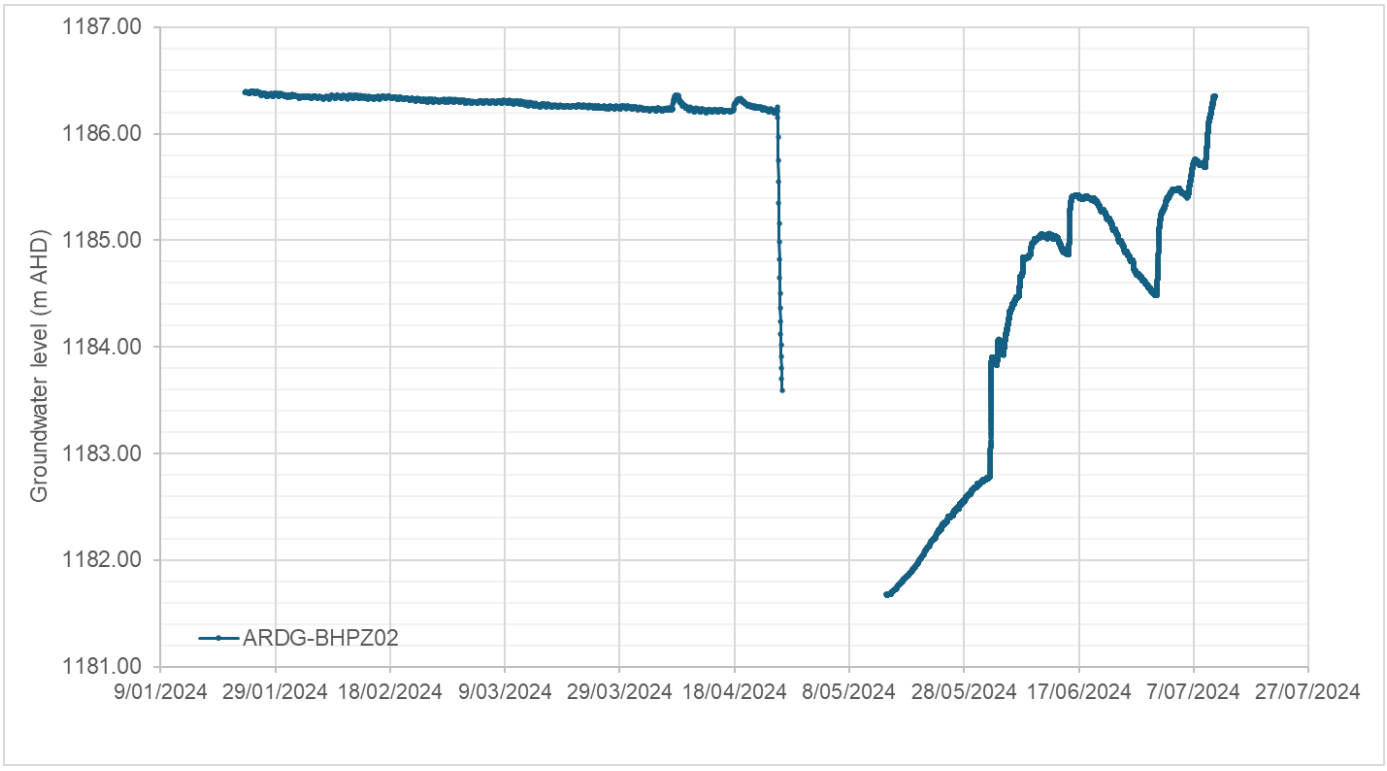

ARDG-BHPZ01 – all monitoring data



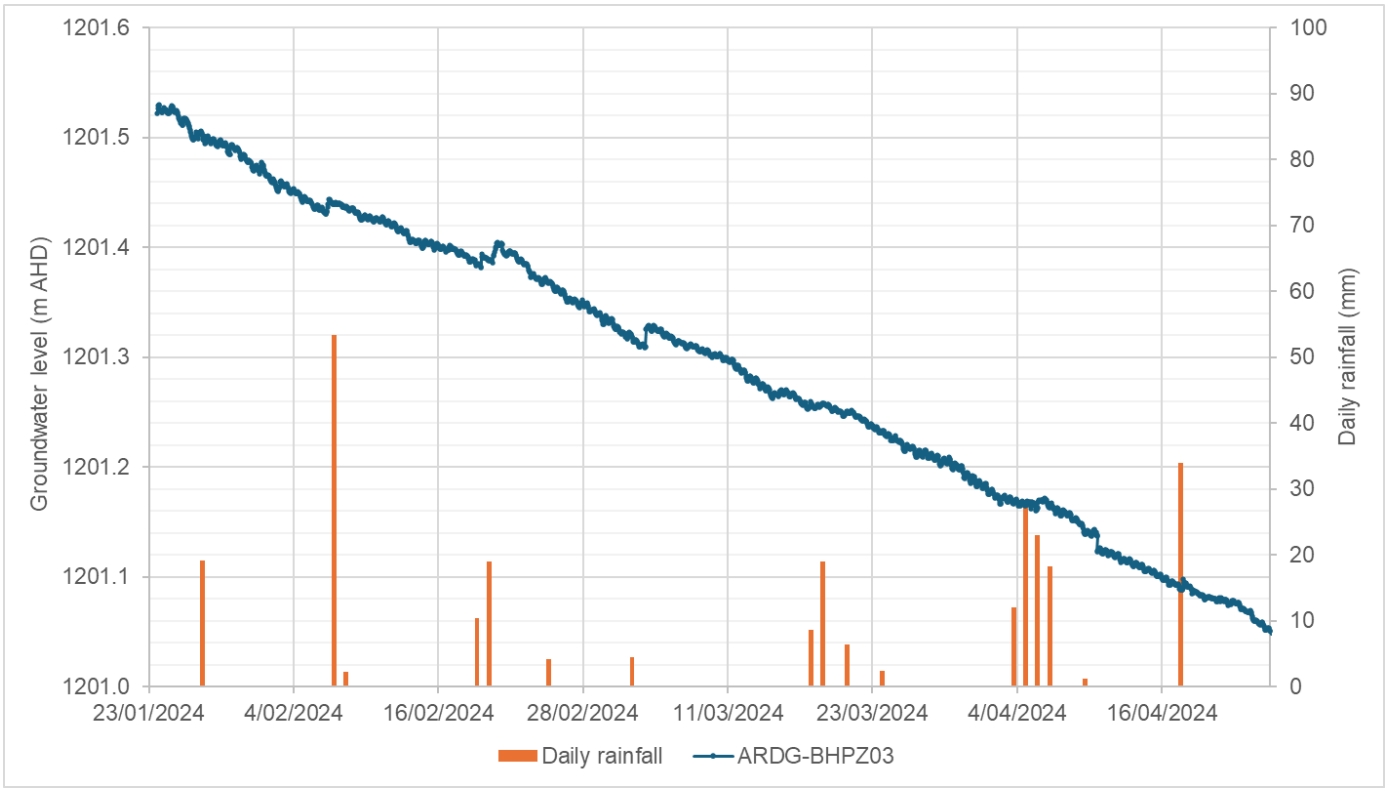
ARDG-BHPZ02 – baseline data and daily rainfall




ARDG-BHPZ02 – all monitoring data



ARDG-BHPZ03 – baseline data and daily rainfall

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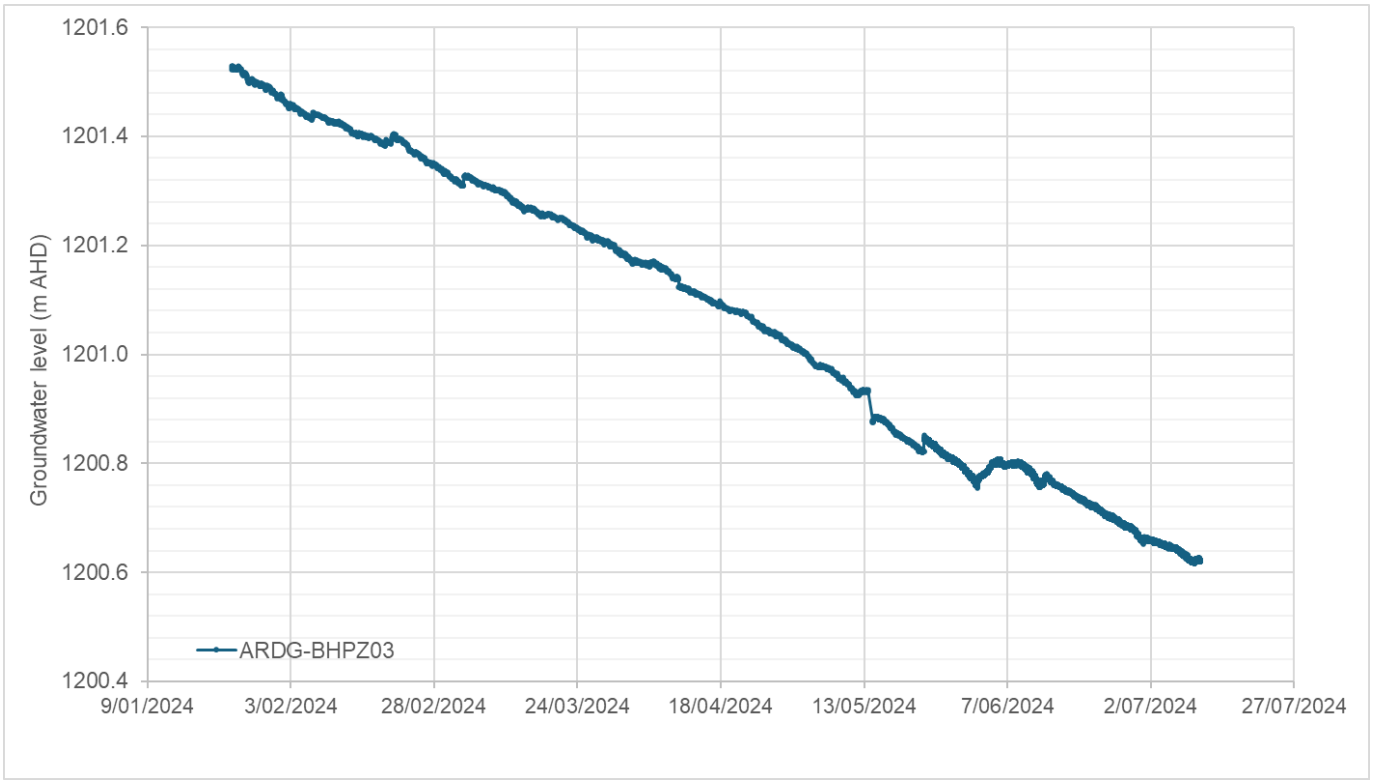
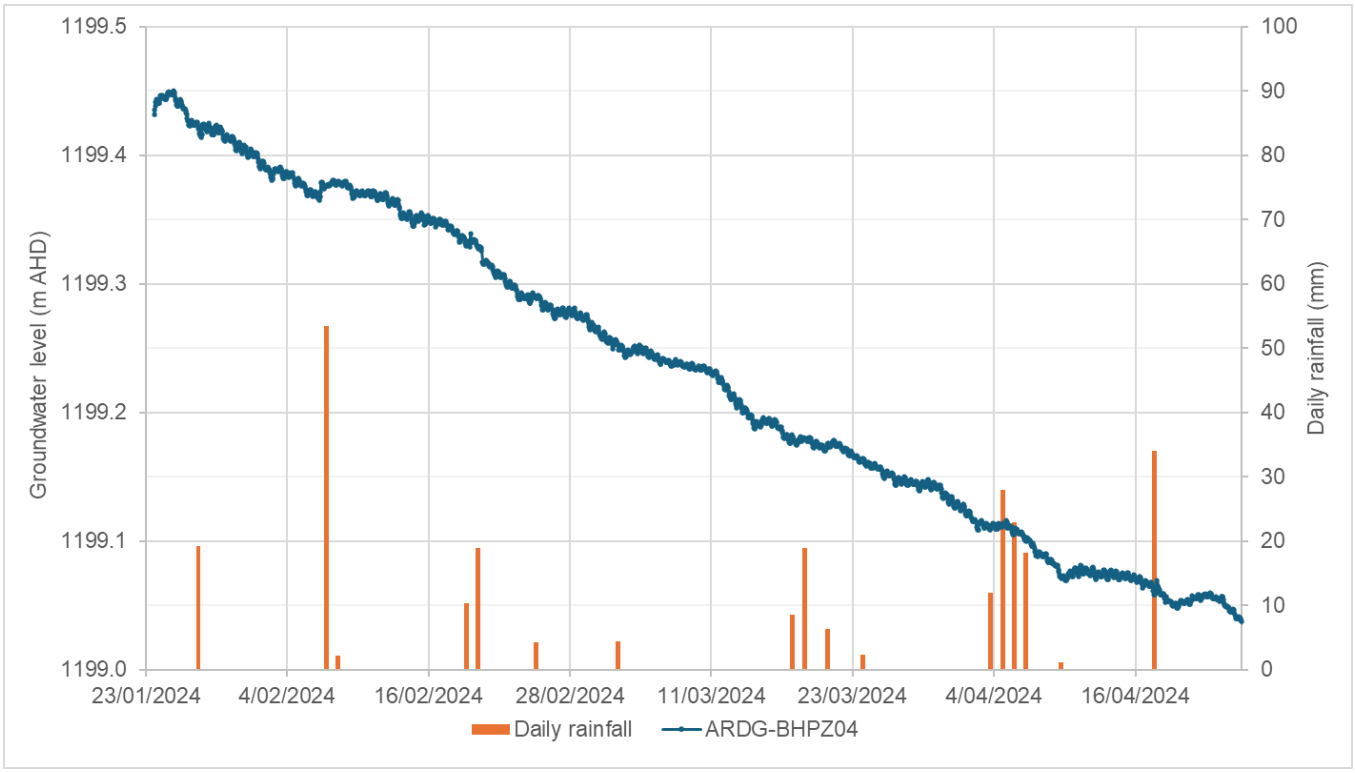
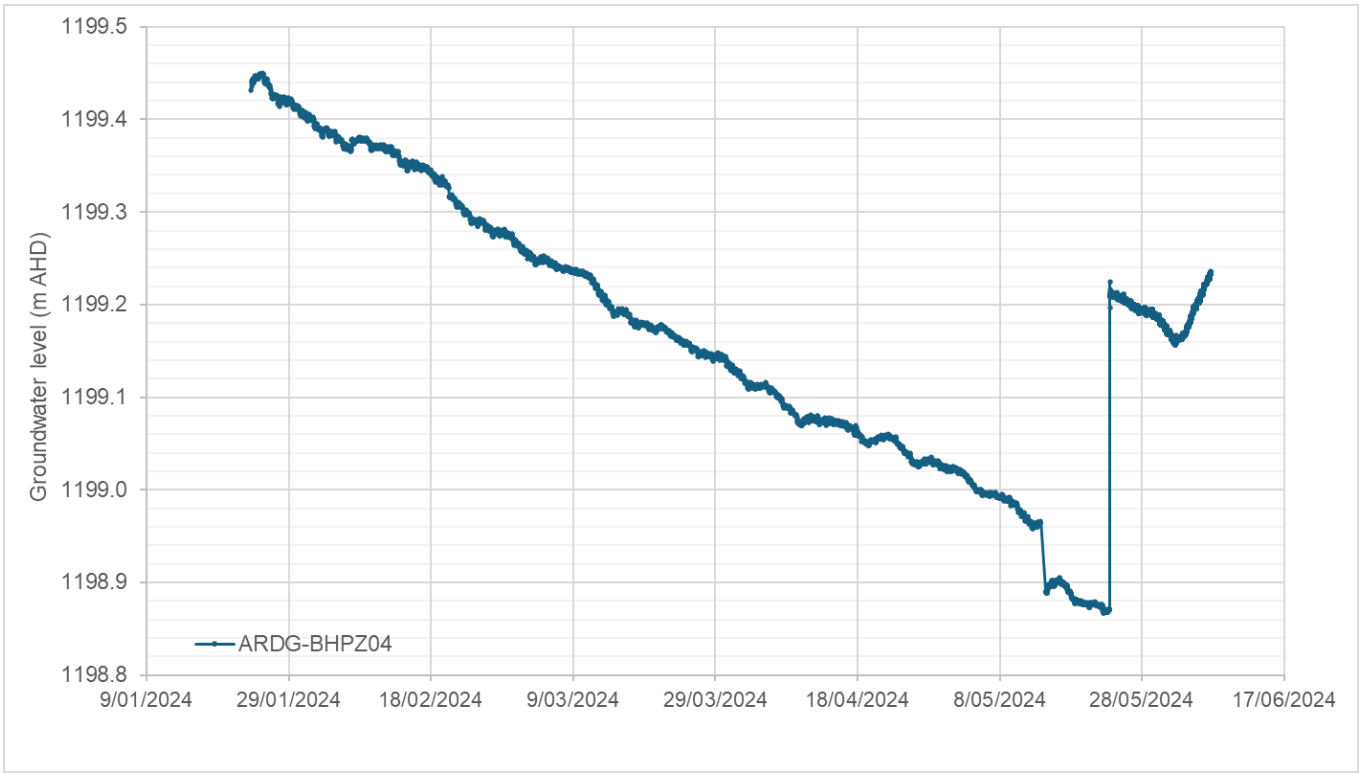


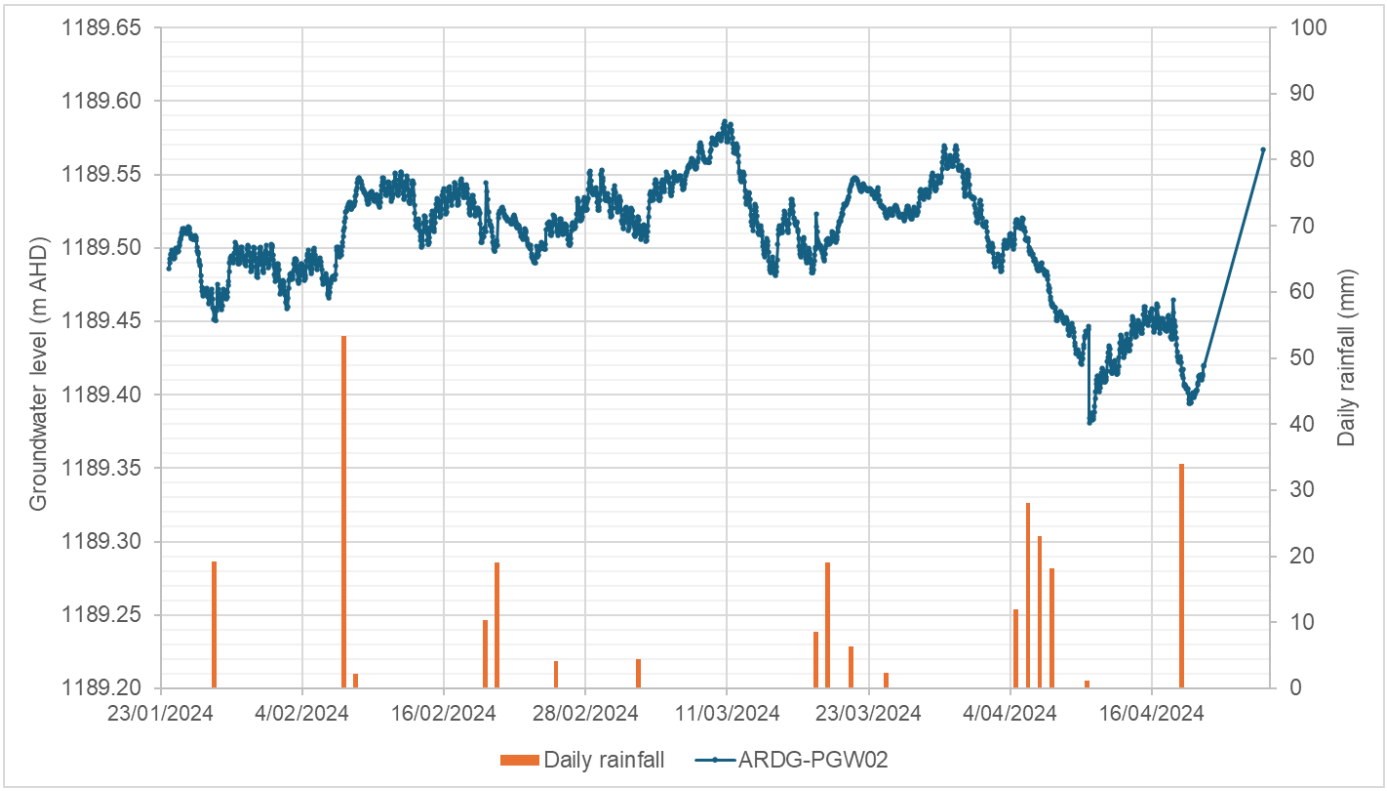
ARDG-BHPZ04 – baseline data and daily rainfall



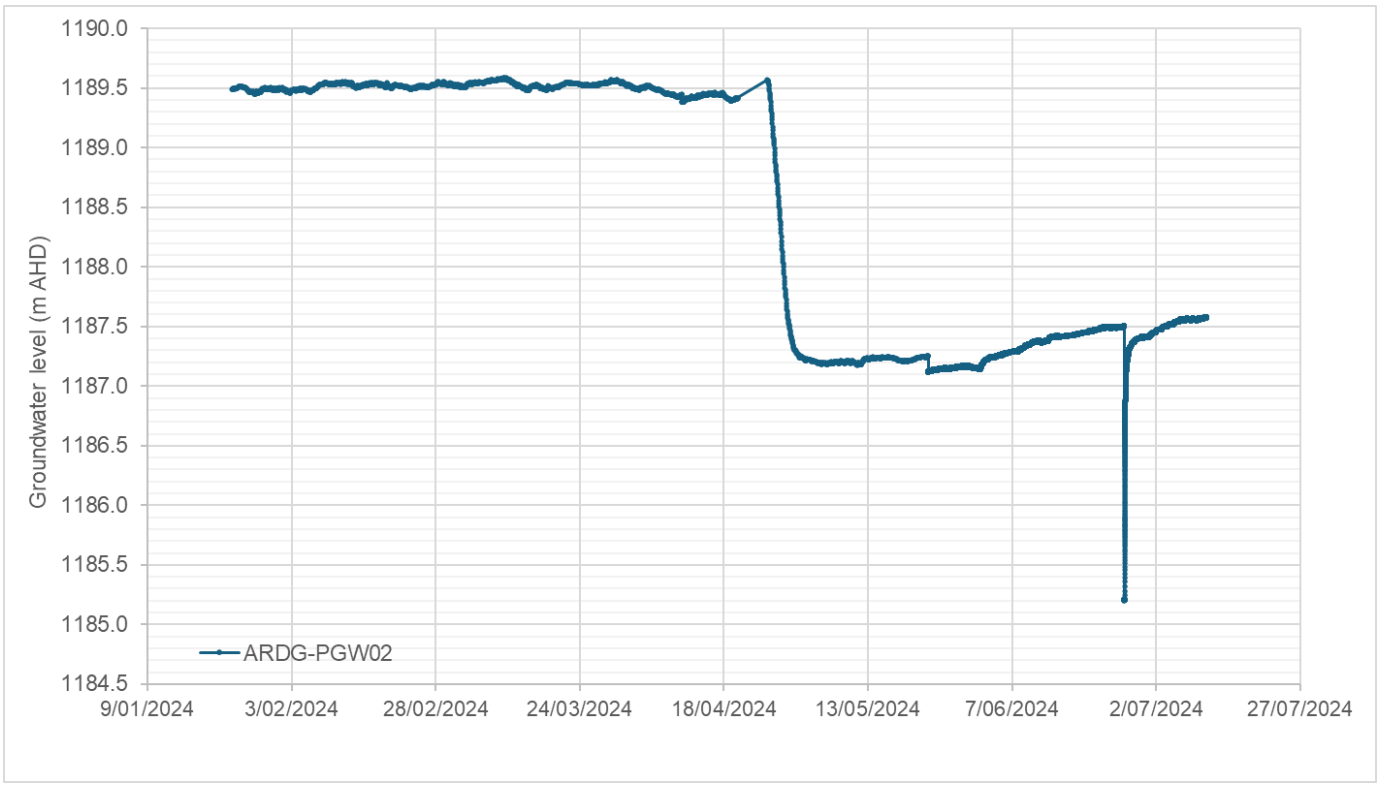

ARDG-BHPZ04 – all monitoring data



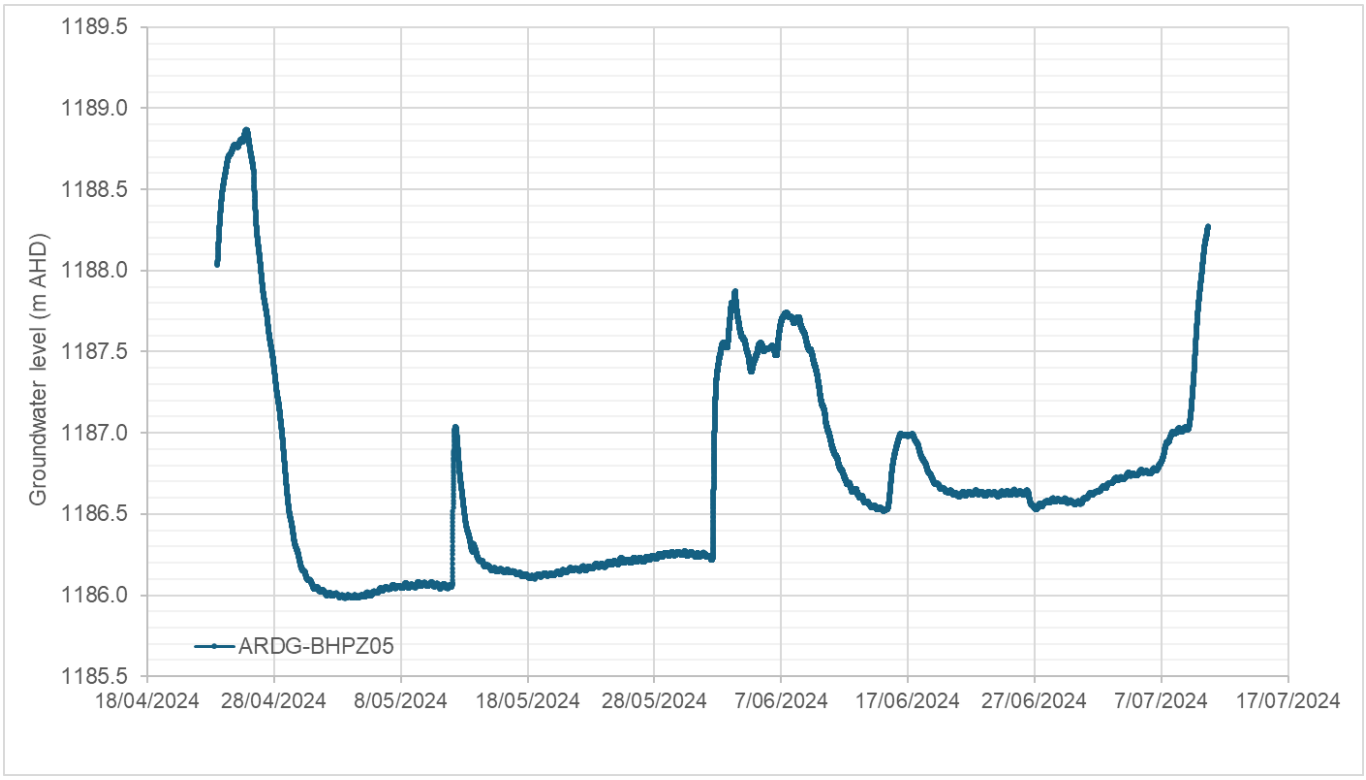
ARDG-PGW02 – baseline data and daily rainfall




ARDG-PGW02 – all monitoring data

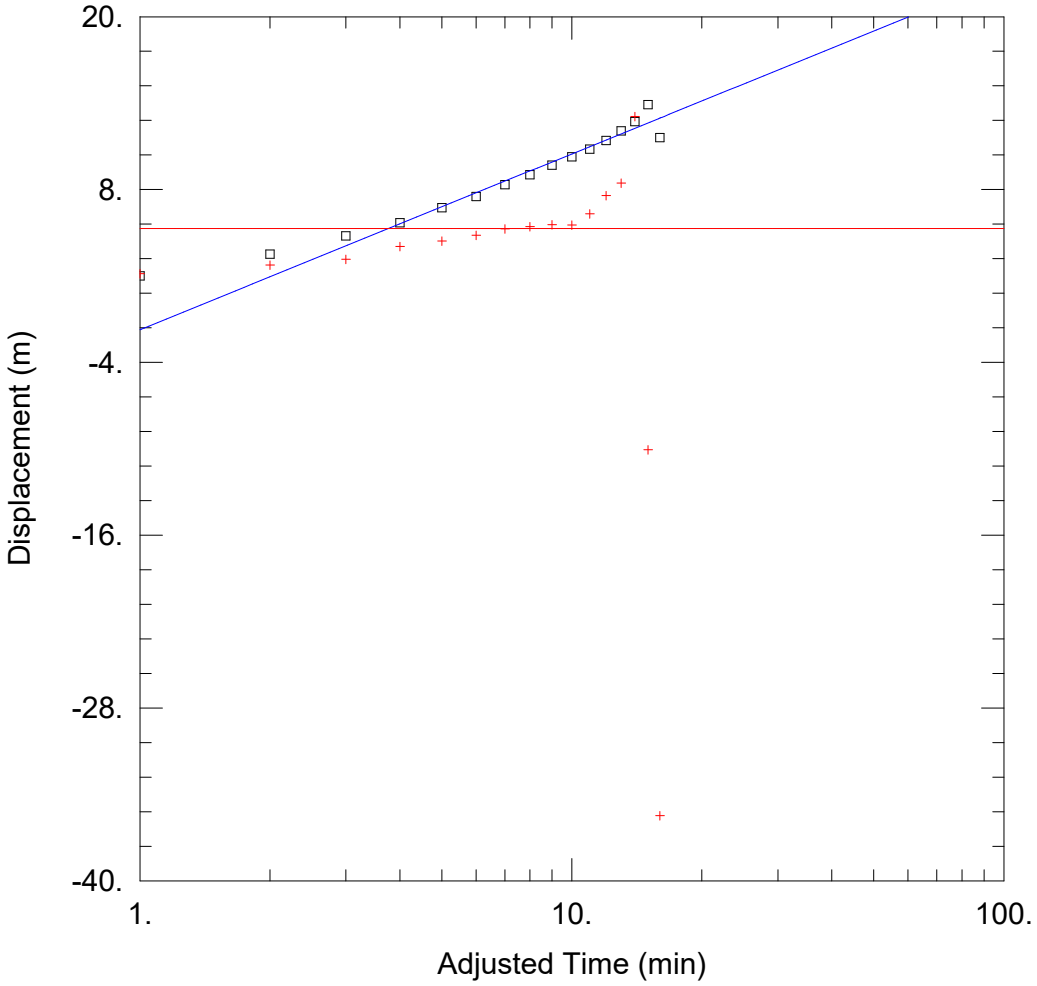


ARDG-BHPZ05 – all monitoring data



# Appendix B

## Pump test interpretation plots




## WELL TEST ANALYSIS

Data Set: \...\PGW02_Q0.aqt
Date: 01/22/24 Time: 13:42:38

## PROJECT INFORMATION

Company: GHD Pty Ltd
Client: ARDG Pty Ltd
Project: 12627449
Location: Bark Hut Quarry
Test Well: ARDG-PGW01
Test Date: 6/12/2023

## AQUIFER DATA

Saturated Thickness: 20. m Anisotropy Ratio (Kz/Kr): 0.1

## WELL DATA

Pumping Wells

| Well Name | X (m) | Y (m) |
|---|---|---|
| ARDG-PGW02 | 0 | 0 |

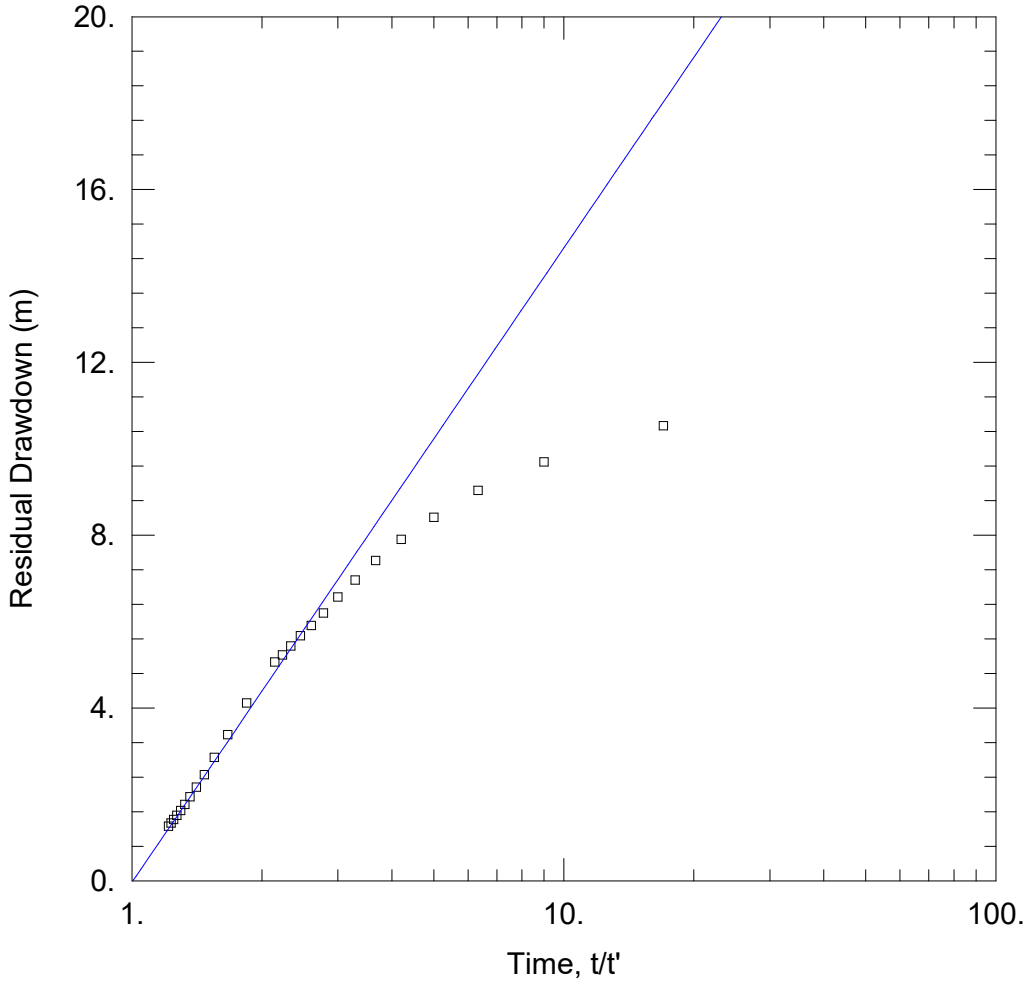
Observation Wells

| Well Name | X (m) | Y (m) |
|---|---|---|
| ▫ ARDG-PGW02 | 0 | 0 |

## SOLUTION

Aquifer Model: Confined Solution Method: Cooper-Jacob

T = 2.229 $m^2$/day S = 0.4827




## WELL TEST ANALYSIS

Data Set: \...\PGW02_Q0.aqt
Date: 01/22/24 Time: 13:44:13

## PROJECT INFORMATION

Company: GHD Pty Ltd
Client: ARDG Pty Ltd
Project: 12627449
Location: Bark Hut Quarry
Test Well: ARDG-PGW01
Test Date: 6/12/2023

## AQUIFER DATA

Saturated Thickness: 20. m Anisotropy Ratio (Kz/Kr): 0.1

## WELL DATA

Pumping Wells

| Well Name | X (m) | Y (m) |
|---|---|---|
| ARDG-PGW02 | 0 | 0 |

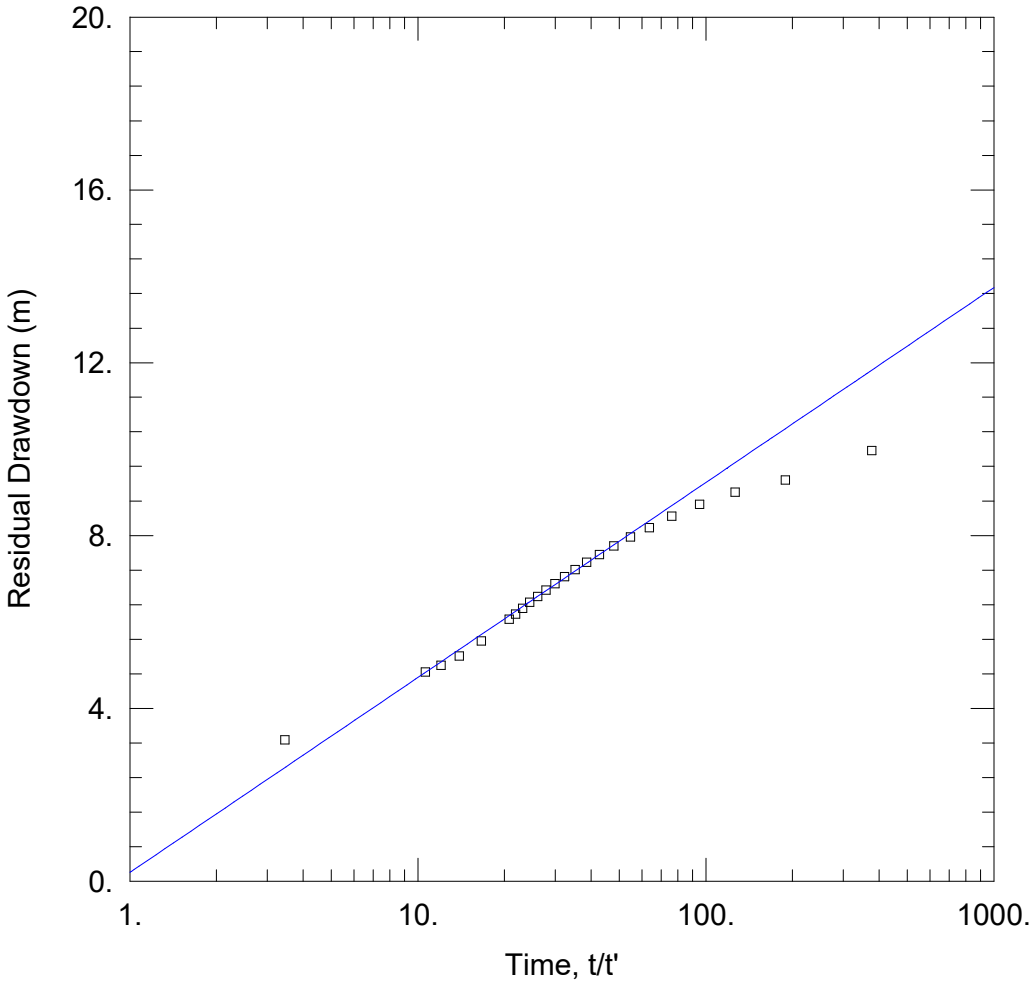
Observation Wells

| Well Name | X (m) | Y (m) |
|---|---|---|
| ARDG-PGW02 | 0 | 0 |

## SOLUTION

Aquifer Model: Confined Solution Method: Theis (Recovery)

T = 1.855 $m^2$/day S/S' = 1.006




## WELL TEST ANALYSIS

Data Set: \...\PGW02_Q2.aqt
Date: 01/25/24 Time: 13:40:06

## PROJECT INFORMATION

Company: GHD Pty Ltd
Client: ARDG Pty Ltd
Project: 12627449
Location: Bark Hut Quarry
Test Well: ARDG-PGW01
Test Date: 6/12/2023

## AQUIFER DATA

Saturated Thickness: 20. m Anisotropy Ratio (Kz/Kr): 0.1

## WELL DATA

Pumping Wells

| Well Name | X (m) | Y (m) |
|---|---|---|
| ARDG-PGW02 | 0 | 0 |

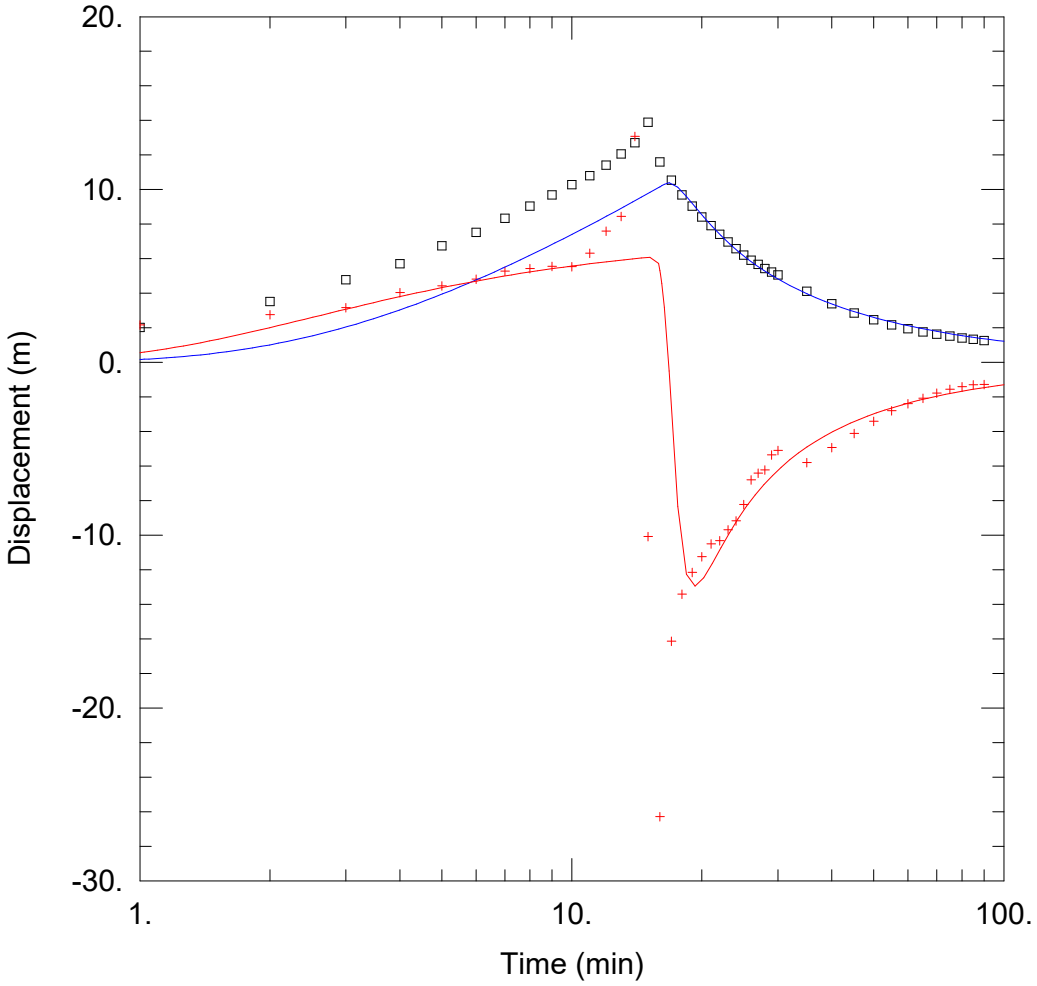
Observation Wells

| Well Name | X (m) | Y (m) |
|---|---|---|
| ARDG-PGW02 | 0 | 0 |

## SOLUTION

Aquifer Model: Confined Solution Method: Theis (Recovery)

T = 1.825 $m^2$/day S/S' = 0.9024




## WELL TEST ANALYSIS

Data Set: \...\PGW02_Q0.aqt
Date: 01/22/24 Time: 13:45:33

## PROJECT INFORMATION

Company: GHD Pty Ltd
Client: ARDG Pty Ltd
Project: 12627449
Location: Bark Hut Quarry
Test Well: ARDG-PGW01
Test Date: 6/12/2023

## WELL DATA

Pumping Wells

| Well Name | X (m) | Y (m) |
|---|---|---|
| ARDG-PGW02 | 0 | 0 |

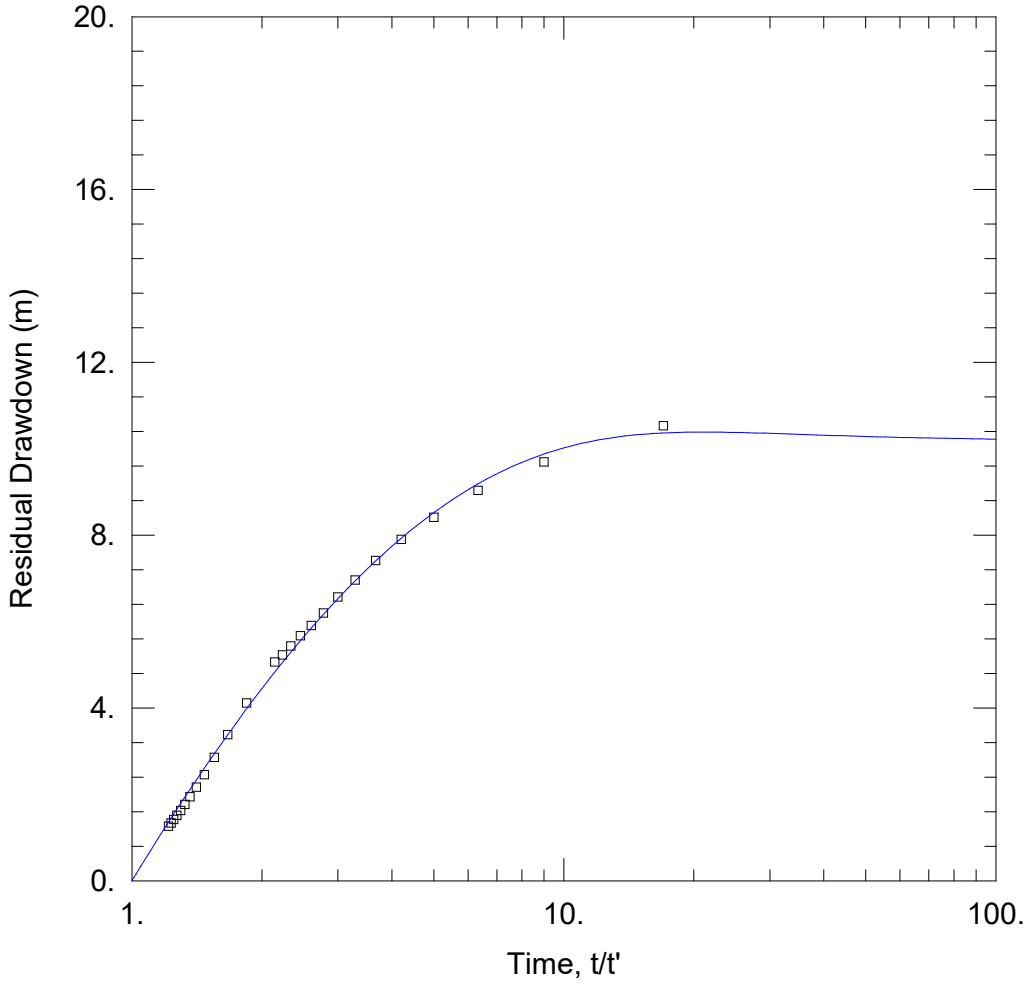
Observation Wells

| Well Name | X (m) | Y (m) |
|---|---|---|
| □ ARDG-PGW02 | 0 | 0 |

## SOLUTION

Aquifer Model: Confined
Solution Method: Theis/Hantush

T = 1.643 $m^2$/day
S = 1.165
Kz/Kr = 0.1
b = 20. m




## WELL TEST ANALYSIS

Data Set: \...\PGW02_Q0.aqt
Date: 01/22/24 Time: 13:45:16

## PROJECT INFORMATION

Company: GHD Pty Ltd
Client: ARDG Pty Ltd
Project: 12627449
Location: Bark Hut Quarry
Test Well: ARDG-PGW01
Test Date: 6/12/2023

## WELL DATA

Pumping Wells

| Well Name | X (m) | Y (m) |
|---|---|---|
| ARDG-PGW02 | 0 | 0 |

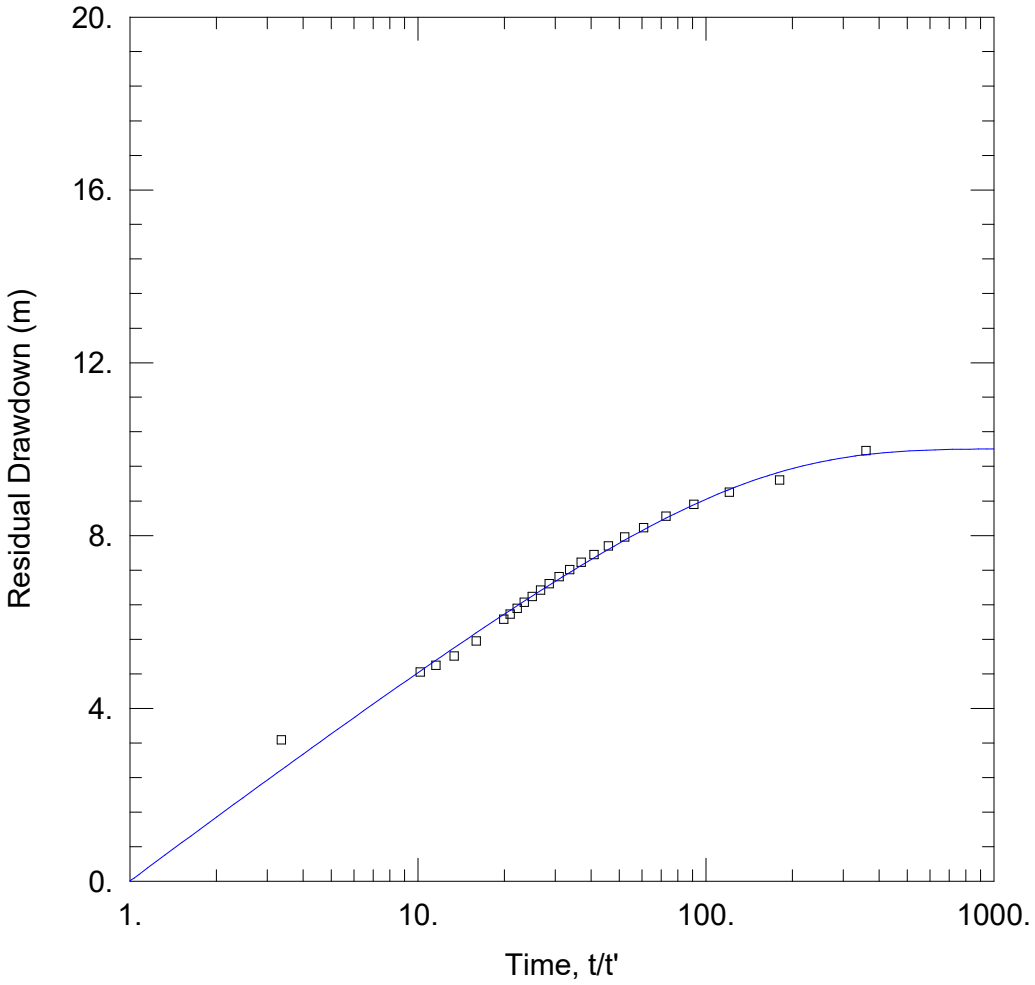
Observation Wells

| Well Name | X (m) | Y (m) |
|---|---|---|
| ARDG-PGW02 | 0 | 0 |

## SOLUTION

Aquifer Model: Confined
Solution Method: Theis/Hantush

T = 1.643 $m^2$/day
S = 1.165
Kz/Kr = 0.1
b = 20. m




## WELL TEST ANALYSIS

Data Set: \...\PGW02_Q2.aqt
Date: 01/25/24 Time: 13:42:29

## PROJECT INFORMATION

Company: GHD Pty Ltd
Client: ARDG Pty Ltd
Project: 12627449
Location: Bark Hut Quarry
Test Well: ARDG-PGW01
Test Date: 6/12/2023

## WELL DATA

Pumping Wells

| Well Name | X (m) | Y (m) |
|---|---|---|
| ARDG-PGW02 | 0 | 0 |

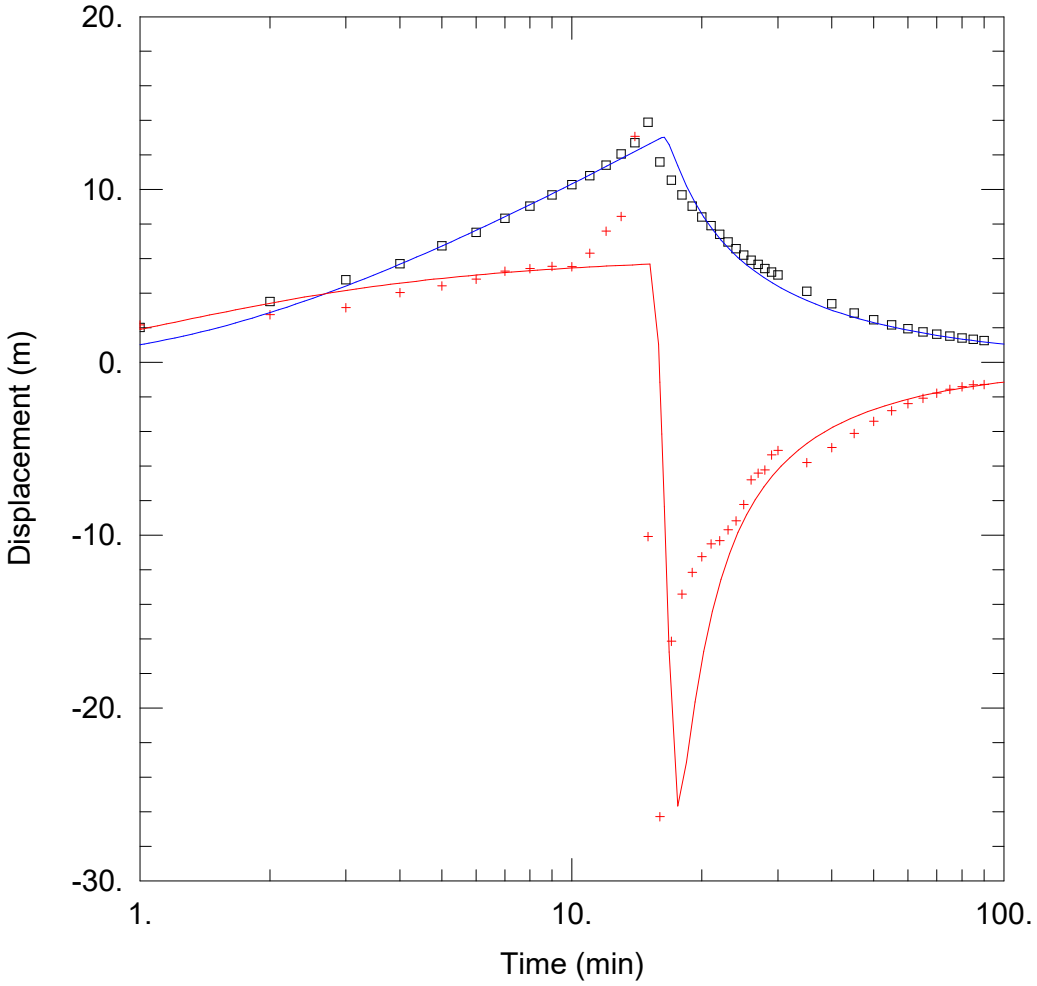
Observation Wells

| Well Name | X (m) | Y (m) |
|---|---|---|
| ▫ ARDG-PGW02 | 0 | 0 |

## SOLUTION

Aquifer Model: Confined
Solution Method: Theis/Hantush

T = 1.705 $m^2$/day
S = 0.8515
Kz/Kr = 0.1
b = 20. m




## WELL TEST ANALYSIS

Data Set: \...\PGW02_Q0.aqt
Date: 01/22/24 Time: 13:46:16

## PROJECT INFORMATION

Company: GHD Pty Ltd
Client: ARDG Pty Ltd
Project: 12627449
Location: Bark Hut Quarry
Test Well: ARDG-PGW01
Test Date: 6/12/2023

## WELL DATA

Pumping Wells

| Well Name | X (m) | Y (m) |
|---|---|---|
| ARDG-PGW02 | 0 | 0 |

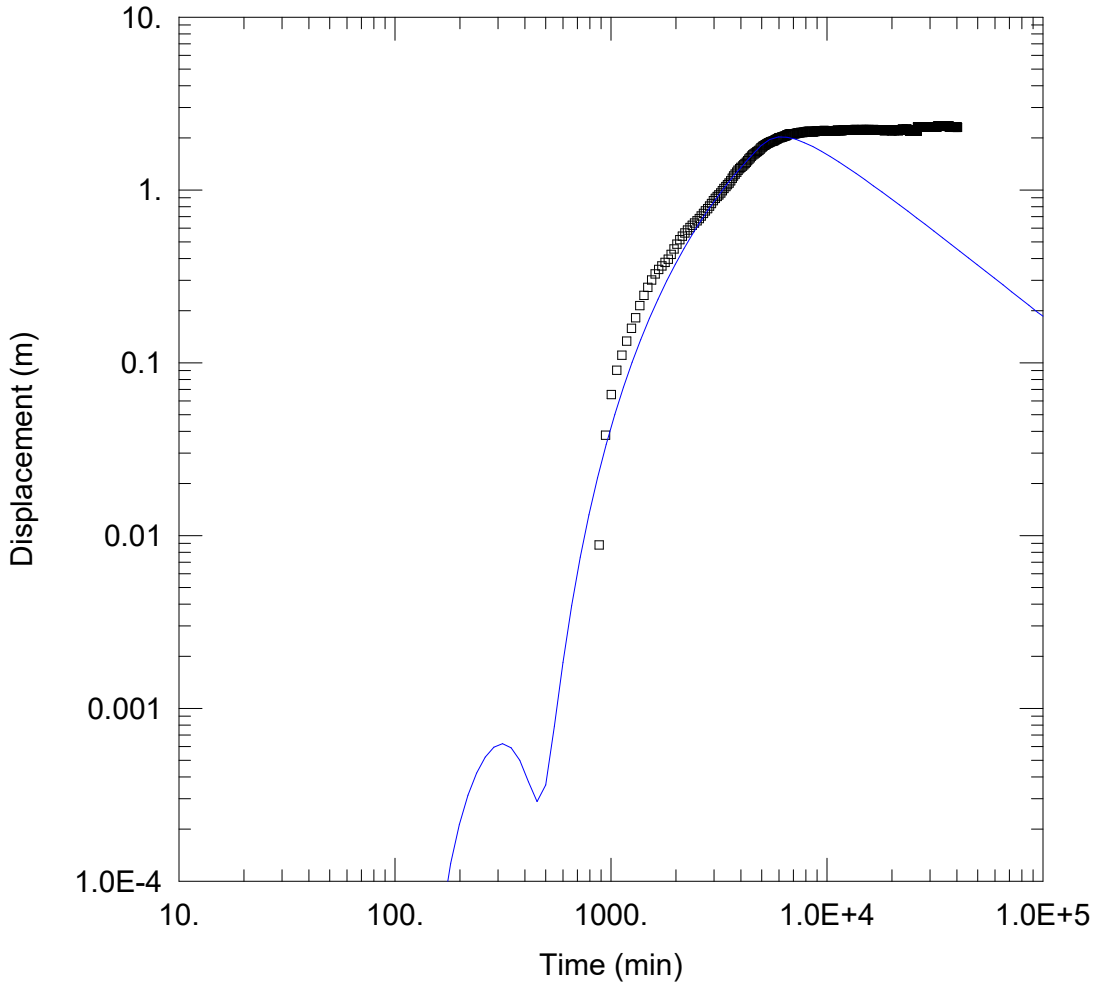
Observation Wells

| Well Name | X (m) | Y (m) |
|---|---|---|
| ▫ ARDG-PGW02 | 0 | 0 |

## SOLUTION

Aquifer Model: Confined
Solution Method: Theis/Hantush

T = 1.926 $m^2$/day
S = 0.6262
Kz/Kr = 0.1
b = 20. m




## WELL TEST ANALYSIS

Data Set: \...\PGW01_OBS_PGW02.aqt
Date: 07/29/24 Time: 13:48:23

## PROJECT INFORMATION

Company: GHD Pty Ltd
Client: ARDG Pty Ltd
Project: 12627449
Location: Bark Hut Quarry
Test Well: ARDG-PGW01
Test Date: 25/04/2024

## AQUIFER DATA

Saturated Thickness: 50. m Anisotropy Ratio (Kz/Kr): 0.09886

## WELL DATA

Pumping Wells

| Well Name | X (m) | Y (m) |
|---|---|---|
| ARDG-PGW01 | 383969 | 6579022 |

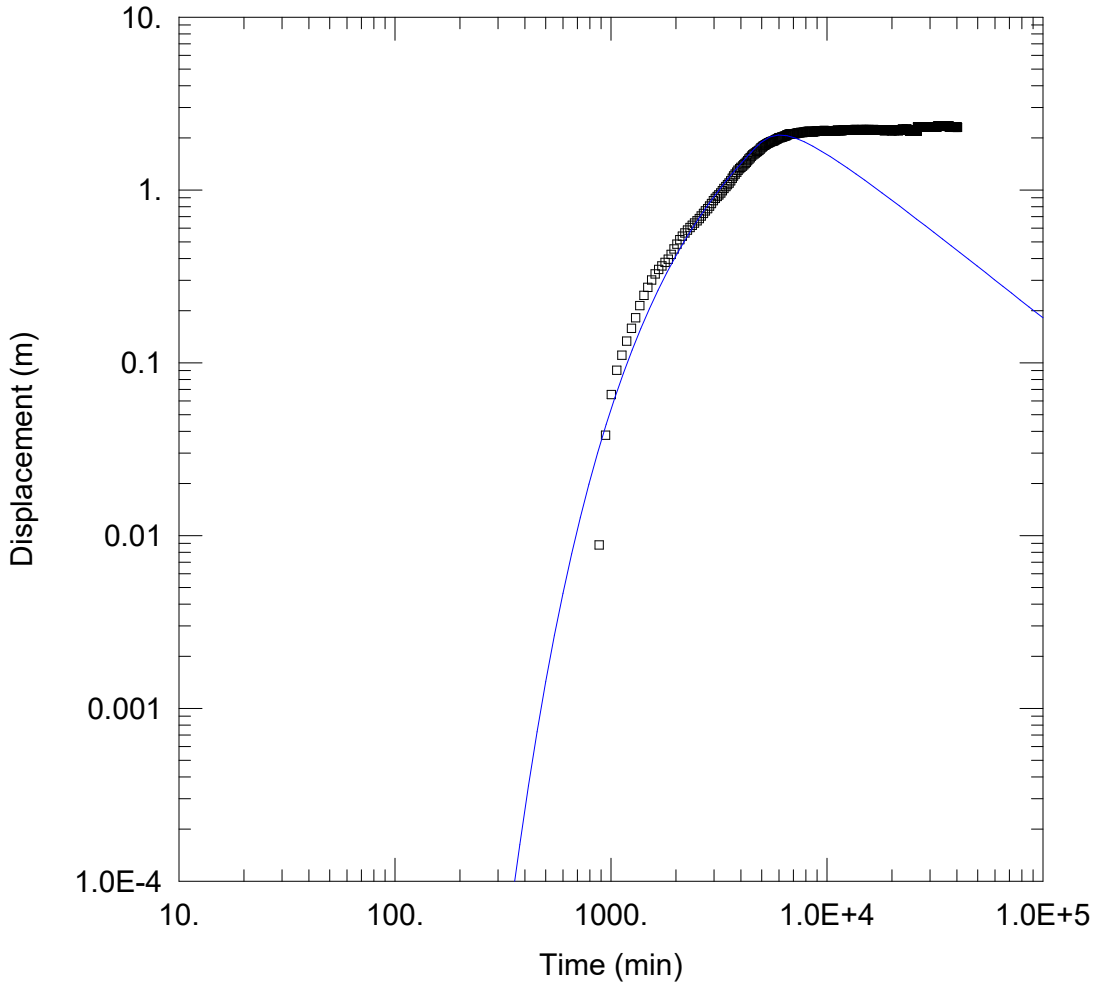
Observation Wells

| Well Name | X (m) | Y (m) |
|---|---|---|
| ▫ ARDG-PGW02 | 383991 | 6578912 |

## SOLUTION

Aquifer Model: Confined Solution Method: Papadopulos-Cooper

T = 8.137 $m^2$/day S = 0.005723
r(w) = 0.1 m r(c) = 0.075 m




## WELL TEST ANALYSIS

Data Set: \...\PGW01_OBS_PGW02.aqt
Date: 07/29/24 Time: 13:47:40

## PROJECT INFORMATION

Company: GHD Pty Ltd
Client: ARDG Pty Ltd
Project: 12627449
Location: Bark Hut Quarry
Test Well: ARDG-PGW01
Test Date: 25/04/2024

## WELL DATA

Pumping Wells

| Well Name | X (m) | Y (m) |
|---|---|---|
| ARDG-PGW01 | 383969 | 6579022 |

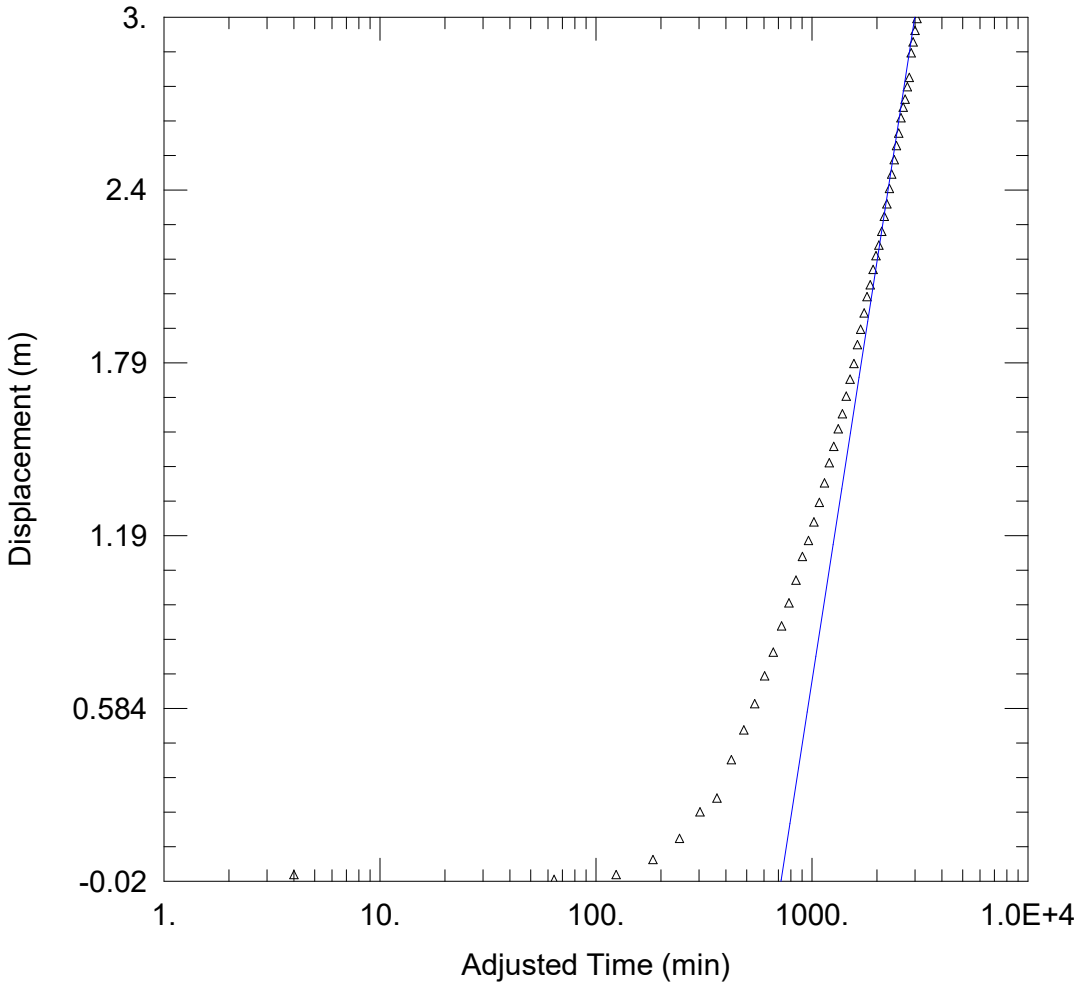
Observation Wells

| Well Name | X (m) | Y (m) |
|---|---|---|
| ▫ ARDG-PGW02 | 383991 | 6578912 |

## SOLUTION

Aquifer Model: Confined
Solution Method: Theis/Hantush

T = 8.32 $m^2$/day
S = 0.005548
Kz/Kr = 0.09886
b = 50. m




## WELL TEST ANALYSIS

Data Set: \...\PGW01_OBS_PZ01.aqt
Date: 07/29/24 Time: 13:11:57

## PROJECT INFORMATION

Company: GHD Pty Ltd
Client: ARDG Pty Ltd
Project: 12627449
Location: Bark Hut Quarry
Test Well: ARDG-PGW01
Test Date: 25/04/2024

## AQUIFER DATA

Saturated Thickness: 50. m Anisotropy Ratio (Kz/Kr): 0.1

## WELL DATA

Pumping Wells

| Well Name | X (m) | Y (m) |
|---|---|---|
| ARDG-PGW01 | 383969 | 6579022 |

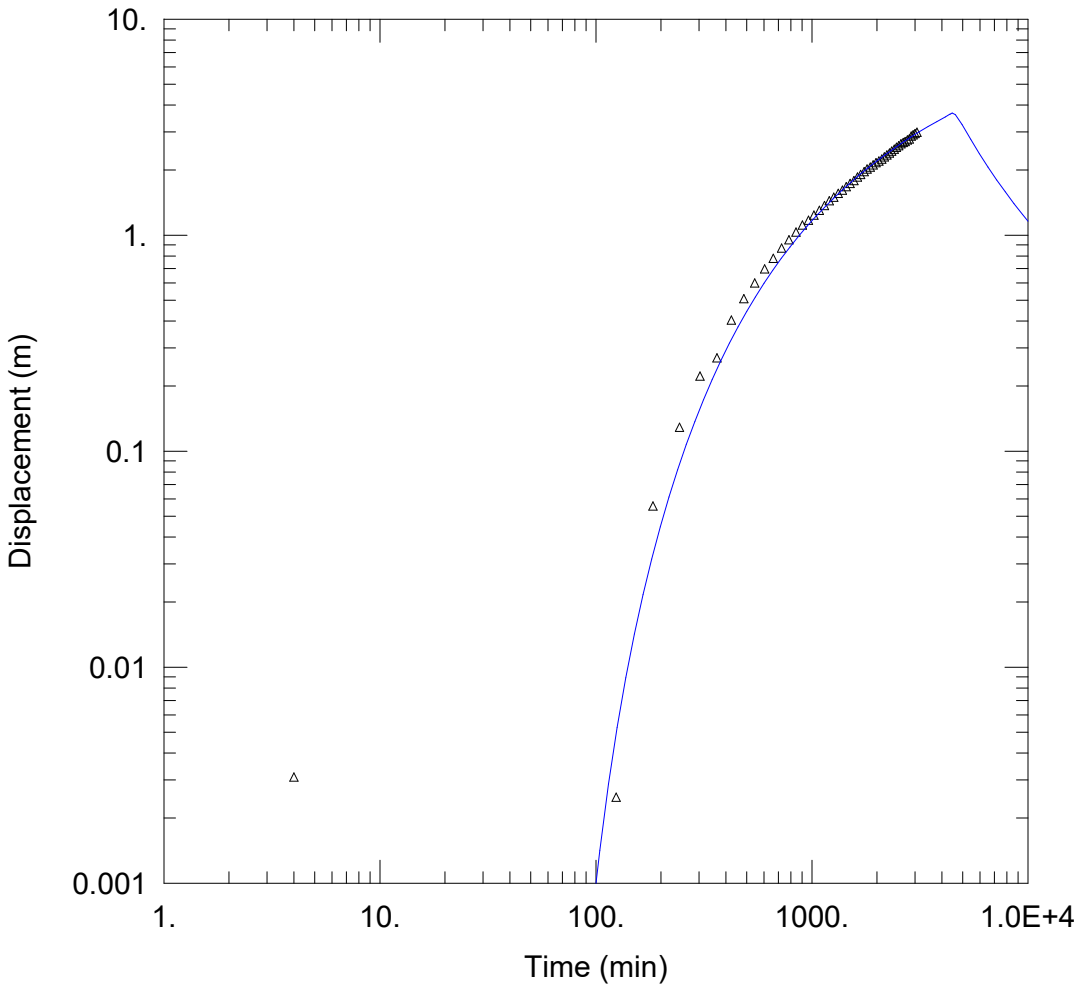
Observation Wells

| Well Name | X (m) | Y (m) |
|---|---|---|
| △ ARDG-BHPZ01 | 383956 | 6578807 |

## SOLUTION

Aquifer Model: Confined Solution Method: Cooper-Jacob

T = 16.59 $m^2$/day S = 0.0004049




## WELL TEST ANALYSIS

Data Set: \...\PGW01_OBS_PZ01.aqt
Date: 07/29/24 Time: 13:10:22

## PROJECT INFORMATION

Company: GHD Pty Ltd
Client: ARDG Pty Ltd
Project: 12627449
Location: Bark Hut Quarry
Test Well: ARDG-PGW01
Test Date: 25/04/2024

## AQUIFER DATA

Saturated Thickness: 50. m Anisotropy Ratio (Kz/Kr): 0.1

## WELL DATA

Pumping Wells

| Well Name | X (m) | Y (m) |
|---|---|---|
| ARDG-PGW01 | 383969 | 6579022 |

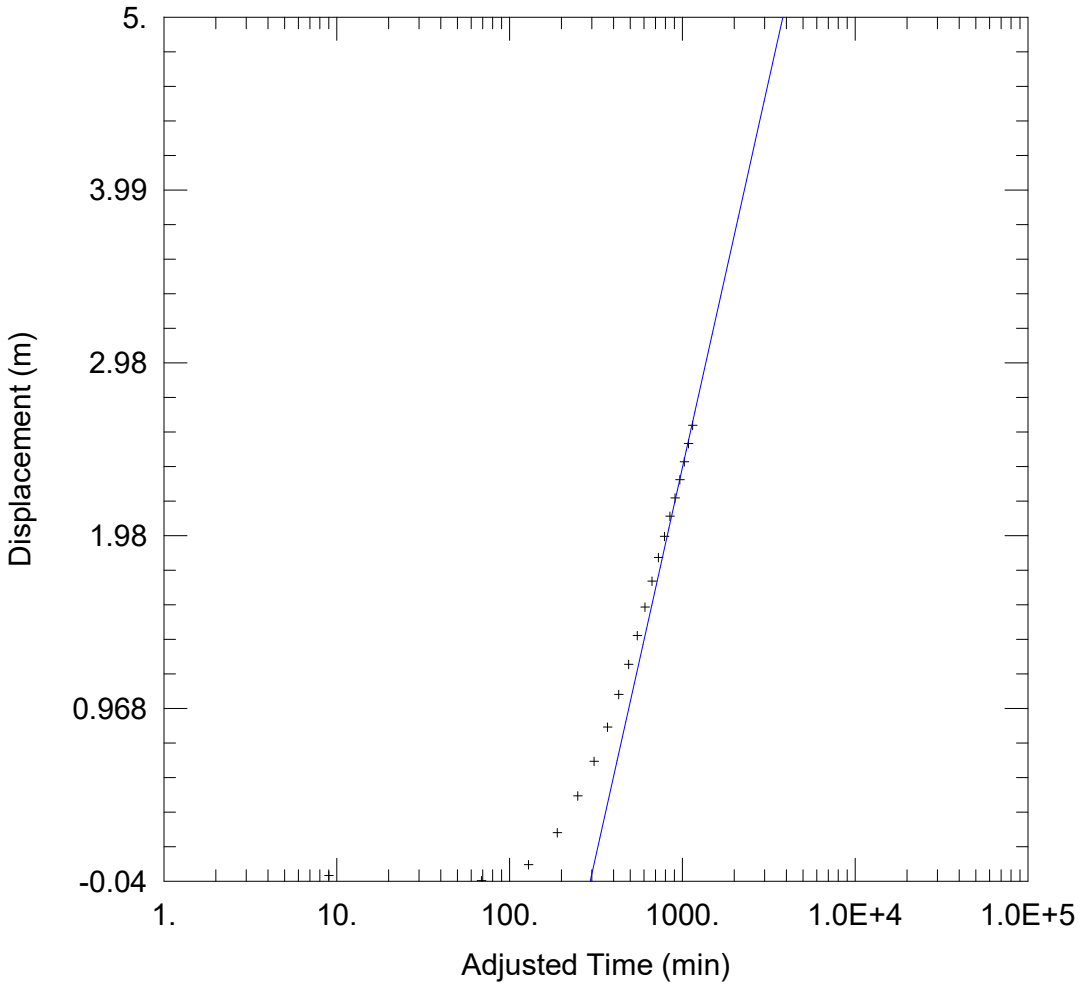
Observation Wells

| Well Name | X (m) | Y (m) |
|---|---|---|
| △ ARDG-BHPZ01 | 383956 | 6578807 |

## SOLUTION

Aquifer Model: Confined Solution Method: Papadopulos-Cooper

T = 16.1 $m^2$/day S = 0.0005021
r(w) = 0.1 m r(c) = 0.075 m




## WELL TEST ANALYSIS

Data Set: \...\PGW01_OBS_PZ02.aqt
Date: 07/29/24 Time: 13:15:14

## PROJECT INFORMATION

Company: GHD Pty Ltd
Client: ARDG Pty Ltd
Project: 12627449
Location: Bark Hut Quarry
Test Well: ARDG-PGW01
Test Date: 25/04/2024

## AQUIFER DATA

Saturated Thickness: 50. m Anisotropy Ratio (Kz/Kr): 0.1

## WELL DATA

Pumping Wells

| Well Name | X (m) | Y (m) |
|---|---|---|
| ARDG-PGW01 | 383969 | 6579022 |

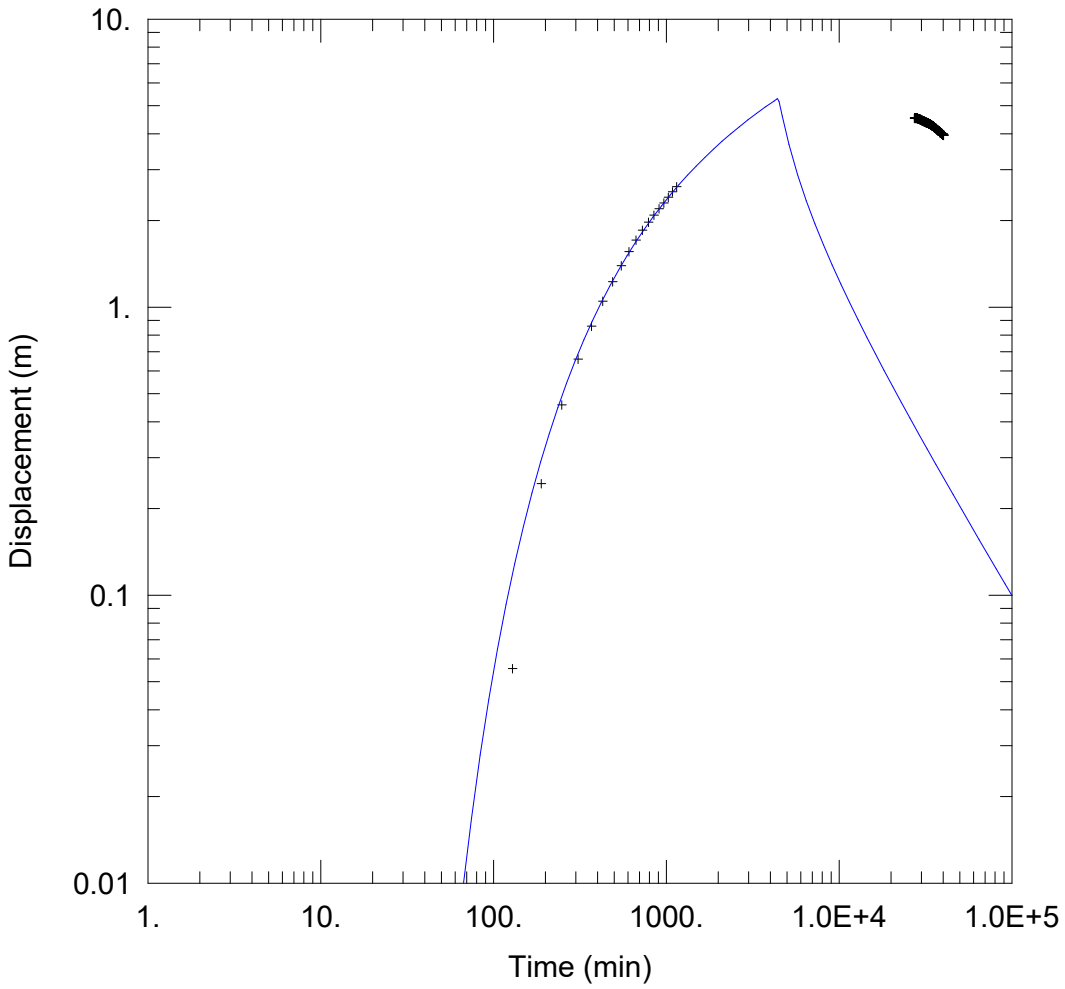
Observation Wells

| Well Name | X (m) | Y (m) |
|---|---|---|
| + ARDG-BHPZ02 | 383957 | 6578805 |

## SOLUTION

Aquifer Model: Confined Solution Method: Cooper-Jacob

T = 17.89 $m^2$/day S = 0.0001767




## WELL TEST ANALYSIS

Data Set: \...\PGW01_OBS_PZ02.aqt
Date: 07/29/24 Time: 13:20:01

## PROJECT INFORMATION

Company: GHD Pty Ltd
Client: ARDG Pty Ltd
Project: 12627449
Location: Bark Hut Quarry
Test Well: ARDG-PGW01
Test Date: 25/04/2024

## AQUIFER DATA

Saturated Thickness: 50. m Anisotropy Ratio (Kz/Kr): 0.1

## WELL DATA

Pumping Wells

| Well Name | X (m) | Y (m) |
|---|---|---|
| ARDG-PGW01 | 383969 | 6579022 |

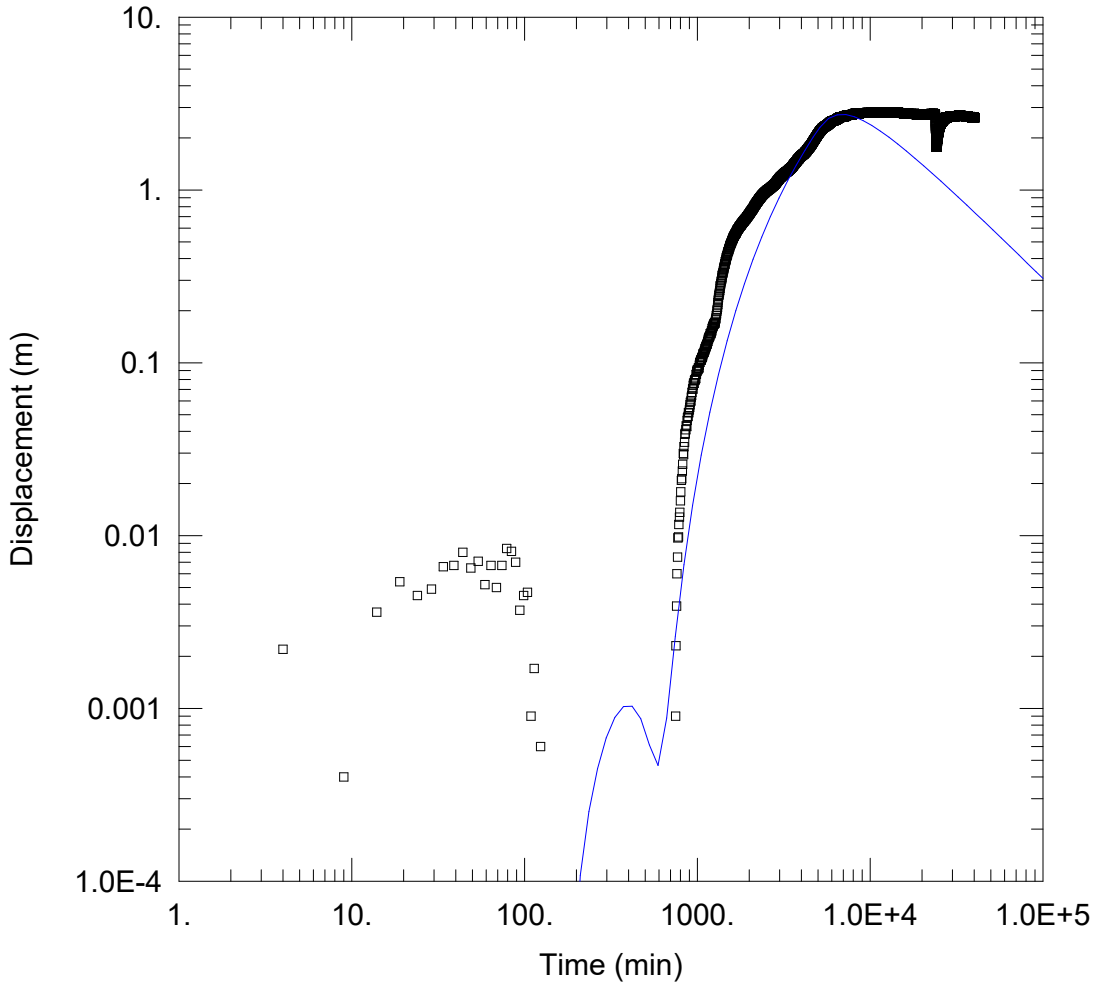
Observation Wells

| Well Name | X (m) | Y (m) |
|---|---|---|
| + ARDG-BHPZ02 | 383957 | 6578805 |

## SOLUTION

Aquifer Model: Confined Solution Method: Papadopulos-Cooper

T = 15.61 $m^2$/day S = 0.0002276
r(w) = 0.1 m r(c) = 0.075 m




## WELL TEST ANALYSIS

Data Set: \...\PGW01_OBS_PZ05.aqt
Date: 07/29/24 Time: 13:29:03

## PROJECT INFORMATION

Company: GHD Pty Ltd
Client: ARDG Pty Ltd
Project: 12627449
Location: Bark Hut Quarry
Test Well: ARDG-PGW01
Test Date: 25/04/2024

## AQUIFER DATA

Saturated Thickness: 50. m Anisotropy Ratio (Kz/Kr): 0.1

## WELL DATA

Pumping Wells

| Well Name | X (m) | Y (m) |
|---|---|---|
| ARDG-PGW01 | 383969 | 6579022 |

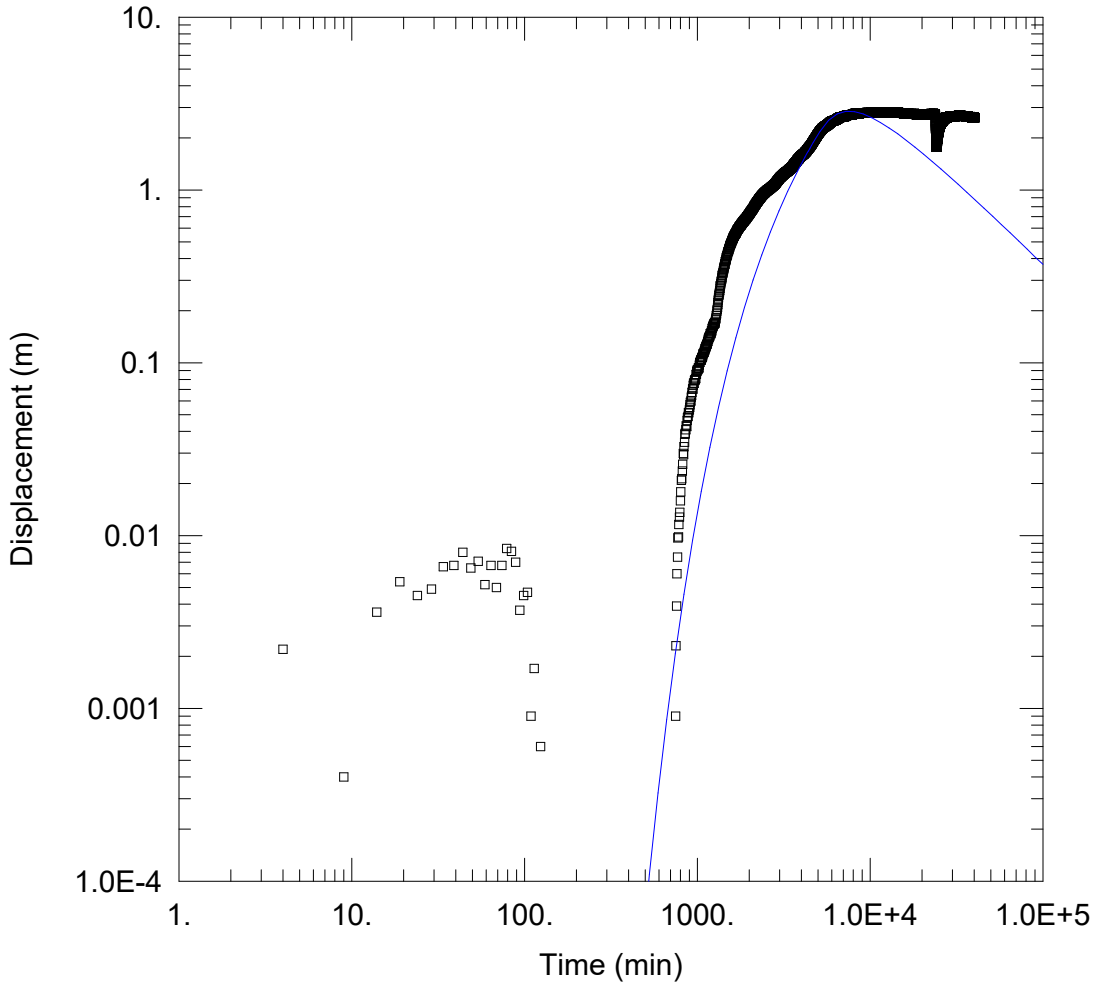
Observation Wells

| Well Name | X (m) | Y (m) |
|---|---|---|
| ARDH-BHPZ05 | 383975 | 6578819 |

## SOLUTION

Aquifer Model: Confined Solution Method: Papadopulos-Cooper

T = 4.871 $m^2$/day S = 0.001321
r(w) = 0.1 m r(c) = 0.075 m




## WELL TEST ANALYSIS

Data Set: \...\PGW01_OBS_PZ05.aqt
Date: 07/29/24 Time: 13:25:42

## PROJECT INFORMATION

Company: GHD Pty Ltd
Client: ARDG Pty Ltd
Project: 12627449
Location: Bark Hut Quarry
Test Well: ARDG-PGW01
Test Date: 25/04/2024

## WELL DATA

Pumping Wells

| Well Name | X (m) | Y (m) |
|---|---|---|
| ARDG-PGW01 | 383969 | 6579022 |

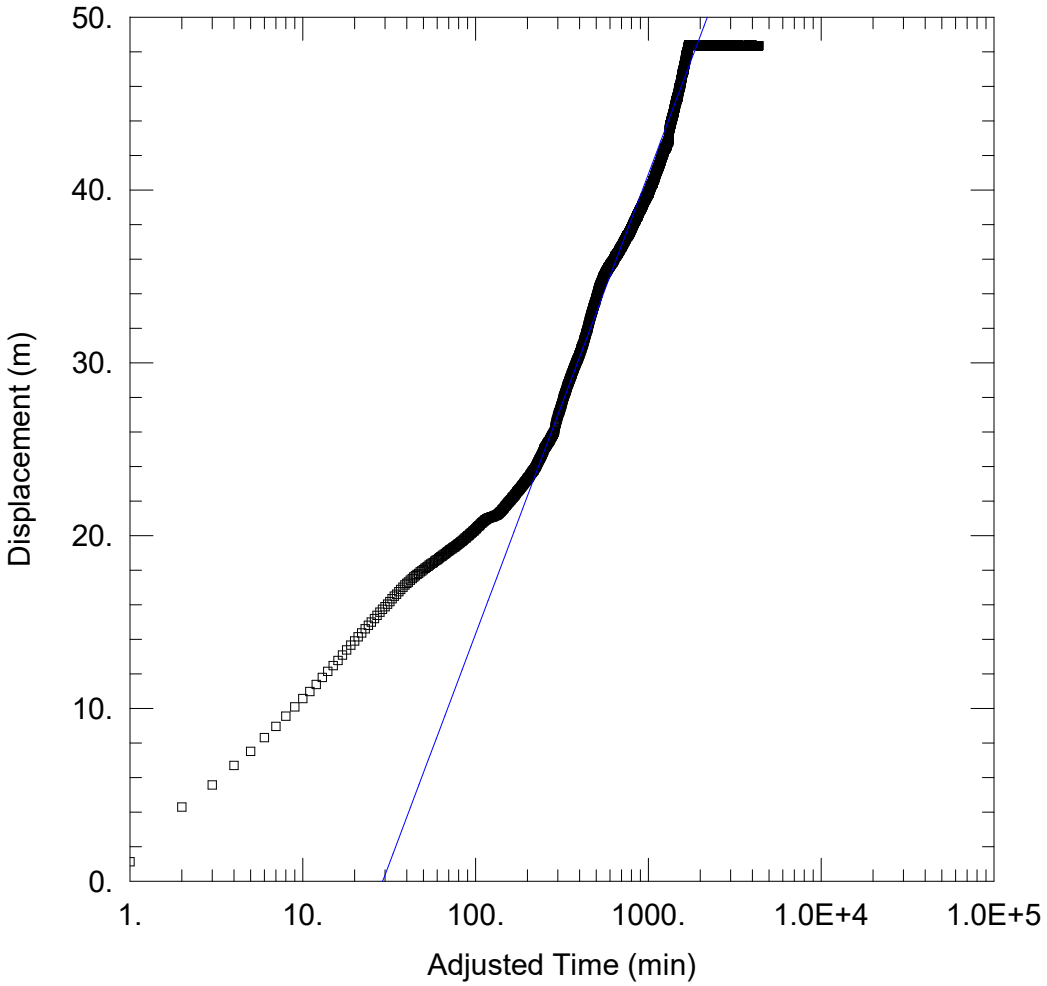
Observation Wells

| Well Name | X (m) | Y (m) |
|---|---|---|
| ▫ ARDH-BHPZ05 | 383975 | 6578819 |

## SOLUTION

Aquifer Model: Confined
Solution Method: Theis/Hantush

T = 4.012 $m^2$/day
S = 0.001283
Kz/Kr = 0.1
b = 50. m




## WELL TEST ANALYSIS

Data Set: \...\PGW01_PB.aqt
Date: 07/04/24 Time: 10:04:04

## PROJECT INFORMATION

Company: GHD Pty Ltd
Client: ARDG Pty Ltd
Project: 12627449
Location: Bark Hut Quarry
Test Well: ARDG-PGW01
Test Date: 25/04/2024

## AQUIFER DATA

Saturated Thickness: 50. m Anisotropy Ratio (Kz/Kr): 0.1

## WELL DATA

Pumping Wells

| Well Name | X (m) | Y (m) |
|---|---|---|
| ARDG-PGW01 | 0 | 0 |

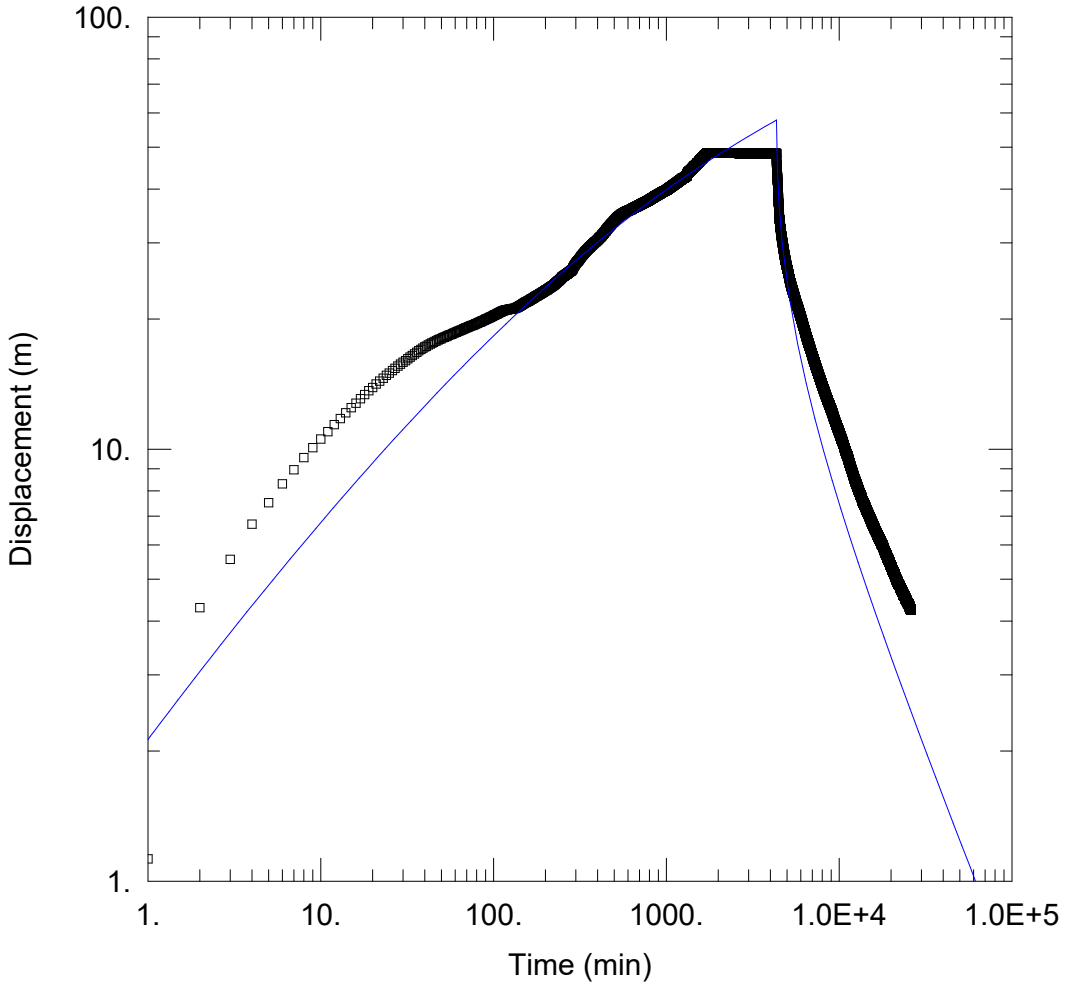
Observation Wells

| Well Name | X (m) | Y (m) |
|---|---|---|
| ARDG-PGW01 | 0 | 0 |

## SOLUTION

Aquifer Model: Confined Solution Method: Cooper-Jacob

T = 3.039 $m^2$/day S = 13.76




## WELL TEST ANALYSIS

Data Set: \...\PGW01_PB.aqt
Date: 07/04/24 Time: 10:09:37

## PROJECT INFORMATION

Company: GHD Pty Ltd
Client: ARDG Pty Ltd
Project: 12627449
Location: Bark Hut Quarry
Test Well: ARDG-PGW01
Test Date: 25/04/2024

## AQUIFER DATA

Saturated Thickness: 50. m Anisotropy Ratio (Kz/Kr): 0.1

## WELL DATA

Pumping Wells

| Well Name | X (m) | Y (m) |
|---|---|---|
| ARDG-PGW01 | 0 | 0 |

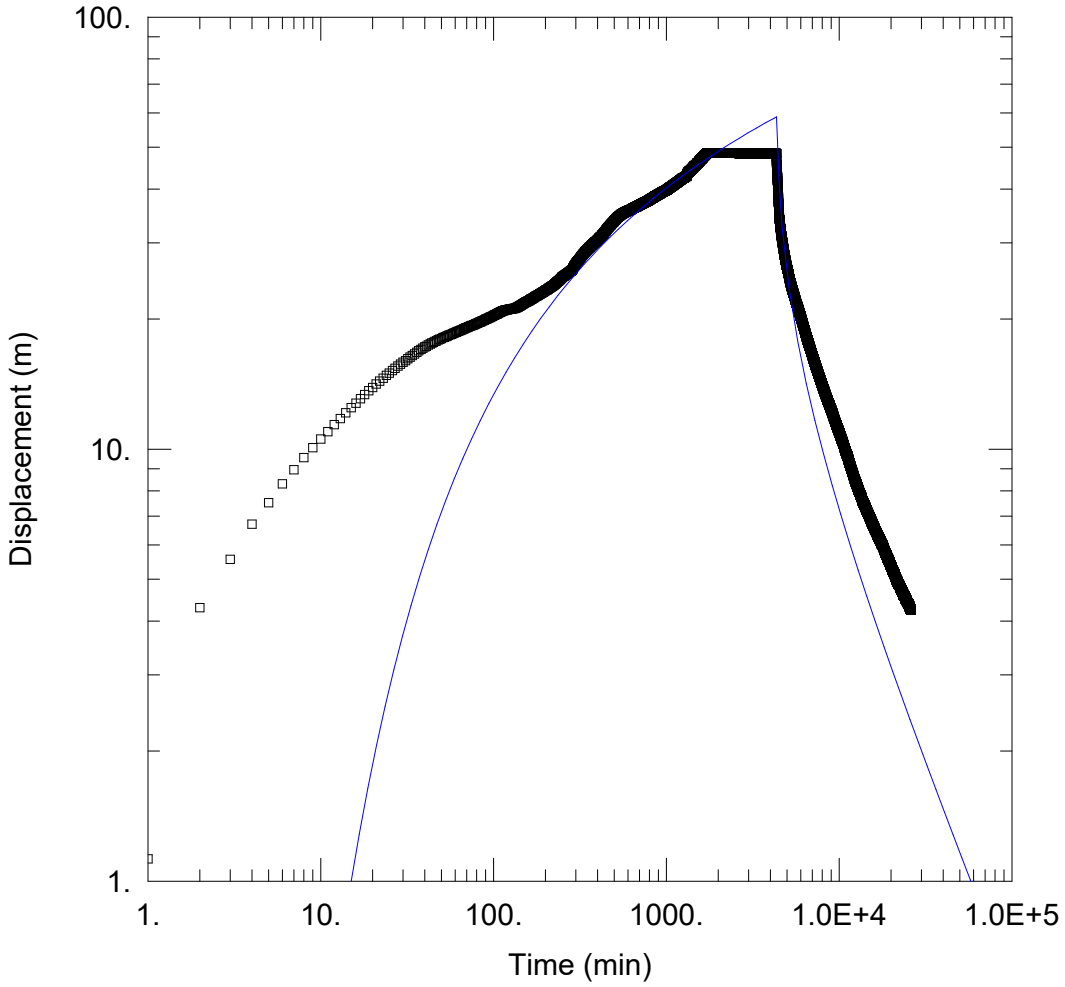
Observation Wells

| Well Name | X (m) | Y (m) |
|---|---|---|
| ARDG-PGW01 | 0 | 0 |

## SOLUTION

Aquifer Model: Confined Solution Method: Papadopulos-Cooper

T = 2.541 $m^2$/day S = 28.94
r(w) = 0.1 m r(c) = 0.075 m




## WELL TEST ANALYSIS

Data Set: \...\PGW01_PB.aqt
Date: 07/04/24 Time: 10:00:31

## PROJECT INFORMATION

Company: GHD Pty Ltd
Client: ARDG Pty Ltd
Project: 12627449
Location: Bark Hut Quarry
Test Well: ARDG-PGW01
Test Date: 25/04/2024

## WELL DATA

Pumping Wells

| Well Name | X (m) | Y (m) |
|---|---|---|
| ARDG-PGW01 | 0 | 0 |

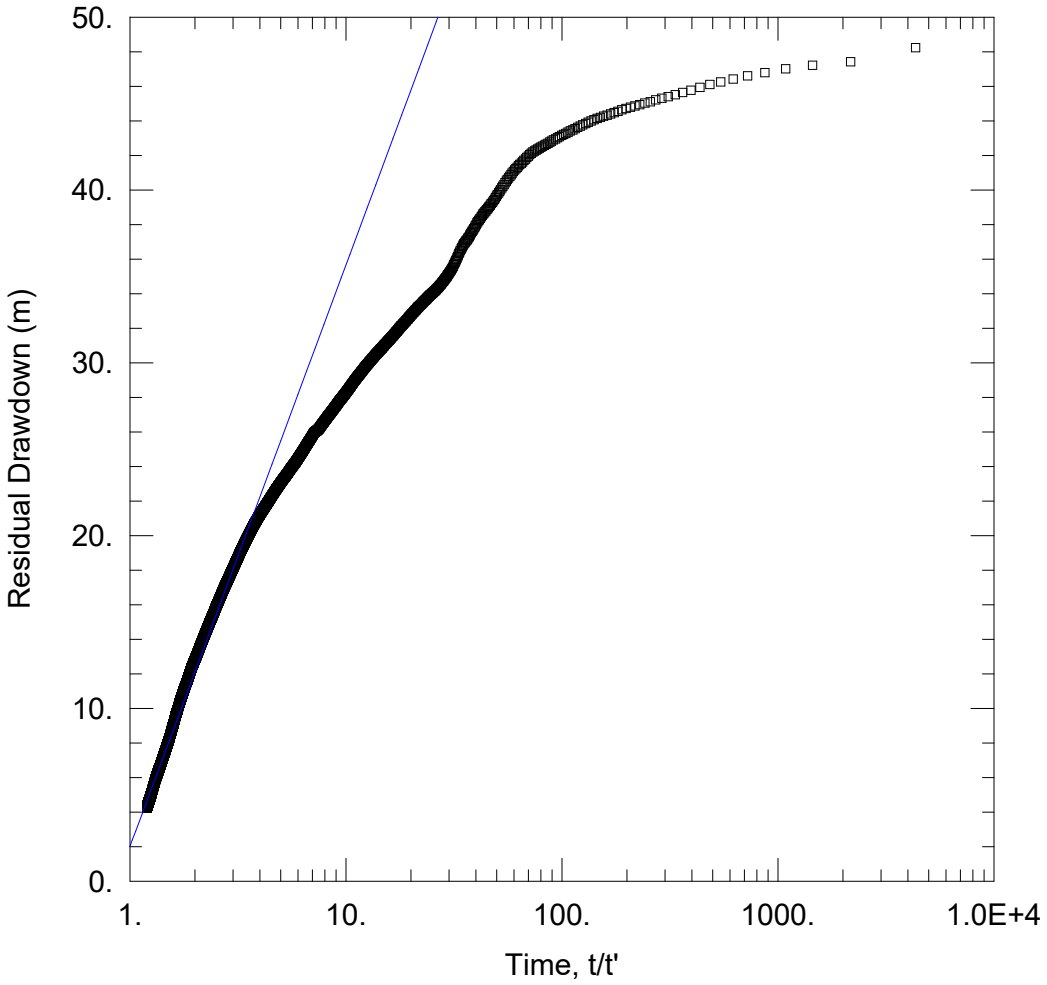
Observation Wells

| Well Name | X (m) | Y (m) |
|---|---|---|
| ▫ ARDG-PGW01 | 0 | 0 |

## SOLUTION

Aquifer Model: Confined
Solution Method: Theis/Hantush

T = 2.74 $m^2$/day
S = 19.05
Kz/Kr = 0.1
b = 50. m




## WELL TEST ANALYSIS

Data Set: \...\PGW01_PB.aqt
Date: 07/04/24 Time: 10:02:11

## PROJECT INFORMATION

Company: GHD Pty Ltd
Client: ARDG Pty Ltd
Project: 12627449
Location: Bark Hut Quarry
Test Well: ARDG-PGW01
Test Date: 25/04/2024

## AQUIFER DATA

Saturated Thickness: 50. m Anisotropy Ratio (Kz/Kr): 0.1

## WELL DATA

Pumping Wells

| Well Name | X (m) | Y (m) |
|---|---|---|
| ARDG-PGW01 | 0 | 0 |

Observation Wells

| Well Name | X (m) | Y (m) |
|---|---|---|
| ARDG-PGW01 | 0 | 0 |

## SOLUTION

Aquifer Model: Confined Solution Method: Theis (Recovery)

T = 2.403 $m^2$/day S/S' = 0.8733

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The Power of Commitment

# Appendix 3

## Noise Impact Assessment

Prepared by Sonus Pty Ltd

# Winterbourne Wind Farm

## Winterbourne Wind Farm Quarry

## Construction Noise Assessment

S6207.1C3

August 2024

sonus.

**Sonus Pty Ltd**
17 Ruthven Ave
Adelaide SA 5000
Phone: +61 (8) 8231 2100
Email: info@sonus.com.au
www.sonus.com.au

| | |
|---|---|
| **Document Title** | : Winterbourne Wind Farm - Winterbourne Wind Farm Quarry Construction Noise Assessment |
| **Client** | : Australian Resource Development Group |
| **Document Reference** | : S6207.1C3 |
| **Date** | : August 2024 |
| **Author** | : Simon Moore, MAAS |

**EXECUTIVE SUMMARY**

A noise assessment has been conducted for a temporary, project-specific quarry proposed as development that is ancillary to the Winterbourne Wind Farm (WWF) Project. The Winterbourne Wind Farm Quarry (WWF Quarry) is being proposed as part of an Amendment to the WWF Project currently being prepared. The WWF Project has a current estimated demand of 1Mt of quarry materials (e.g. road base/capping, concrete aggregates, gabion / drainage rock / TR sand) over the estimated 3 – 4 year construction period. It is proposed that the majority of this material could be supplied from this quarry site. The sole purpose of the quarry would be to supply materials to the WWF Project only.

Construction and operation of the temporary quarry would be undertaken during daytime hours, being Monday to Friday 7:00am to 6:00pm and Saturday 8:00am to 6:00pm, with minor works to be undertaken outside of these hours (e.g. maintenance activities).

As the WWF Quarry is proposed to only be used as part of the construction of the Winterbourne Wind Farm, the assessment has been undertaken in accordance with the Interim Construction Noise Guidelines.

The closest dwellings to the proposed WWF Quarry are SR119 (closest associated dwelling) and SR240 (closest non-associated dwelling, over 4km from the site). The assessment considered all of the quarry noise sources operating concurrently throughout the 15-minute assessment period. “Worst-case” and “typical” usage cases have been made for time the noise sources would operate during the assessment period. The utilisation percentages for each usage case as well as the assumed sound power levels of the equipment are shown in Appendix A.

Noise Management Levels for the construction work have been established by the NSW Interim Construction Noise Guidelines. Noise predictions have been made for two scenarios, with the results compared against the Noise Management Levels for work conducted Monday to Friday 7am to 6pm and Saturday 8am to 6pm.

Based upon the noise predictions, it was found that the highest noise level at the nearest non-associated residence (Receiver SR240) is predicted to be less than 20 dB(A) during both worst-case and typical operation scenarios. It is noted that the predicted noise levels are much less than the minimum night-time RBLs provided by the NSW Noise Policy for Industry. The predicted noise levels easily achieve the (most onerous) Saturday 1pm – 6pm NML of 40 dB(A).

Noise levels of up to 46 dB(A) were predicted at the nearest associated residence (Receiver SR119) during the "worst-case" operation of the WWF Quarry, however as SR119 is an associated receiver, it is assumed that a higher noise level would be agreeable during the quarry operations. Notwithstanding, it is also noted that SR119 is an unoccupied dwelling.

Decommissioning noise is not considered to be louder than the noise associated with operation and will therefore achieve the NMLs.

It is noted that minor works (e.g. maintenance activities) may be undertaken outside of operational hours. These types of operations would typically include only light vehicles and hand tools and a portable generator. The noise levels from such activities would be significantly lower than the predicted noise levels during quarry operations, which already achieve the NML of 35 dB(A) at Receiver SR240.

An assessment of traffic noise associated with the WWF Quarry confirms that the NSW Road Noise Policy will be achieved at both associated and non-associated residences.

# 1 INTRODUCTION

A noise assessment has been conducted for the proposed **Winterbourne Wind Farm Quarry (WWF Quarry**) that will support the construction of the Winterbourne Wind Farm project (the **Project**). The WWF Quarry is proposed as development that is ancillary to the Winterbourne Wind Farm (WWF) Project. The quarry is being proposed as part of an Amendment to the WWF Project currently being prepared.

The WWF Quarry site is located at the eastern end of Bark Hut Road on Lot 95 / DP1128816, within the WWF Project site boundary. Construction and operation of the quarry would be undertaken during daytime hours, being Monday to Friday 7:00am to 6:00pm and Saturday 8:00am to 6:00pm, with minor works to be undertaken outside of these hours (e.g. maintenance activities).

All materials produced by the WWF Quarry would supply the Project only. No quarry material will be provided to other parties unrelated to the construction of the Project, and upon completion of wind farm construction and public road rectification works, the quarry will be decommissioned and rehabilitated.

As the WWF Quarry is proposed to only be used as part of the construction of the Winterbourne Wind Farm, the assessment has been undertaken in accordance with the Interim Construction Noise Guidelines.

The closest dwellings to the WWF Quarry are SR119 (closest associated dwelling - unoccupied) and SR240 (closest non-associated dwelling, over 4km from the site).

# 2 CRITERIA

## 2.1 Noise Criteria

Construction noise should be managed in accordance with the NSW *Interim Construction Noise Guideline* (**ICNG**). Standard hours for construction work within the ICNG are recommended as shown in Table 1.

*Table 1: Recommended standard hours for construction work in accordance with the ICNG*

| Work type | Recommended standard hours of work |
|---|---|
| Normal construction | Monday to Friday 7 am to 6 pm<br>Saturday 8 am to 1 pm<br>No work on Sundays or public holidays |

The ICNG provides an emphasis on implementing "feasible" and "reasonable" noise reduction measures and does not set mandatory objective criteria; rather it sets "management levels" based on the existing background noise environment. The existing background noise environment is defined by the rating background noise Level (**RBL**), which is determined from the lower tenth percentile of the measured background noise levels ($L_{A90,\ 15\ minute}$) in the environment. This effectively represents the quietest periods of the environment, down to a specified minimum RBL. Background noise levels have not been measured at each location, as such the minimum rating background noise level as per the Noise Policy for Industry have conservatively been used, see Table 2.

*Table 2: Minimum Rating Background Noise Levels*

| Time of Day | Minimum Rating Background Noise Level |
|---|---|
| Day (7 am–6 pm) | 35 dB(A) |
| Evening (6 am–10 pm) | 30 dB(A) |
| Night (10 pm–7 am) | 30 dB(A) |

Based upon the ICNG and the minimum RBLs, the applicable management levels are shown in Table 3.

*Table 3: Noise at residences using quantitative assessment*

| Time of Day | Management Level $L_{eq(15\ min)}$ | How to Apply |
|---|---|---|
| Recommended standard Hours:<br>Monday to Friday 7 am to 6 pm<br>Saturday 8am to 1 pm<br>No work on Sunday or public holidays | Noise affected<br>RBL + 10 dB(A) | The noise affected level represents the point above which there may be some community reaction to noise.<br>• Where the predicted or measured $L_{eq\ (15\ min)}$ is greater than the noise affected level, the proponent should apply all feasibly and reasonable work practices to meet the noise affected level.<br>• The proponent should also inform all potentially impacted residences of the nature of works to be carried out, the expected noise levels and duration, as well as contact details. |
| | Highly noise affected<br>75 dB(A) | The highly noise affected level represents the point above which there may be strong community reaction to noise.<br>• Where noise is above this level, the relevant authority (consent, determining or regulatory) may require respite periods by restricting the hours that the very noisy activities can occur, taking into account:<br>1. times identified by the community when they are less sensitive to noise (such as before and after school for works near schools, or mid-morning or mid-afternoon for works near residences<br>2. if the community is prepared to accept a longer period of construction in exchange for restrictions on construction times. |
| Outside recommended standard hours | Noise affected<br>RBL + 5 dB(A) | • A strong justification would typically be required for works outside the recommended standard hours.<br>• The proponent should apply all feasible and reasonable work practices to meet the noise affected level.<br>• Where all feasible and reasonable practices have been applied and noise is more than 5 dB(A) above the noise affected level, the proponent should negotiate with the community.<br>• For guidance on negotiating agreements see Section 7.2.2 of the ICNG. |

### 2.2 Annoying Noise Sources

The ICNG defines the following activities as "particularly annoying":

- use of 'beeper' style reversing or movement alarms, particularly at night-time
- use of power saws, such as used for cutting timber, rail lines, masonry, road pavement or steel work
- grinding metal, concrete or masonry
- rock drilling
- line drilling
- vibratory rolling
- rail tamping and regulating
- bitumen milling or profiling
- jackhammering, rock hammering or rock breaking
- impact piling.

If any these activities are present, 5 dB(A) should be added to the predicted noise levels to factor in the greater annoyance that may be caused. For the purpose of this assessment, it has been assumed that the WWF Quarry will operate some equipment that is considered to be annoying, including 'beeper' style reversing alarms, rock drilling and rock breaking activities, and as such, a 5dB(A) penalty has been applied to predictions at non-associated residences.

### 2.3 Traffic Noise

The proposed use of a local quarry will inherently minimise traffic noise as the material from the quarry would otherwise be transported from a greater distance to the site. Notwithstanding, an assessment has been made against the NSW *Road Noise Policy* (**RNP**).

The RNP aims to identify the strategies that address the issue of road traffic noise from:

- Existing roads
- New road projects
- Road redevelopment projects
- New traffic-generating developments

The WWF Quarry can be defined as a new traffic-generating development. The RNP defines the criteria to be used in assessing the impact of such noise. The assessment criteria are defined by road categories, the type of project or land use and the time of day under which the noise is created. Table 4 shows the assessment criteria for road traffic noise within residential land uses. Where appropriate, the criteria applicable to the assessment has been made **BOLD**.

*Table 4: Road traffic noise assessment criteria for residential land uses*

| Road Category | Type of project/land use | Assessment Criteria – dB(A) | |
|---|---|---|---|
| | | Day (7am – 10pm) | Night (10pm – 7am) |
| Freeway / arterial / sub-arterial roads | • Existing residences affected by noise from new freeway/arterial/sub-arterial road corridors | $L_{Aeq, (15\ hour)}$ 55 (external) | $L_{Aeq, (9\ hour)}$ 50 (external) |
| | • Existing residences affected by noise from redevelopment of existing redevelopment of existing freeway/arterial/sub-arterial roads<br>• Existing residences affected by additional traffic on existing freeways/arterial/sub-arterial road generated by land use developments | $L_{Aeq, (15\ hour)}$ 60 (external) | $L_{Aeq, (9\ hour)}$ 55 (external) |
| Local roads | • Existing residences affected by noise from new local road corridors<br>• Existing residences affected by noise from redevelopment of existing local roads<br>• **Existing residences affected by additional traffic on existing local roads generated by land use developments** | **$L_{Aeq, (1\ hour)}$ 55 (external)** | **$L_{Aeq, (1\ hour)}$ 50 (external)** |

## 2.4 Summary

Table 5 provides a summary of the noise criteria for the operation of the WWF Quarry from the ICNG.

*Table 5: Construction Noise Management Level Summary*

| Land Use | Time of day | | RBL | Noise Management Level |
|---|---|---|---|---|
| Residential | Recommended Standard Hours | Monday to Friday 7 am – 6 pm<br>Saturday 8am to 1 pm | 35 dB(A) | 45 dB(A) |
| | Outside Recommended Standard Hours | Saturday 7am – 8am and 1pm – 6pm<br>Sunday or Public Holidays 7am – 6pm | 35 dB(A) | 40 dB(A) |
| | | Evening (6pm – 10pm) | 30 dB(A) | 35 dB(A) |
| | | Night (10pm – 7am) | 30 dB(A) | 35 dB(A) |

NMLs guide the need to apply work practices to minimise noise impacts, but it is not mandatory to meet these noise levels. Where NMLs are exceeded, all "feasible and reasonable work practices" should be applied to meet the NMLs. In addition, all potentially impacted residents should be informed of the nature of the works to be carried out, the expected noise levels and durations, as well as relevant contact details in the event of a complaint.

Table 6 provides a summary of the road traffic noise criteria for the operation of the WWF Quarry from the RNP.

*Table 6: Road traffic noise assessment criteria for residential land uses*

| **Type of project/land use** | **Assessment Criteria – dB(A)** | |
|---|---|---|
| | **Day (7am – 10pm)** | **Night (10pm – 7am)** |
| Existing residences affected by additional traffic on existing local roads generated by land use developments | $L_{Aeq, (1\ hour)}$ 55 (external) | $L_{Aeq, (1\ hour)}$ 50 (external) |

# 3 ASSESSMENT

## 3.1 Quarry Operation

The construction noise assessment has considered the concept layout of the quarry (refer to Figure 1) and the location and noise generation from the following equipment:

- Blasthole Rig
- Dozer
- Dump Truck
- Excavators
- Mobile Cone Crusher
- Mobile Jaw Crusher
- Mobile Screen
- Mobile VSI Barmac Crusher
- Pug Mill
- Water Cart
- Wheel Loader
- Truck and Dog (along access roads)
- Diesel Generator

The assessment considered each of the above noise sources operating concurrently throughout the 15-minute assessment period[1]. "Worst-case" and "typical" usage cases have been made for time the noise sources would operate during the assessment period. The utilisation percentages for each usage case as well as the assumed sound power levels of the equipment are shown in Appendix A.

Other than standard OEM controls on plant, no additional shielding or bunding has been considered in these operational scenarios.

[1] The ICNG nominates a 15-minute assessment period

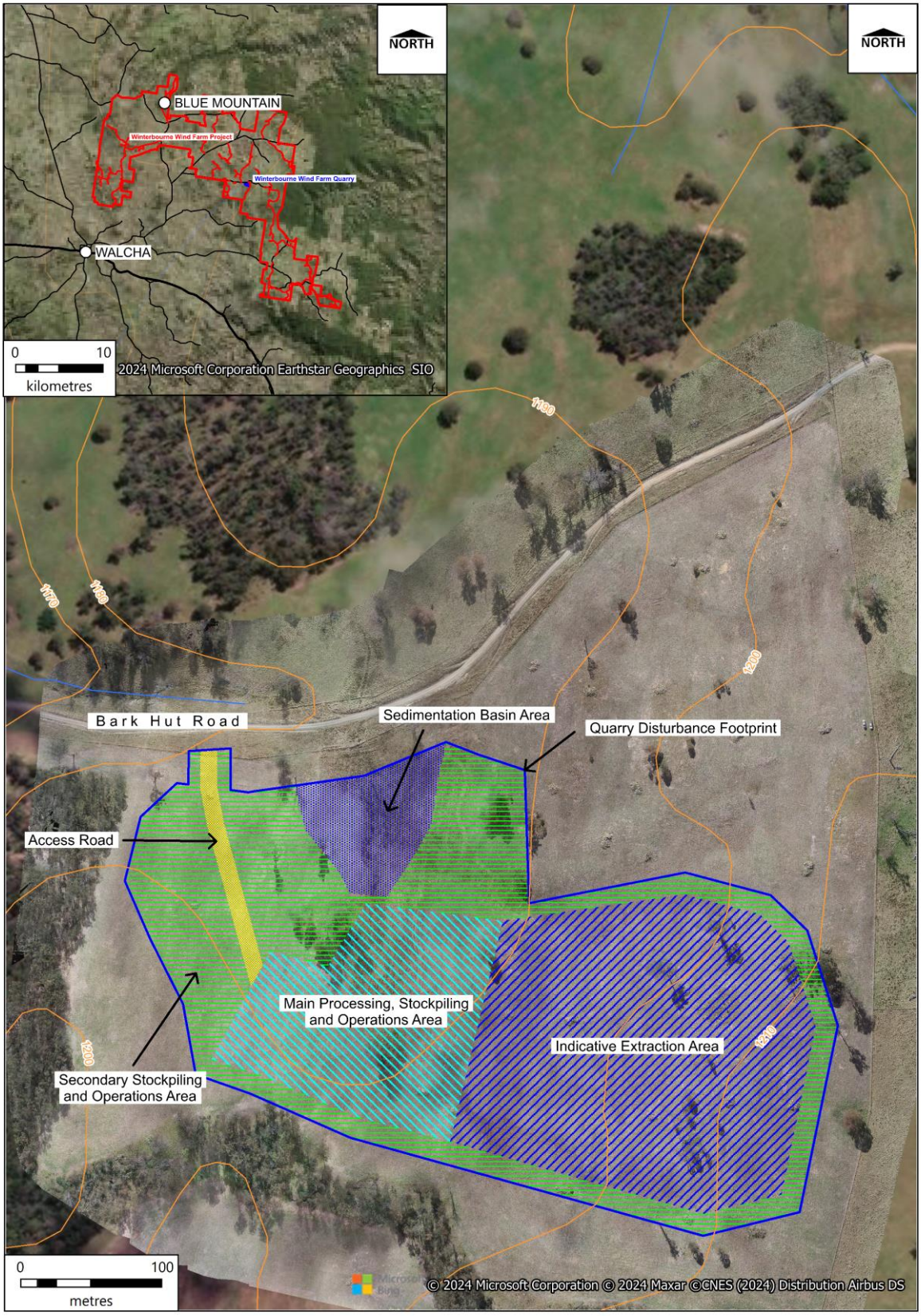


*Figure 1: WWF Quarry Concept Layout*

Environmental noise predictions have been made using the CONCAWE noise propagation model within the SoundPLAN noise modelling software. The CONCAWE algorithm has been widely used and accepted by authorities for the prediction of environmental noise and takes into account the sound power generated by a source, its relative location within the site, its height, topography, ground absorption, air absorption, meteorological conditions and the separation distance between the noise sources and the receivers. The modelled conditions correspond to CONCAWE weather category 5 during the day/evening and CONCAWE weather category 6 at night. The modelled weather conditions are described as "noise-enhancing meteorological conditions" in accordance with Fact Sheet D of the NSW Noise Policy for Industry.

Based upon information provided for the proposed quarry operations, two scenarios have been considered for:

1. The "worst-case" (highest possible) 15-minute noise levels during use of the WWF Quarry, refer to Figure 2.
2. The typical[2] 15-minute noise levels expected for most of the time during use of the WWF Quarry, refer to Figure 3.

[2] The "typical" noise levels are based upon the expected utilisation of the equipment over the course of the works being conducted at the WWF Quarry. Though these levels will be exceeded at times, they can provide a useful indication of the predicted average levels of noise receivers may experience.

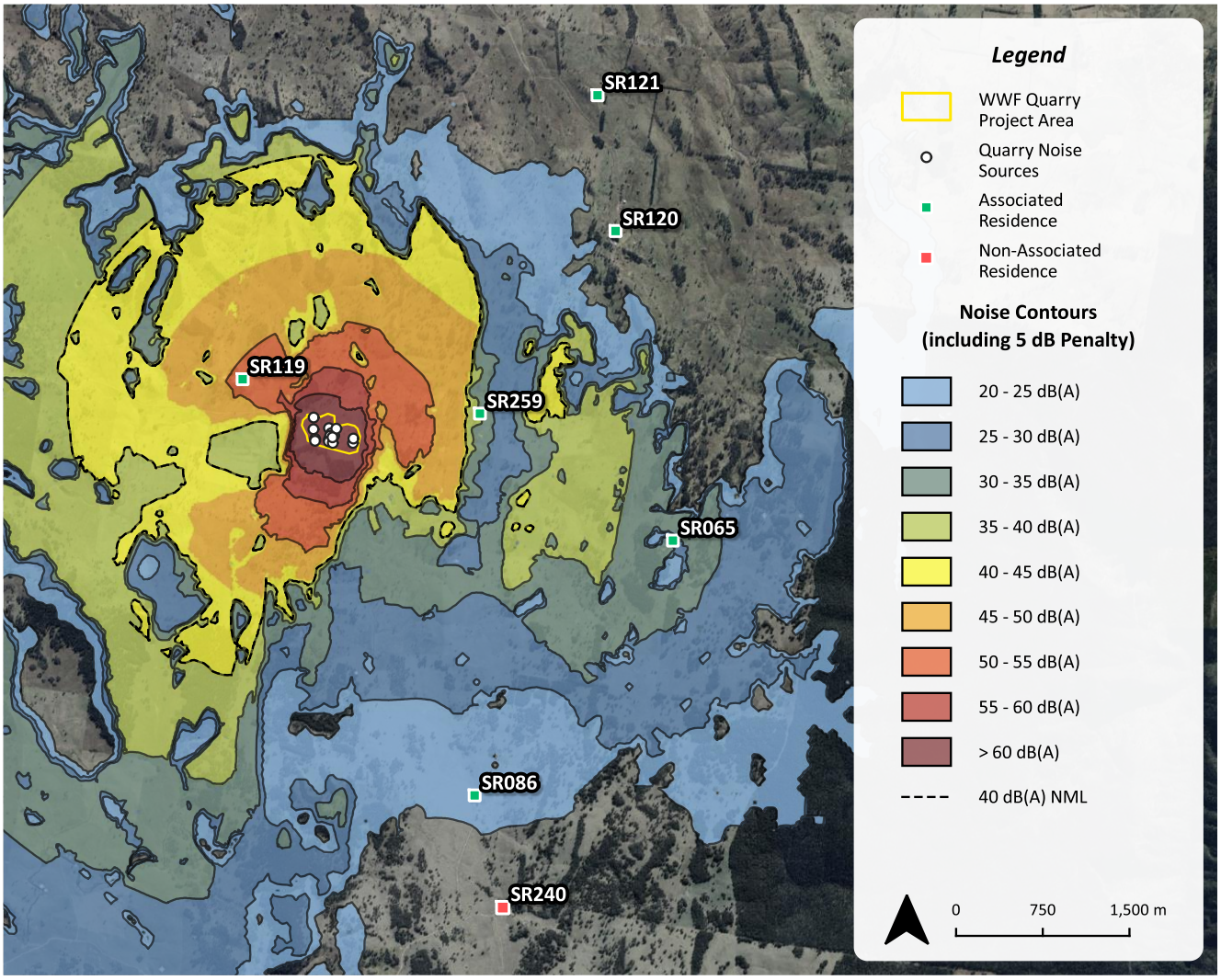


*Figure 2: Worst-case noise levels during operation of quarry*

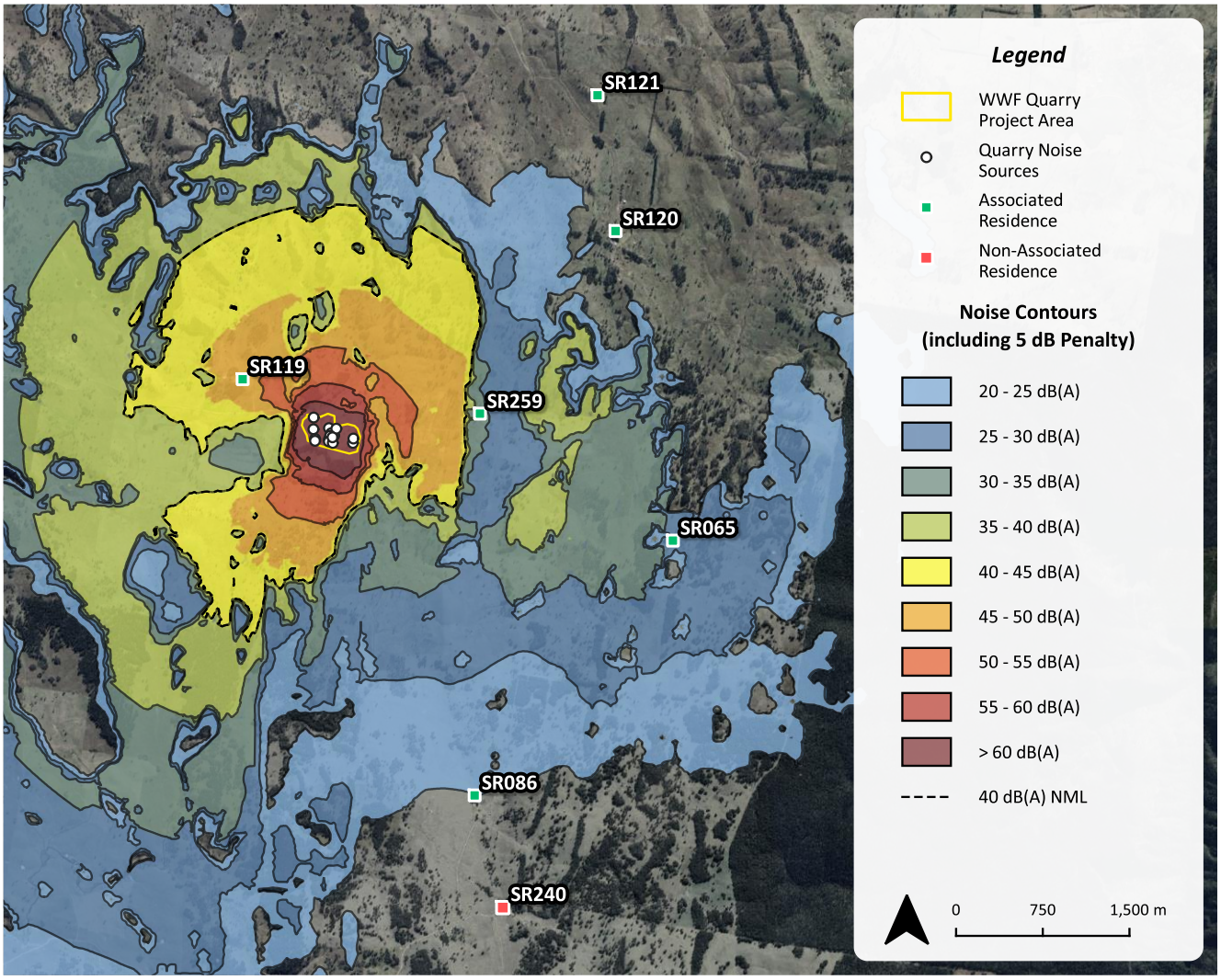


*Figure 3: Typical noise levels during operation of quarry*

Based on the noise model, it was found that the highest noise level at the non-associated residence (receiver SR240) is predicted to be less than 20 dB(A) during both the worst-case and typical operation scenarios, including the application of a 5 dB penalty. The predicted noise levels easily achieve the (most onerous) Saturday 1pm – 6pm NML of 40 dB(A).

The highest predicted noise level at the associated residences (specifically, receiver SR119) is 44 dB(A) under typical operation and 46 dB(A) under worst-case operation. However, the predicted noise levels for associated receivers are provided for information only. As SR119 is an associated receiver, it is assumed that a higher noise level would be agreeable during the quarry operations.

### 3.2 Decommissioning

At the completion of construction of the Project, the WWF Quarry operations will cease and the site will be rehabilitated in consultation with the landowner to determine an appropriate, safe and stable landform(s) that can facilitate ongoing rural activities. Rehabilitation will be undertaken in accordance with the requirements of all relevant approvals. The WWF Quarry will be stabilised and returned to pre-disturbance existing condition in consultation with the landowner (e.g. re-seeded with appropriate pasture grass). Stabilisation will be undertaken in accordance with the requirements of all relevant approvals. Decommissioning noise is not considered to be louder than the noise associated with operation and will therefore achieve the NMLs.

### 3.3 Maintenance Activities

It is noted that minor works (e.g. maintenance activities) may be undertaken outside of standard operating hours. These types of operations would typically include only light vehicles and hand tools and a portable generator. The noise levels from such activities would be significantly lower than the predicted noise levels for Scenario 1 and 2, which already achieve the NML of 35 dB(A) at Receiver SR240.

### 3.4 Traffic Noise

The WWF Quarry would change the origin for quarry products required for the Project. The proposed heavy vehicle traffic route would increase traffic along Bark Hut Road (between the WWF Quarry and Winterbourne Road), this is shown in Figure 4. Heavy vehicle traffic on all other roads would remain unchanged as a result of the WWF Quarry (compared against the current Project proposal).

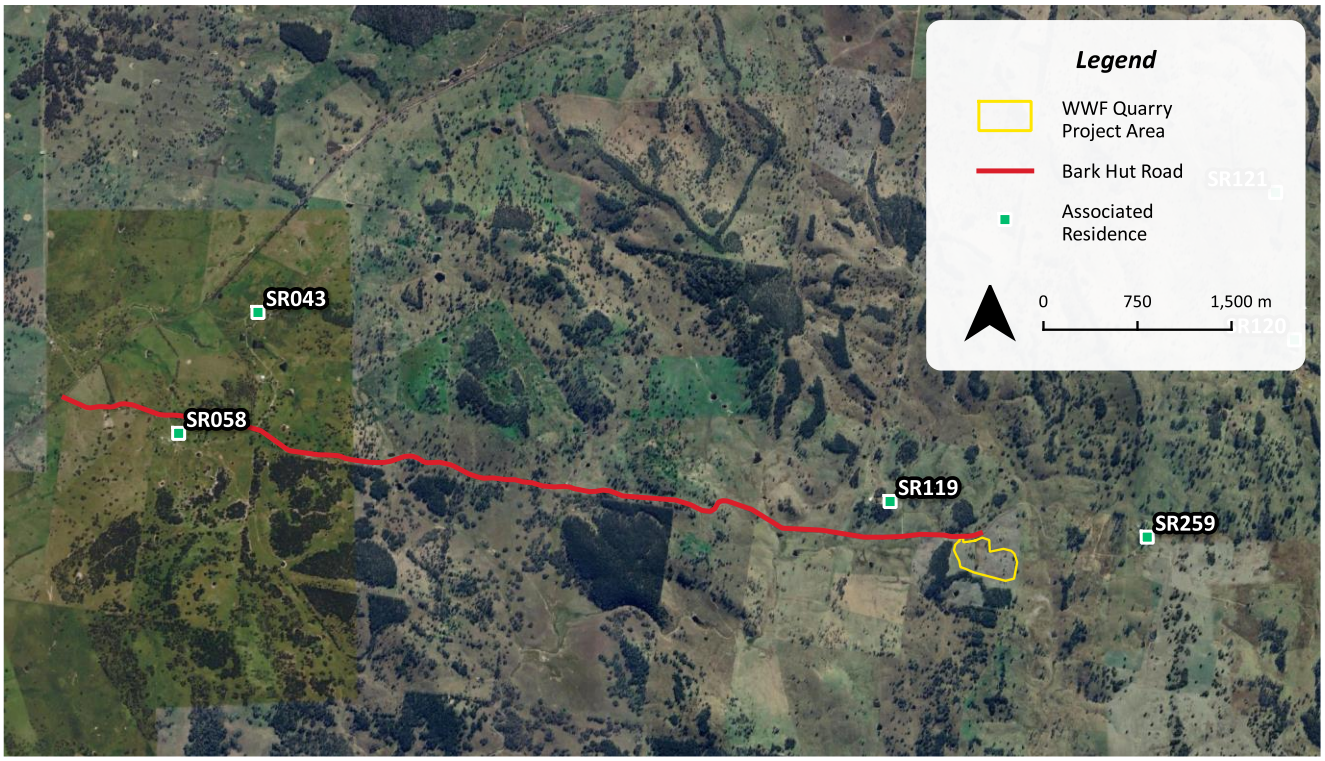


*Figure 4: WWF Quarry heavy vehicle transport route*

There are two associated receivers located along Bark Hut Road that may be adversely impacted by traffic noise associated with the WWF Quarry (SR058 and SR119). There are no non-associated receivers in the vicinity of Bark Hut Road (over 4.5km to nearest non-associated receiver, SR240). Nevertheless, the noise impact due to traffic noise on the associated receivers has been assessed at the residence closest to Bark Hut Road (SR058), for information only.

Traffic volumes along Bark Hut Road between Winterbourne Road and the WWF Quarry have been provided by the traffic engineer. It is noted that the assessment has been based on the construction year with the highest anticipated traffic volumes, as shown in Table 7.

*Table 7: Traffic Volumes - Bark Hut Road – first 7.5km from Winterbourne Road Intersection*

| Scenario | LV | HV |
|---|---|---|
| With WWF Quarry (peak hour) | 60 | 20 |
| Without WWF Quarry (peak hour) | 3 | 1 |

Assumptions for the assessment include the following:

- 100 km/h vehicle speed limit along Bark Hut Road.
- 90% / 10% split of day time and night time traffic (note although the WWF Quarry would only operate during the day time hours, it is envisaged that some vehicle movements along Bark Hut Road would occur prior to the WWF Quarry starting time of 7am).
- Peak hour traffic is approximately 10% of the AADT.

Based upon the maximum expected road traffic volumes during construction, the predicted road traffic noise levels at receiver SR058 are shown in Table 8. The predictions show that the applicable road traffic noise criteria can be met at the nearest sensitive receiver on Bark Hut Road, with or without the WWF Quarry.

*Table 8: SR058 Road Traffic Noise Predictions*

| Time | Criteria | Scenario Predictions | |
|---|---|---|---|
| | | With WWF Quarry | Without WWF Quarry |
| Day (Peak Hour) | $L_{Aeq\ (1\ hour)} \leq 55$ dB(A) externally | 47 dB(A) | 32 dB(A) |

## 4 CONCLUSION

A noise assessment has been made of the proposed quarry which will be used as part of the construction of Winterbourne Wind Farm.

Noise Management Levels for the construction work have been established by the NSW Interim Construction Noise Guidelines. Noise predictions have been made for two scenarios, with the results compared against the Noise Management Levels for work conducted Monday to Friday 7am to 6pm and Saturday 8am to 6pm.

Based upon the noise predictions, it was found that the highest noise level at the nearest non-associated residence (Receiver SR240) is predicted to be less than 20 dB(A) during both worst-case and typical operation scenarios. The predicted noise levels easily achieve the (most onerous) Saturday 1pm – 6pm NML of 40 dB(A).

Noise levels up to 46 dB(A) were predicted at the nearest associated residence (Receiver SR119) during worst-case operation of WWF Quarry, however as SR119 is an associated receiver, it is assumed that a higher noise level would be agreeable during the quarry operations.

Decommissioning noise is not considered to be louder than the noise associated with operation and will therefore achieve the NMLs.

An assessment of traffic noise associated with the WWF Quarry confirms that the NSW Road Noise Policy will be achieved at both associated and non-associated residences.

## APPENDIX A: UTILISATION OF CONSTRUCTION NOISE SOURCES

| Equipment Type | Worst Case Utilisation Percentage | Typical Utilisation Percentage | Sound Power Level [dB(A)] |
|---|---|---|---|
| Blasthole Rig 1 | 100 | 45 | 115 |
| Dozer 1 | 100 | 10 | 108 |
| Excavator 1 | 100 | 100 | 104 |
| Mobile Cone Crusher 1 | 100 | 100 | 112 |
| Mobile Jaw Crusher 1 | 100 | 100 | 121 |
| Mobile Stacker | 100 | 80 | 110 |
| Truck and Dog | 100 | 50 | 113 |
| Water Cart 1 | 100 | 30 | 104 |
| Wheel Loader 1 | 100 | 80 | 113 |
| Diesel Generator | 100 | 100 | 93 |

# Appendix 4

## Blasting Impact Assessment

Prepared by Envirostrata Pty Limited

**ENVIRO STRATA CONSULTING Pty Ltd**
A.B.N. 35 122 301 795

24 Albert Street
Valentine NSW 2280

T: (02) 4946 1864
M: 0407 005 352
E: enviro.strata@gmail.com

**Thomas Lewandowski**
B.E. (Mining), M.M.Mgt,
M.Aus.I.M.M.,
M.I.S.E.E.,
M.EFEE.

# WINTERBOURNE WIND FARM QUARRY - BLASTING IMPACT ASSESSMENT

Report prepared for Australian Resource Development Group Pty Ltd

## Report No. AR-2403-230824

**Thomas Lewandowski**
**23rd August 2024**

**ENVIRO STRATA CONSULTING Pty Ltd**
A.B.N. 35 122 301 795

24 Albert Street
Valentine NSW 2280

T: (02) 4946 1864
M: 0407 005 352
E: enviro.strata@gmail.com

**Thomas Lewandowski**
B.E. (Mining), M.M.Mgt,
M.Aus.I.M.M.,
M.I.S.E.E.,
M.EFEE.

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**ENVIRO STRATA CONSULTING Pty Ltd**
A.B.N. 35 122 301 795

24 Albert Street
Valentine NSW 2280

T: (02) 4946 1864
M: 0407 005 352
E: enviro.strata@gmail.com

**Thomas Lewandowski**
B.E. (Mining), M.M.Mgt,
M.Aus.I.M.M.,
M.I.S.E.E.,
M.EFEE.

# 1.0 INTRODUCTION

Enviro Strata Consulting Pty Limited (Enviro Strata Consulting) was engaged by Australian Resource Development Group Pty Ltd (ARDG) to undertake a Blasting Impact Assessment (BIA) for the proposed Winterbourne Wind Farm (WWF) Quarry.

The WWF Quarry will be situated about 20 km north-east of Walcha and approximately 80 km north-east of Tamworth, in New South Wales.

The proposed development will include drill and blast operations to extract hard rock material. The material is to be supplied exclusively to the nearby Winterbourne Wind Farm Project for construction usage.

The BIA study is based on ground vibration and airblast overpressure modelling, utilising parameters representative for the area. The assessment outcomes are presented in the context of relevant criteria for ground vibration, airblast overpressure and flyrock limit for the items being assessed.

# 2.0 WINTERBOURNE WIND FARM QUARRY PROJECT BACKGROUND

Vestas Development Australia Pty Ltd (Vestas) is proposing a temporary, project-specific quarry as development that is ancillary to the Winterbourne Wind Farm (WWF) Project. The quarry is being proposed as part of an Amendment to the WWF Project currently being prepared. The WWF Project has a current estimated demand of 1Mt of quarry materials (e.g. road base/capping; concrete aggregates; gabion/drainage rock/ TR sand) over the estimated 3 – 4 year construction period. It is proposed that the majority of this material could be supplied from this quarry site. The sole purpose of the quarry would be to supply materials to the WWF Project only.

The quarry would be located within the existing WWF Project Area (refer **Figure 1**) (i.e. an 'on-site' quarry) and be located on project-associated land adjacent to Bark Hut Road, a key transport spine for much of the proposed project infrastructure, and immediately adjacent to the access track for wind turbines B177, B100A, B101A and B102.

Justification for the on-site quarry to be considered as development that is ancillary to the WWF Project is provided by the proposed quarry being temporary in nature, it occupying a very small proportion of the WWF Project Area, and having a clear nexus with the WWF Project, given it is proposed to be operated for the sole purpose of facilitating the construction of the WWF Project.

Australian Resource Development Group Pty Limited (ARDG) has been engaged to assist with the development of the quarry. Detailed site geological investigations undertaken by ARDG indicate that the quarry resource is suitable for the production of a range of products (*e.g.* roadbase, concrete aggregates, drainage rock) required for construction of the public road upgrades, wind

farm access tracks, hardstand areas, turbine foundations and other associated civil works associated with the Project.

Approval for the transport of up to 500,000 tonnes per annum of material from the quarry site to the WWF Project is being sought as development that is 'ancillary development' to Electricity Generation Works as part of an amendment to the application (SSD 10471) that is currently being assessed by the NSW Department Planning and Environment (DPE). An Environmental Protection Licence (EPL) would also be sought for the quarry operation, separate to the EPL required for the WWF Project.

The WWF Quarry (the quarry site) is located within the WWF Project Site Boundary on 'Bark Hut' (Lot 95 DP1128816), with direct access form the quarry site on to Bark Hut Road (part of the WWF construction haulage route).

Given its location within the WWF Project Site Boundary close to where the quarry product will be required during construction, sourcing of construction materials from the quarry site (compared to sourcing from commercial quarries located considerable distances away in the broader region) would significantly reduce construction traffic on the broader local and regional road network. The key material benefits likely to result from the proposed quarry location for the local and broader community include:

- the removal of quarry haul trucks from the Oxley Highway and Thunderbolts Way, as well as from the township of Walcha;
- reduced construction traffic noise amenity impacts for residents and road users, in particular those located along the broader public road network;
- improved road safety (substantially reducing heavy/light vehicle interactions) along the broader public road network;
- reduced damage to the broader public road network by significantly reducing total distances travelled on the broad public road network.

Supply of quarry products from this on-site quarry would also reduce the carbon footprint of the WWF Project (via substantially reduced fuel consumption associated with haulage), and also provide significant construction cost savings, by significantly reducing the haulage distance for construction materials supplied to the Project.

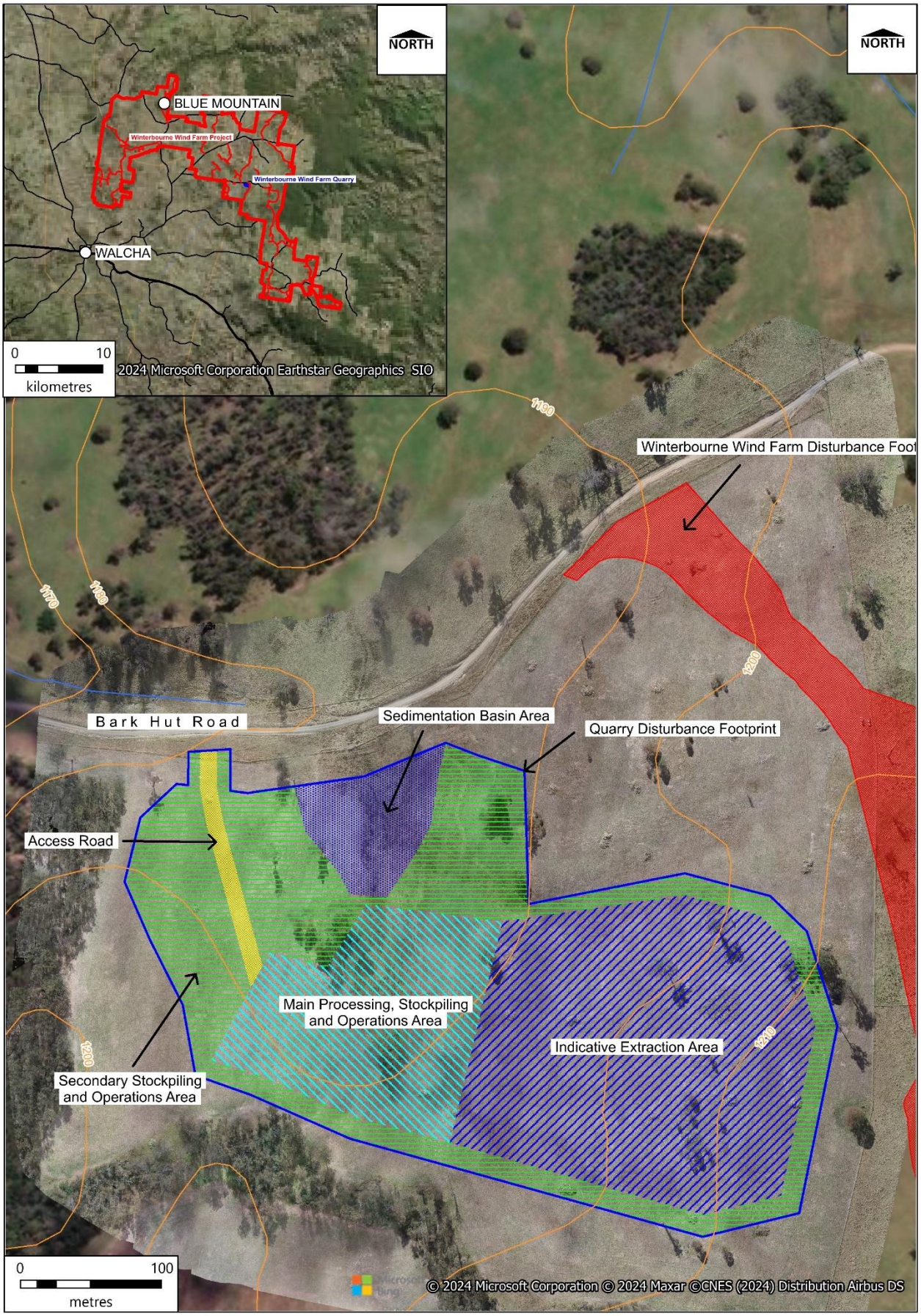



**Figure 1 – Key features of Winterbourne Wind Farm Quarry**

# 3.0 ASSESSMENT REQUIREMENTS AND STUDY AREA

This BIA is a comprehensive evaluation of the potential effects of blasting from the proposed quarry site, including ground vibrations, airblast overpressure and flyrock, focusing on the relevant items in the area:

- private residences including people
- infrastructure items

The quarrying facilities and associated assets owned by the WWF Project were not evaluated in this BIA. The quarry operator will oversee their management to ensure safe working practices and environment.

The BIA follows the guidelines outlined in the Australian and New Zealand Environment Council guideline titled 'Technical Basis for guidelines to minimise annoyance due to blasting overpressure and ground vibration' (ANZECC, 1990) and Australian Standard (AS 2187.2-2006), or other relevant norms / criteria. Detailed information on these criteria is provided in Section 6.2 of the report.

# 4.0 EXISTING ENVIRONMENT AND IDENTIFIED RECEPTORS

The study examines the effects of blasting from the proposed quarry site on identified sensitive receptors, such as private residences and infrastructure. It evaluates an area extending up to a 4 km radius, beyond which the blasting effects are considered insignificant, falling below human perception levels.

This section introduces the identified sensitive receptors, their location and distance relative to the quarry site (refer to **Figure 2**).

## 4.1 PRIVATE RESIDENTIAL RECEPTORS

**Figure 2** displays the locations of identified private residential receptors in relation to the quarry's pit**.**

The main points to note are as follows:

- The area is sparsely populated with only six (6) residential receptors identified within a 4 km radius, all of which are associated with the WWF. Note that the closest receptor, located to the north-west of the quarry site is also directly associated with the quarry project (i.e., residence owned by the quarry site landowner, though unoccupied).
- Walcha, the nearest town to the quarry, is located 20 km to the south-west of the quarry site. At this distance, any potential impact from blasting is considered negligible, well below the threshold of human perception, and therefore does not necessitate an assessment.

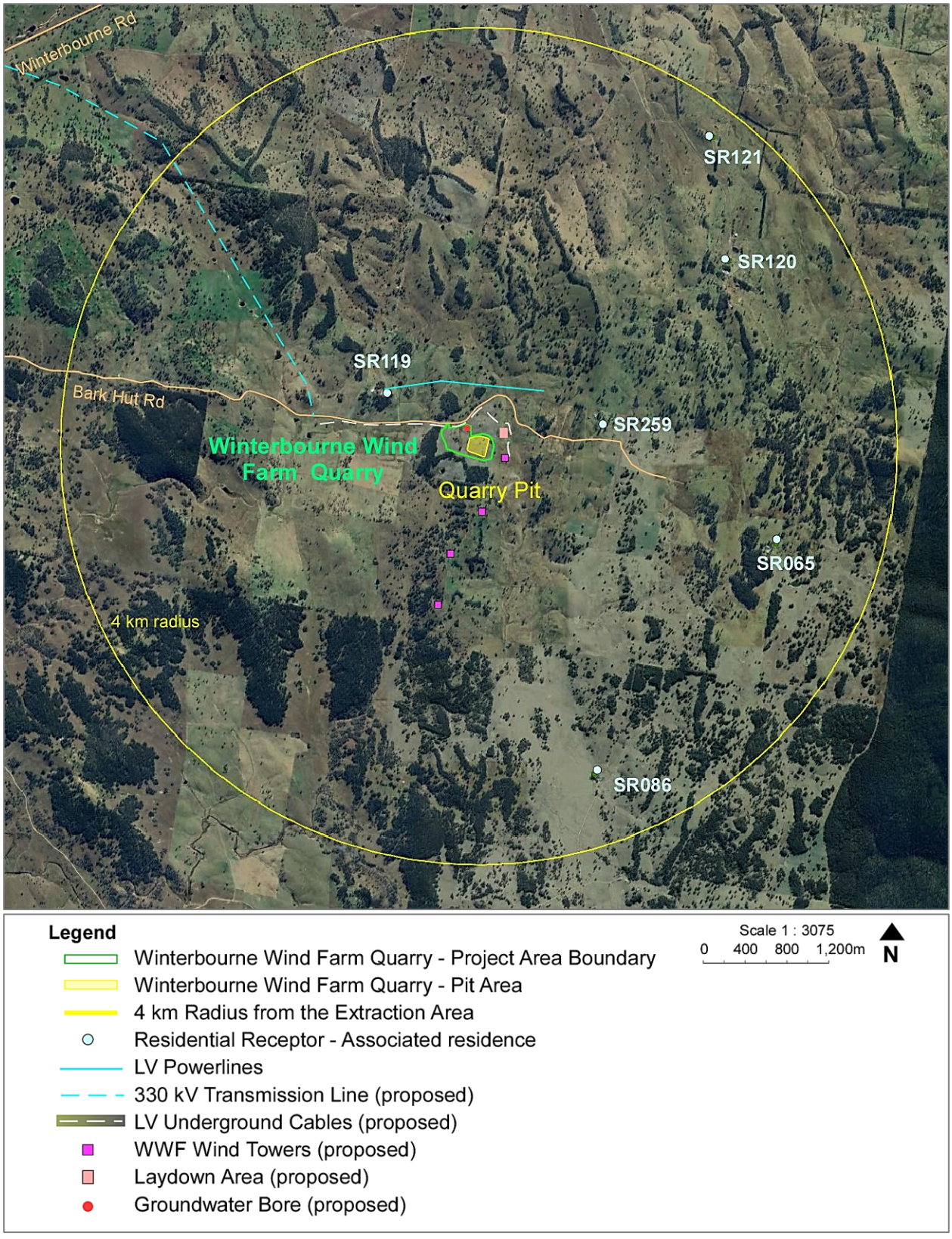



**Figure 2 - Locations of the Winterbourne Wind Farm Quarry Area with respect to Residential Receptors, and Infrastructure within a 4 km Radius**

## 4.2 INFRASTRUCTURE

As indicated above, the area around the proposed quarry site is sparsely populated, resulting in limited infrastructure. Only public infrastructure was identified in this area. The locations of the identified infrastructure in relation to the quarry pit are shown in **Figure 2.**

The following infrastructure facilities, were identified in this BIA:

- Public road, specifically Bark Hut Road, located at a minimum distance of 180 m from the quarry pit boundary.
- Existing low voltage (LV) powerlines (located to the North) with the closest timber power pole situated 490 m away.
- Proposed 330 kV transmission line easement located a minimum distance of approximately 1,500 m from the quarry pit boundary
- Nearest proposed underground LV power cables located adjacent to Bark Hut Road, a minimum distance of approximately 150 m from the quarry pit boundary.
- Nearest proposed WWF tower located a minimum distance of 185 m from the quarry pit boundary.
- Nearest proposed laydown area located a minimum distance of 100 m from the quarry pit boundary.
- Proposed groundwater bore located a minimum distance of 100 m from the quarry pit boundary.

# 5.0 GEOLOGY AND EXTRACTION METHODS

**Geology and the Quarry Site Implications**

Geology of the quarry site area has been determined from a detailed resource assessment program that included surface mapping, as well as a percussion / diamond drilling program undertaken by ARDG in 2024 with a total of 62 exploration holes drilled, see **Appendix 1.**

The assessment was supported by laboratory rock testing (including Atterberg and core testing). The dominant rock formation targeted by the quarry site is a quality meta-greywacke rock. The geological assessment model concluded that the potential extraction depth could reach approximately 33 - 34 m in the deepest section below the surface level, with steeply designed highwalls. Due to ground undulation, the eastern side of the quarry will have the steepest highwall section, see **Appendix 2**.

The quarry site will operate for approximately 3 - 4 years with an anticipated transport of up to 500,000 tonnes of quarry products from the site per year (i.e., approximate total extraction of 1.5 – 2 Mt).

Based on the geological assessment model, the conceptual quarry site extraction will comprise:

- The conceptual quarry design covers an area of approximately 4.45 hectares from where meta-greywacke and minor interbedded meta-siltstone would be drilled, blasted and extracted, prior to processing. The proposed quarry would be developed to a floor level of approximately 1,175 metres AHD, with extraction undertaken from two benches, each with a maximum height of 15 metres. A 10-metre-wide berm would be retained around the perimeter of the pit at an elevation of approximately 1,190 metres AHD, following the completion of extraction of the upper bench.

## Drilling and Blasting Process

The extraction method to be employed for the quarry site will involve drilling and blasting operations. Prior to blasting, the area will be surveyed, and proposed blast holes will be marked. This will be followed by drilling the design pattern and loading the holes with explosives. The top section of each hole will be filled with stemming material to ensure better energy distribution and noise suppression.

A delay system, which is incorporated on the surface of the blast area, allows for single hole initiation.

Following the blast firing, the blasted and fractured rock strata will be removed for further processing (including crushing and screening) in the quarry's mobile plant.

## Blast Details

Based on the parameters assessed (consistent with the quarry design), it is anticipated that maximum 15 m benches will be targeted, which corresponds to a maximum instantaneous charge (MIC) mass for blasting in the order of 100 kg per hole or 300 kg (allowing for 3 holes when fired simultaneously). The proposed blast hole diameter is 102 mm.

All these details together with other parameters (summarised in **Table 1)** were considered in the blasting impact study undertaken.

**Table 1: Proposed Drilling and Blasting Design Details for the WWF Quarry.**

| Parameter | Value |
|---|---|
| Blast Hole Diameter (mm) | 102 |
| Number of Holes per Blast | 200 (typically) |
| Drilling Length per Blast (m) | 2,500 |
| Burden (m) | 2.8 |
| Spacing (m) | 3.8 |
| Bench Height (m) | 15 |
| Stemming (m) | 2.5 (typically) |
| Stemming Product: | 10/14 stemming aggregate (i.e., 30t / blast) |
| Blasting Product | Bulk emulsion or water gel products |
| Blasting Product Density ($t/m^3$) | 1.2 |
| MIC (kg) | 100 kg (single hole) - up to 300 kg (3 holes combined) |
| Rock Density ($g/cm^3$) | 2.8 |
| Powder Factor ($kg/m^3$) | 0.75 nominal |
| Blast Size Volume (bcm) | 26,000 |
| Operational Period | 48 weeks / year |
| Blasting Frequency | Variable (approximately 6 – 12 blasts / year) |

**Times and Frequency of Blasting**

Blasting will be undertaken Monday to Friday (between 9am and 5pm); drilling activities will be undertaken Monday to Saturday (between 7am and 6pm).

The quarry site operations will be undertaken in such a manner as to ensure the consent conditions are met. It is anticipated that the quarry will only fire a limited number of blasts per year approximately 6 – 12 blasts per year.

# 6.0 PREDICTIVE MODELS AND BLAST EMISSION CRITERIA

## 6.1 PREDICTIVE MODELS

Ground vibration and airblast overpressure models for the quarry conditions have not been developed yet, as the quarry itself is not operational. To address this, air and ground vibration models from a comparable mining operation have been used as an interim solution.

These models were initially developed for a smaller open-cut coal mine that utilised blasting parameters similar to those proposed for the quarry. For instance, the mine employed charge masses ranging from 42 to 225 kg for various blasts, including overburden and interburden blasts.

### 6.1.1 Ground Vibration Predictive Model

The site law formula recommended by the Australian Standard (AS 2187.2-2006) is accepted by relevant NSW Government agencies as appropriate for mining and quarrying blast assessments.

The site law formula equation is specified as follows:

$$PPV = k\left(\frac{D}{\sqrt{m}}\right)^{a}$$

where:

| | | | |
|---|---|---|---|
| | ***PPV*** | = | Ground vibration as vector Peak Particle Velocity (mm/s) |
| | ***D*** | = | Distance between charge and point of measurement (m) |
| | ***m*** | = | Maximum Instantaneous Charge (MIC), effective charge mass per delay (kg) |
| | ***a*** | = | Site exponent |
| | ***k*** | = | Site constant |

The site law analysis, based on a comparable blasting operation, presented below utilises a standard log/log scale. It plots Peak Particle Velocity values (PPV) monitored against the scaled distance (see **Figure 3)**.

For assessment purposes, two lines have been drawn. The first line represents a median line (i.e., the 50% level line), indicating that 50% of vibration responses are above the line and 50% are below it. The second line is a 95% level line* where 95% of vibration responses fall below this line. The 95% level, advocated by the Australian and New Zealand Environment and Conservation Council (ANZECC) Guidelines (1990), accommodates inherent variation in emission levels and allows for a 5% exceedance of the general blast criterion.

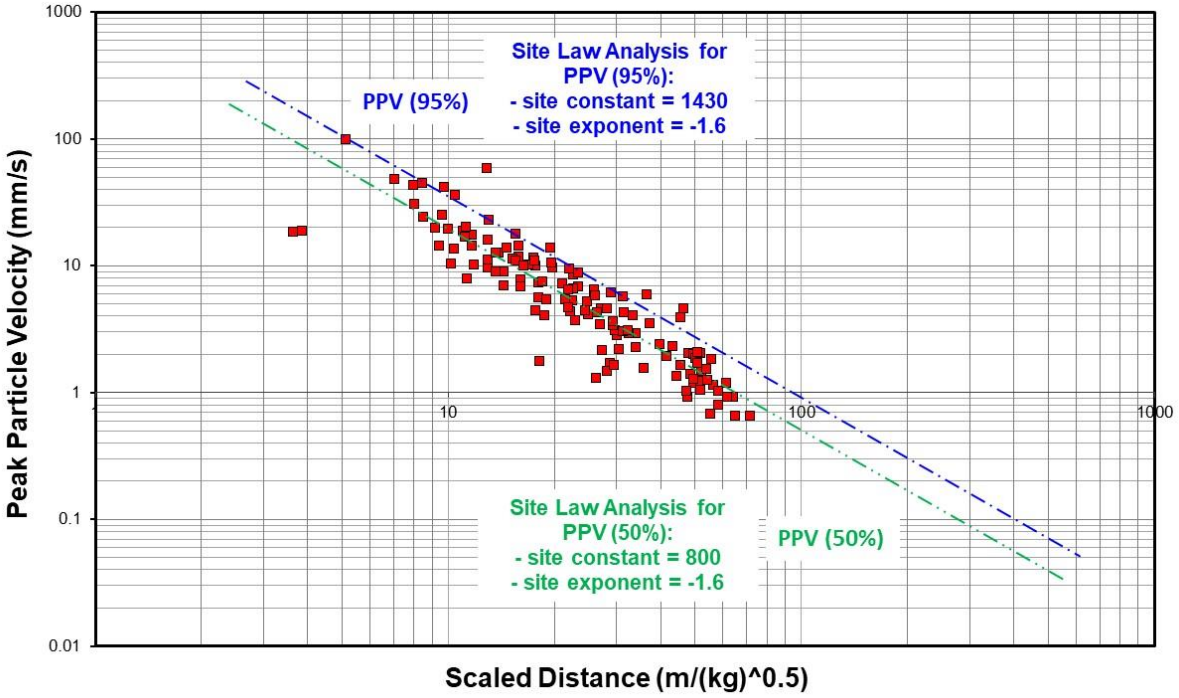



**Figure 3 – Site Law Analysis from Comparative Blasting Operations**

The estimated site law parameters, based on the assessment above (using the 95% confidence level), are as follows:

- site exponent a = -1.6
- site constant $k$ = 1,430

Therefore, as an interim measure, the formula for ground vibration modelling for the quarry area is:

$$PPV = 1{,}430 \left( \frac{D}{\sqrt{m}} \right)^{-1.6}$$

Where: ***PPV*** = Ground vibration as vector Peak Particle Velocity (mm/s)

***D*** = Distance between charge and point of measurement (m)

***m*** = Maximum Instantaneous Charge (MIC), effective charge mass per delay (kg)

***Note**: The 95% criterion is utilised in accordance with ANZECC guideline (1990), which allows for an inherent variation in emission levels by allowing 5% exceedance of general criterion.

### 6.1.2 Airblast Overpressure Predictive Model

The impact of generated airblast levels from the blast source is generally guided by the sonic decay law outlined in the Australian Standard (AS 2187.2-2006). The sonic decay formula is specified as follows:

$$P = k\left(\frac{D}{\sqrt[3]{m}}\right)^{a}$$

Where:

| | | |
|---|---|---|
| $P$ | = | Peak Pressure (kPa) |
| $D$ | = | Distance between charge and point of measurement (m) |
| $m$ | = | Maximum Instantaneous Charge (MIC), effective charge mass per delay (kg) |
| $a$ | = | Site exponent |
| $k$ | = | Site constant |

The airblast overpressure monitoring results (from the comparable mine) were plotted and together with other parameters, they contributed to the airblast predictive model shown in **Figure 4.** To facilitate accuracy of the assessment, the forced exponent of -1.45 was utilised. This corresponds to an attenuation rate of 8.6 dBL with a doubling of distance, as specified in Australian Standard, Explosives – Storage and use, Part 2 – Use of explosives (AS 2187.2-2006).

The sonic decay law analysis features two lines corresponding to the median of the measured data set (marked as Sound Pressure Level (SPL) 50%) and SPL 95% corresponding to 95% of the total population of data.

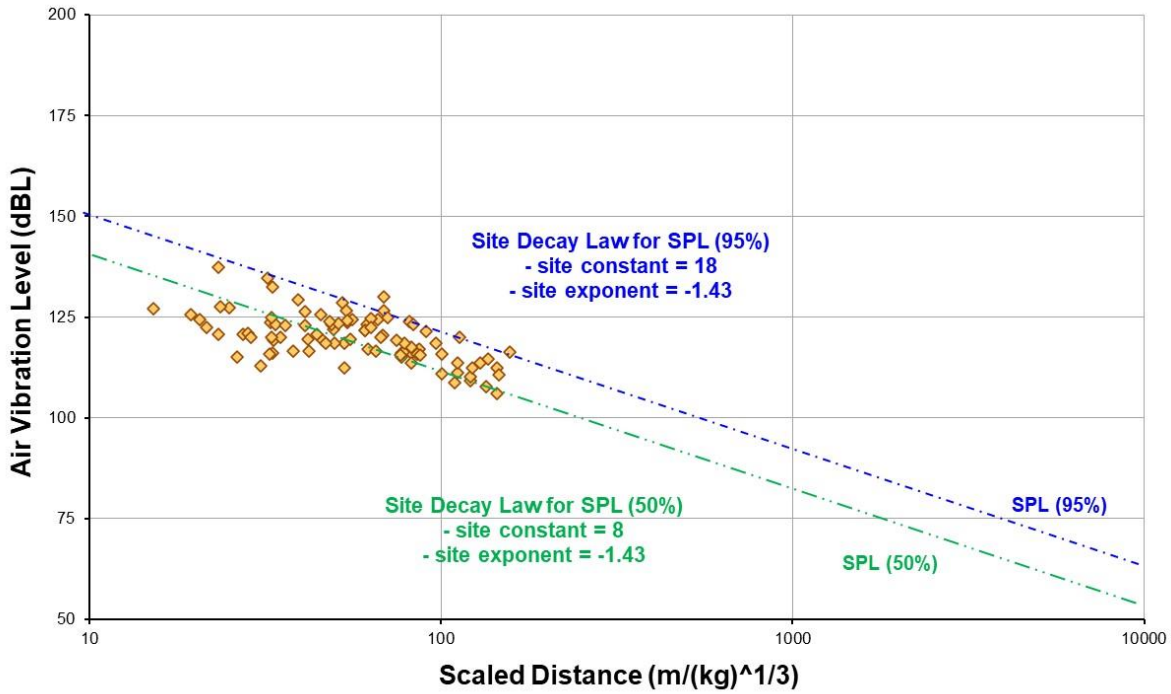



**Figure 4 –Sonic Decay Law from Comparative Blasting Operations**

The estimated sonic decay parameters, based on the assessment above (using the 95% confidence level), are as follows:

- site exponent $a$ = -1.45
- site constant $k$ = 18

Therefore, as an interim measure, the formula for blast overpressure modelling for the quarry area is:

$$\boldsymbol{P} = 18\left(\frac{D}{\sqrt[3]{m}}\right)^{-1.45}$$

Where: $\boldsymbol{P}$ = Peak Pressure (kPa)

$\boldsymbol{D}$ = Distance between charge and point of measurement (m)

$\boldsymbol{m}$ = Maximum Instantaneous Charge (MIC), effective charge mass per delay (kg)

## 6.2 BLAST EMISSION CRITERIA

### 6.2.1 Criteria for Private Residential Receptors

*Blast Emission Criteria for Human Comfort*

To minimise the impact on residential receptors, the NSW Department of Planning and Environment (DPE) adopts the ANZECC guidelines, "Technical Basis for Guidelines to Minimise Annoyance due to Blasting Overpressure and Ground Vibration" (1990). These guidelines indicate the following:

- The general criterion for ground vibration is 5 mm/s, Peak Particle Velocity (PPV).
- The PPV of 5 mm/s may be exceeded up to 5% of the total number of blasts over a 12-month period. The upper PPV level of 10 mm/s not be exceeded at any time.
- The general airblast criterion is 115 dBL (decibel Linear).
- The level of 115 dBL may be exceeded up to 5% of the total number of blasts over a 12-month period. The airblast level is not to exceed 120 dBL at any time.

The same criteria are assumed for the proposed quarry site. Therefore, the impacts of the quarry have been assessed against these same conditions.

### 6.2.2 Criteria for Infrastructure

Some guidelines on vibration limits for infrastructure are provided in Australian Standard AS 2187.2-2006 "Explosives – Storage and Use – Part 2: Use of Explosives". Other sources such as the ACARP Report No. C14057 present a comprehensive overview of existing allowable vibration limits for various infrastructure including buried communication cables and pipelines.

A major electricity supplier in NSW, Ausgrid, generally uses a vibration limit of 100 mm/s for timber power poles.

Therefore, the relevant vibration criteria include:

- 100 mm/s – for public roads (applicable to sealed surface only, e.g., asphalt, bitumen, concrete)
- 100 mm/s – for timber power poles
- 100/50 mm/s – for high voltage power line (330kV), for suspension and tension towers respectively
- 100 mm/s – for buried communication cables and pipelines
- 100 mm/s – for wind turbines / laydown area
- 100 mm/s – for groundwater bore including steel case lining and pipelines

These vibration limits are used as the assessment criteria for the quarry site.

**NOTE:** Generally, unoccupied infrastructure facilities are not assessed in terms of airblast overpressure exposure as the levels required to inflict damage are not applicable and/or not reached.

A summary of blast emission criteria used in the assessment is presented in **Table 2.**

**Table 2: Summary of Blast Emission Criteria**

| Item | Vibration Criteria (mm/s) | Airblast Criteria (dBL) |
|---|---|---|
| Private residences (1) | | |
| Limit applicable to 95% of blasts over a 12-month period, | 5 | 115 |
| Limit not to be exceeded | 10 | 120 |
| Unoccupied infrastructure including: | | |
| Public roads and bridges<br>Buried electrical cables<br>Wind towers (2)<br>Groundwater bore / pipelines<br>Timber power poles | 100 | n/a |
| High voltage transmission towers (330 kV) | 100 / 50 (3) | n/a |

*1 – applies to buildings and sheds only (after ANZECC (1990))*

*2 – to be verified against wind turbine manufacturer's guidelines for specific vibration tolerance limits*

*3 – 100 mm/s applies to suspension towers, 50 mm/s applies to tension towers.*

## 7.0 BLASTING IMPACT ASSESSMENT

The BIA utilised ground vibration and airblast overpressure modelling using the models, as stated in Section 6.1. The generated ground vibration and airblast overpressure estimates have been evaluated in the context of relevant limits and/or criteria as detailed in Section 6.2. This allowed for the identification of blasting impacts on the surrounding environment and highlighted any potential blasting risks for the proposed quarry.

The modelling involved simulations using charge masses of 100 and 300 kg. These charge masses were derived from the blasting parameters proposed for use by the quarry. The modelling accounted for the worst-case scenario, i.e., blasting from the edge of the quarry, which corresponds to the minimum distance between the blasting area and the receptors. The result tables compiled therefore highlight the maximum ground vibration and airblast overpressure levels that will be generated at these receptors over the lifetime of the quarry.

## 7.1 COMMUNITY

The modelling evaluated ground vibration and airblast overpressure levels for private residential receptors located within a 4 km radius of the quarry extraction area, see **Figure 2.** Note that for a small-scale quarry, such as the proposed site, the impact of blasting -including ground vibration and airblast overpressure - beyond a 3-4 km radius is difficult to detect i.e., beyond the human perception levels.

### 7.1.1 Assessments Results – Community

**Ground Vibration and Airblast Overpressure**

The results of the vibration modelling, for residential receptors located within a 4 km radius are summarised in the tables below. The modelling results for ground vibration and airblast overpressure are presented in **Table 3** and **Table 4** respectively.

**Table 3: Results of Ground Vibration Modelling for Residential Receptors**

| Residential Receptor ID | Min. Distance (1) (m) | Direction from Blasting Area | Estimated Max. Ground Vibration (mm/s) | | Applicable Vibration Criteria (mm/s) |
|---|---|---|---|---|---|
| | | | MIC (kg) | | |
| | | | 100 | 300 | |
| SR259 (3) | 1,100 | E | 0.8 | 1.9 | 5 / 10 (2) |
| SR065 (3) | 2,900 | E | 0.2 | 0.4 | |
| SR120 (3) | 2,840 | NE | 0.2 | 0.4 | |
| SR086 (3) | 3,180 | SE | 0.1 | 0.3 | |
| SR121 (3) | 3,580 | NE | 0.1 | 0.3 | |
| SR119 (4) | 900 | NW | 1.1 | 2.6 | |

*1 – Minimum distance over the lifetime of the quarry site, i.e., from the edge of the blasting boundary*

*2 – 5 mm/s limit for 95% of blasts over a 12-month period, 10 mm/s not to be exceeded*

*3 – Residence associated with the WWF*

*4 – Residence associated with the WWF and WWF Quarry. NB: Residence is unoccupied*

**Table 4: Results of Airblast Overpressure Modelling for Residential Receptors**

| Residential Receptor ID | Min. Distance [1] (m) | Direction from Blasting Area | Estimated Max. Airblast Overpressure (dBL) | | Applicable Vibration Criteria (dBL) |
|---|---|---|---|---|---|
| | | | MIC (kg) | | |
| | | | 100 | 300 | |
| SR259 [3] | 1,100 | E | 110 | 115[5] | 115 / 120 [2] |
| SR065 [3] | 2,900 | E | 98 | 103 | |
| SR120 [3] | 2,840 | NE | 98 | 103 | |
| SR086 [3] | 3,180 | SE | 97 | 101 | |
| SR121 [3] | 3,580 | NE | 95 | 100 | |
| SR119 [4] | 900 | NW | 113 | 117 | |

*1 – Minimum distance over the lifetime of the quarry, (from the edge of the blasting boundary)*

*2 – 115 dBL limit for 95% of blasts over a 12-month period, 120 dBL not to be exceeded*

*3 – Residence associated with the WWF Quarry*

*4 – Residence associated with the WWF and WWF Quarry. NB: Residence is unoccupied*

*5 – Maximum estimate below 115 dBL, 114.8 dBL rounded up to a whole number*

The ground vibration and airblast overpressure impact modelling results for private residential receptors are summarised as follows:

- The maximum ground vibration exposure, as estimated using two modelled scenarios, was found to be in the range of 0.1 to 2.6 mm/s for associated residences. These estimates are below the applicable limits specified as 5 mm/s (for 95% of blasts) and 10 mm/s (not to be exceeded).
- The maximum airblast overpressure exposure, as estimated using two modelled scenarios, was found to be in the range of 95 to 115 dBL for occupied associated residences and 117 dBL for the unoccupied associated residence. These estimates are within the applicable limits specified as 115 dBL (for 95% of blasts) and 120 dBL (not to be exceeded).

## 7.2 INFRASTRUCTURE

The relevant infrastructure items were described in Section 4.2. The closest identified public infrastructure item is located at a distance of 180 m. The assessed items are shown on **Figure 2**.

### 7.2.1 Assessments Results - Infrastructure

**Ground Vibration**

The results of the modelling, focusing on the maximum ground vibration generated for a particular MIC are summarised in **Table 5.**

**Table 5: Results of Ground Vibration Modelling for Infrastructure**

| Receptor | Min. Distance[(1)] (m) | Estimated Max. Ground Vibration (mm/s) | | Applicable Vibration Criteria (mm/s) and/or other criteria |
|---|---|---|---|---|
| | | MIC (kg) | | |
| | | 100 | 300 | |
| **Public Infrastructure** | | | | |
| **Roads** | | | | |
| Bark Hut Road (gravel road – unsealed) | 180 | 14 | 34 | Vibration limit not applicable; Temporary Road closure required |
| **Powerlines** | | | | |
| LV Powerlines, timber power poles | 490 | 3 | 7 | 100 |
| 330 kV transmission line (proposed) | 1,500 | <1 | 1 | 100 / 50 |
| Underground LV cables (proposed) | 150 | 19 | 45 | 100 |
| **Private Infrastructure** | | | | |
| WWF Wind Towers (proposed) | 185 | 13 | 32 | 100 |
| Laydown Area (proposed) | 110 | 31 | 74 | 100 |
| Groundwater Bore (proposed) | 100 | 36 | 87 | 100 |

*1 – minimum distance over the lifetime of the quarry site, i.e., from the edge of the blasting boundary*

The analysis of ground vibration impacts for infrastructure is summarised as follows:

- **Public roads** - the maximum estimated vibration exposure is 34 mm/s. Since the road is an unsealed gravel road, the vibration limit is not applicable. However, due to its proximity to the quarry pit, an exclusion zone and temporary road closure will need to be implemented.
- **Power**
  - (LV power poles) - the maximum estimated vibration exposure is 7 mm/s, this is below the applicable vibration limit of 100 mm/s.
  - (proposed 330 kV line) - the maximum estimated vibration exposure is 1 mm/s, this is below the applicable vibration limit of 100 / 50 mm/s.
  - (proposed underground LV cables) - the maximum estimated vibration exposure is 45 mm/s, this is below the applicable vibration limit of 100 mm/s.

- **Proposed WWF Towers -** the maximum estimated vibration exposure is 32 mm/s, this is below the applicable vibration limit of 100 mm/s.
- **Proposed Laydown Area -** the maximum estimated vibration exposure is 74 mm/s, this is below the applicable vibration limit of 100 mm/s.
- **Proposed Groundwater Bore - -** the maximum estimated vibration exposure is 87 mm/s, this is below the applicable vibration limit of 100 mm/s.

In summary, the assessment concluded negligible impact of blast vibration, therefore no additional blast control measures are required to comply with the ground vibration criteria for infrastructure.

## 7.3 FLYROCK

The positioning of the quarry pit area, being in excess of 900 m from private residential receptors creates particularly favourable conditions to manage blasting risks that include flyrock.

For the identified closest points of interest, the study concluded:

- The closest private residential receptor (unoccupied and located approximately 900 m distance) – the flyrock risk is low / negligible.
- The closest public infrastructure, is a public road located approximately 180 m distance) will require implementation of a Road Closure Management Procedure to manage flyrock risks and ensure public safety.
- The closest private infrastructure – wind towers/laydown area/underground power cables / groundwater bore (located minimum approximately 100 - 185 m distance) – will require implementation of procedures to be outlined in a Blast Management Plan to coordinate activities with the appointed balance of plant (BOP) contractor to manage flyrock risks and ensure safety.

Flyrock risk will be further mitigated and managed such that it is contained within the boundary of Lot 95 by adhering to the following:

- Implementing a blast methodology that ensure blasting heaves material in a westerly direction (*i.e.* away from WWF infrastructure located to the east).
- Adopting more conservative values (compared to those detailed in **Table 1**) for blast hole spacing and diameter, stemming and powder factor.

Further, as pit development progresses to the east (and deeper into the second bench), the risk associated with flyrock is further reduced and the blast parameters in **Table 1** will be amended accordingly.

In accordance with standard operating procedures, a site-specific Blast Management Plan will be prepared by the proponent and drill and blast contractor that will address all occupational health and safety (OH&S) requirements, including procedures for neighbour notification of blasting.

Based on the location of the pit and proposed mitigation strategies outlined above, the flyrock impact can be adequately managed and potential risks are considered to be negligible.

# 8.0 MANAGEMENT AND MITIGATION MEASURES

Several blast control measures and technologies are available to minimise the impact of blasting on the surrounding environment. These tools enable blasts to be designed to conform to relevant criteria and constraints.

The proposed blast management measures recommended for the quarry are as follows:

**Management measures for controlling ground vibration:**

- Utilising an appropriate charge mass design to avoid overcharging holes;
- Employing a suitable initiation sequence to minimise the risk of blast-hole interactions, aiming for single-hole initiation.

**Management measures for controlling airblast:**

- Utilising an appropriate charge mass design to avoid overcharging holes;
- Employing a suitable initiation sequence to minimise the risk of blast-hole interactions, aiming for single-hole initiation.
- Maintaining the use of quality stemming material and controlling stemming height to ensure proper confinement of explosive charges, thereby minimising high airblast overpressure emissions.

**Management measures for controlling flyrock:**

- Ensuring the appropriate quality of stemming material and stemming height to facilitate the confinement of explosives, thereby minimising the risk of stemming ejection and/or flyrock incidents.

**Blast Monitoring System**

The proposed monitoring system for private residences should consist of two (2) monitoring stations to capture ground vibration and airblast overpressure impacts from blasting at the quarry site. The stations should be positioned near residences SR199 and SR259 to provide coverage for the north and east areas respectively.

**Temporary Road Closure**

Due to the close proximity to a public road (Bark Hut Road), a temporary road closure for the duration of the blast will be required. To ensure the safety of the public, the quarry will develop and implement a procedure for temporary closure of the road as part of the Blast Management Plan and seek approval from Walcha Council.

**Pre-blast Assessment Protocol**

The quarry will implement and maintain a suitable protocol, considering weather impacts and including the positioning of blasting sentries, to manage blasting operations and to minimise the impacts on the surrounding area.

**Public Notification**

Establish a landowner notification system for each blast, for adjoining landowners. Determine notification preferences (*e.g.* phone/text/email) with each landowner. This should encompass scheduled blast dates and times, along with any updates or changes.

# 9.0 CONCLUSIONS AND RECOMMENDATIONS

Enviro Strata Consulting was engaged by ARDG to undertake BIA assessment for the proposed WWF Quarry. The quarry is intended to supply quarry products solely for the construction of the nearby Winterbourne Wind Farm.

The conducted BIA evaluates the effects of blasting from the proposed quarry on the surrounding environment, including private residences (and occupants) and public infrastructure.

The BIA conclusions are summarised as follows:

**FINDINGS**

- **Impact on Private Residential Receptors**:

- The estimated ground vibration and airblast overpressure impacts from the proposed quarry were below the recommended ANZECC guideline limits and within the specified blasting parameters at all assessed private receptors within the 4 km radius.
- To mitigate flyrock impacts blasting will be designed and undertaken such that flyrock is contained within the boundary of Lot 95. Accordingly, risks for all identified residential receptors, including the closest residence at 900 m, are considered low to negligible.

- **Impact on Infrastructure**:
  - The modelling for all infrastructure in the vicinity of the quarry site concluded no significant blast vibration impacts (i.e., well below assessment criteria). The risk of flyrock can be effectively managed through the implementation of Road Closure Management Procedure.

## RECOMMENDATIONS FOR MANAGEMENT OF BLASTING IMPACTS

- Various management and mitigation measures for proposed quarry blasting, aimed at minimising blast impacts on the adjacent environment, were provided in Section 8.
- A suggested blast monitoring program, consisting of two monitoring stations as outlined in Section 8, will assist the quarry in complying with vibration and overpressure limits.
- To ensure public safety, the quarry will develop and implement a Road Closure Management Procedure applicable whenever blasting occurs in proximity to the adjacent public road.
- The quarry will develop a notification system to inform adjoining landowners of scheduled blasts.

## PARAMETERS / ASSUMPTIONS / CRITERIA

The BIA was based on the following parameters / assumptions / criteria:

- Due diligence process based on all available data at the time of the report preparation.
- The geological model for the quarry area (based on a borehole logging program undertaken by ARDG), which allowed for the determination of blasting parameters.
- The use of ground vibration and airblast overpressure models suitable for similar blasting conditions.
- The commonly accepted blast emission criteria (including ANZECC guideline (1990) and AS 2187.2-2006) for assessed items specified in Section 6.2.

**Thomas Lewandowski**
**23rd August 2024**
**Enviro Strata Consulting**

# REFERENCES

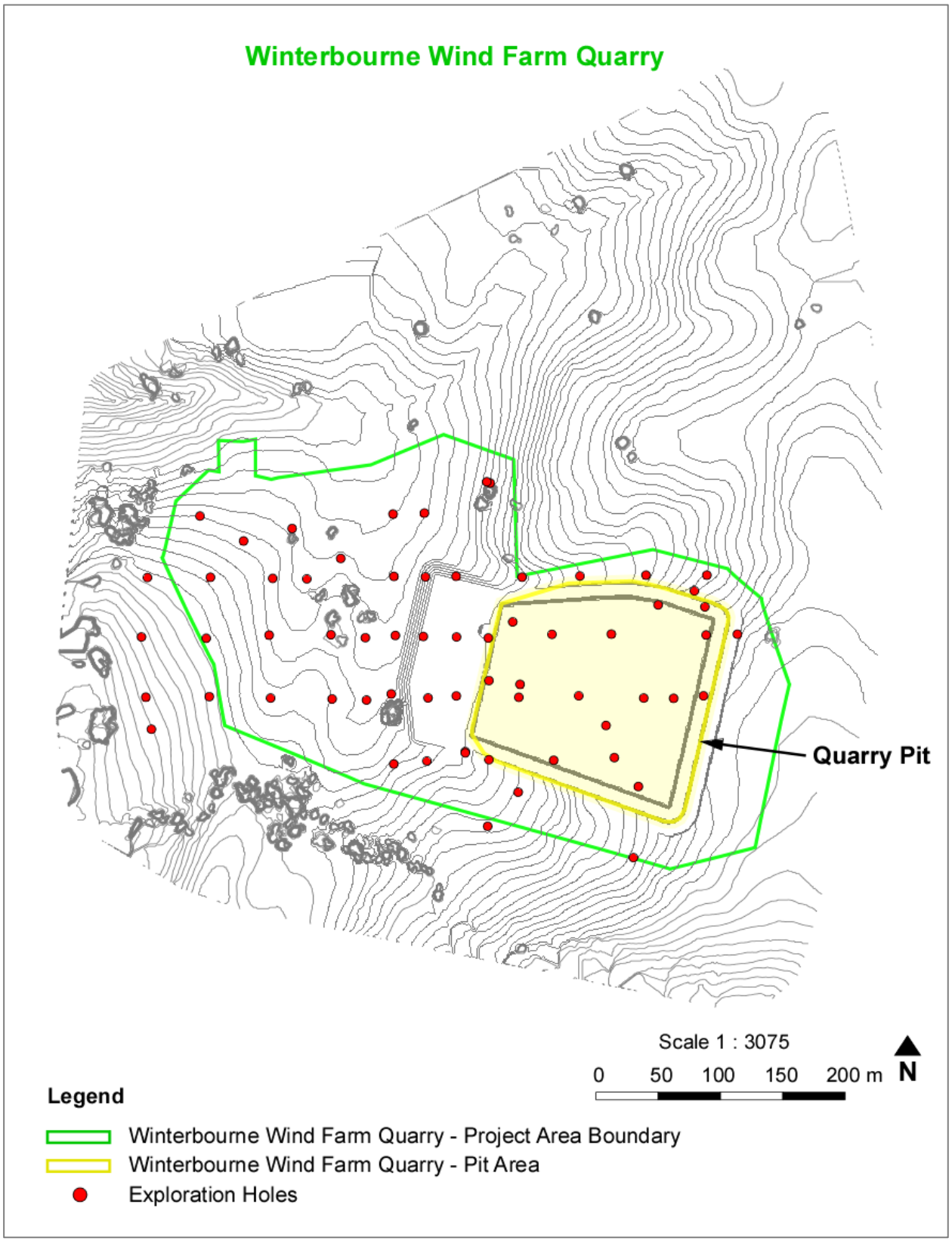

1. ACARP Report Reference No. C14057 ‘Effect of Blasting on Infrastructure’ Alan Richards, Adrian Moore, 2008

2. Australian & New Zealand Environment and Conservation Council (ANZECC) (1990). ‘Guidelines Technical Basis for Guidelines to Minimise Annoyance due to Blasting Overpressure and Ground Vibration’ September 1990.

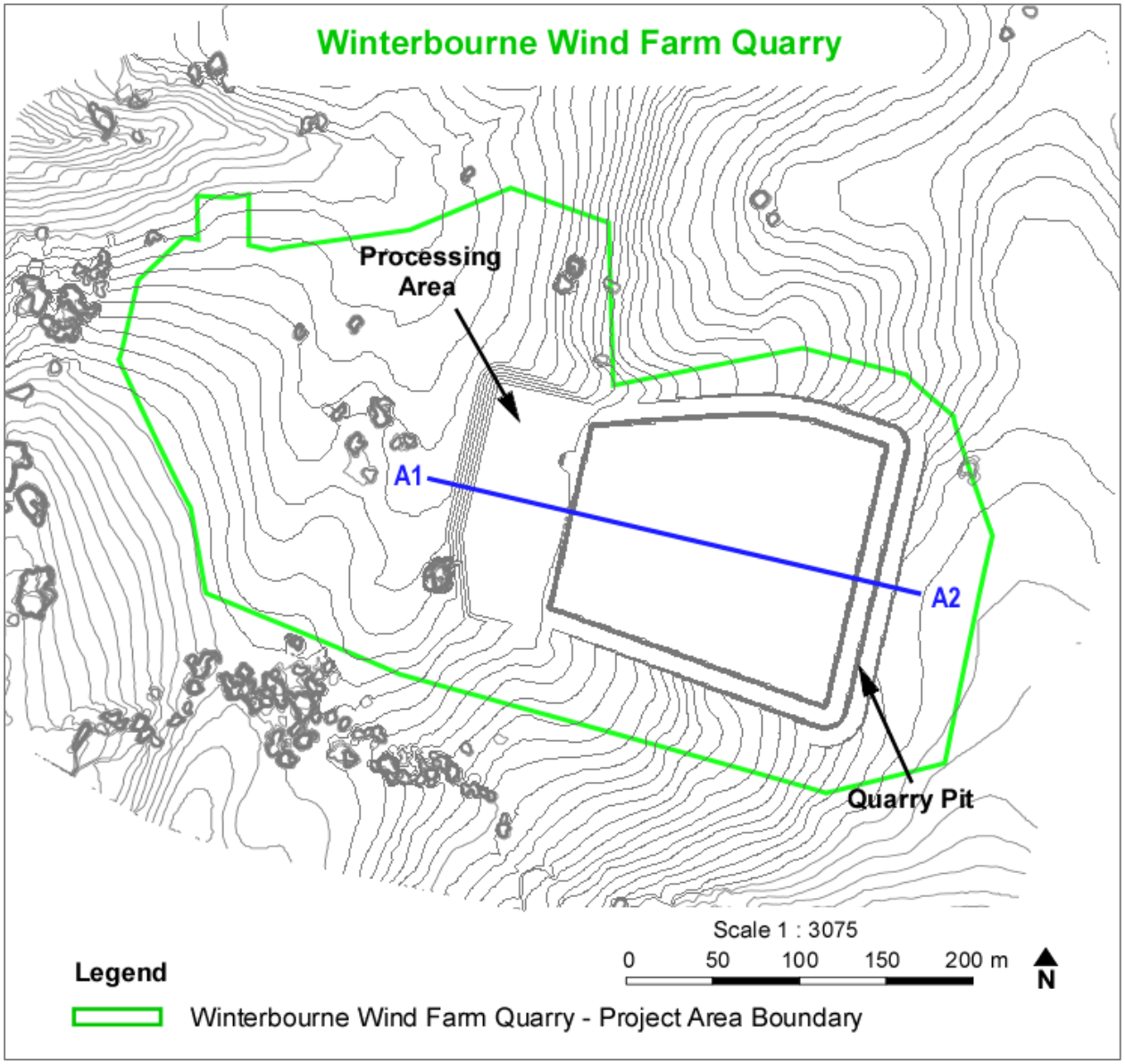
3. Australian Standard AS 2187.2:2006, Explosives – Storage and use, Part 2 – Use of explosives (AS 2187 Part 2).

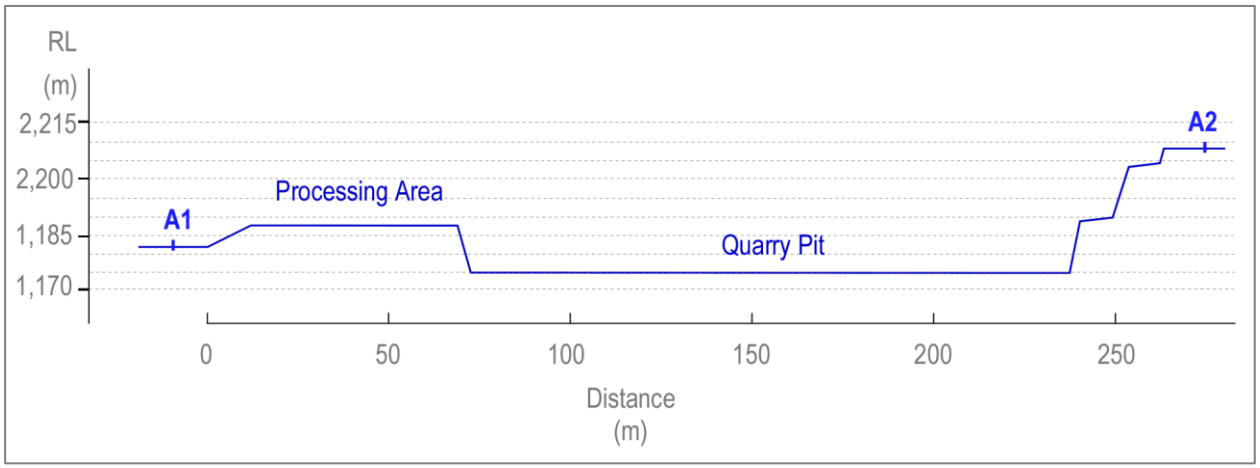
# APPENDICES

## Appendix 1 – Location of Exploration Holes for Winterbourne Wind Farm Quarry



## Appendix 2 – Topography of the Area and Cross-section for Winterbourne Wind Farm Quarry



# Appendix 5

## Air Quality and Greenhouse Gas Impact Assessment

Prepared by Airen Consulting Pty Ltd

# WINTERBOURNE WIND FARM QUARRY

## Air Quality and Greenhouse Gas Assessment

Final | Revision 4

22 August 2024

Project: 24029

## Winterbourne Wind Farm Quarry

| | |
|---|---|
| Project number | 24029 |
| Title | Winterbourne Wind Farm Quarry |
| Subject | Air Quality and Greenhouse Gas Assessment |
| Version | Final |
| Revision | Revision 4 |
| Date | 22 August 2024 |
| Client | Australian Resource Development Group Pty Limited |
| Project manager | Shane Lakmaker |
| File name | 24029_WWF Quarry_Air Quality and GHG_Final_rev4.docx |

| Version | Date | Description | Author | Review |
|---|---|---|---|---|
| D1R0 | 25/06/24 | Draft report | SL | NL |
| D2R0 | 17/07/24 | Draft report | SL | NL, ARDG |
| Final R4 | 22/08/24 | Final report | SL | NL, ARDG, WWPL |
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## Acronyms and definitions

| Abbreviation | Definition |
|---|---|
| BoM | Bureau of Meteorology |
| CO | Carbon monoxide |
| CSIRO | Commonwealth Scientific and Industrial Research Organisation |
| DPHI | Department of Planning, Housing and Industry |
| EPA | NSW Environment Protection Authority |
| EPL | Environment Protection Licence |
| GHG | Greenhouse gas |
| HVAS | High volume air sampler |
| NGER | National Greenhouse Gas and Energy Reporting |
| NEPM | National Environment Protection Measure |
| NEPC | National Environment Protection Council of Australia |
| NO | Nitric oxide |
| $NO_2$ | Nitrogen dioxide |
| $NO_x$ | Oxides of nitrogen |
| OEH | Office of Environment and Heritage, now part of the Department of Planning and Environment as Environment, Energy and Science |
| $PM_{2.5}$ | Particulate matter with equivalent aerodynamic diameters less than 2.5 microns |
| $PM_{10}$ | Particulate matter with equivalent aerodynamic diameters less than 10 microns |
| POEO Act | Protection of the Environment Operations (POEO) Act 1997 |
| $SO_2$ | Sulphur dioxide |
| TEOM | Tapered Element Oscillating Microbalance |
| TSP | Total suspended particulate matter |
| WWF | Winterbourne Wind Farm |

# Executive Summary

WinterbourneWind Pty Ltd (WWPL) is proposing a temporary, project-specific quarry as development that is ancillary to the Winterbourne Wind Farm (WWF) Project. The quarry is being proposed as part of an Amendment to the WWF Project currently being prepared. The WWF Project has a current estimated demand of 1 million tonnes (Mt) of quarry materials (e.g. road base/capping; concrete aggregates; gabion/drainage rock/ TR sand) over the estimated 3 to 4 year construction period, with maximum production of up to 500,000 tonnes per annum. It is proposed that the majority of this material could be supplied from this quarry site. Road transport of quarry products will occur on an 'as needed' basis. Transport of processed quarry material would be managed by the appointed civil contractor for the WWF using only vehicles from the wind farm approved heavy vehicle fleet and travelling only on existing approved haulage routes. The sole purpose of the quarry would be to supply materials to the WWF Project only.

This report represents an air quality and greenhouse gas (GHG) assessment of the WWF Quarry to support the SSD application. The assessment involved identifying the key air quality issues, characterising the existing environment, quantifying emissions to air, and modelling the potential impact of the Project on local air quality. The key air quality issues were identified as operational dust, post-blast fume and diesel exhaust. These issues were the focus of the assessment. GHG emissions were also estimated in accordance with recognised methodologies.

A detailed review of the existing environment was carried out including an analysis of historically measured concentrations of key quality indicators from regional monitoring stations. The review showed that air quality in many parts of NSW, including the Northern Tablelands, is heavily influenced by climatic conditions such as drought. However, due to the absence of any significant sources of air pollution, the concentrations of key air quality indicators near the Project are expected to be very low and well within acceptable levels.

The key outcomes of the modelling and subsequent assessment were as follows:

- The Project would not cause adverse impacts with respect to dust concentrations or deposition levels, based on modelling which showed compliance with air quality assessment criteria at all sensitive receptors.
- Post blast fume emissions are not expected to result in any adverse air quality impacts, based on modelling which showed compliance with air quality assessment criteria at all sensitive receptors.
- Emissions from diesel exhausts associated with off-road vehicles and equipment are not expected to result in any adverse air quality impacts, based on modelling which showed compliance with air quality assessment criteria at all sensitive receptors.
- The direct GHG emissions from the Project (i.e. Scope 1) are estimated to average 2,186 t $CO_2$-e per year. These emissions represent a very small fraction of Australia's emissions. In addition, the Project is estimated to reduce GHG emissions relative to the currently approved source of quarry materials for the WWF which would require haulage of quarry material over a distance of approximately 300 km return. These reductions in travel distances are estimated to avoid in the order of 10,747 t $CO_2$-e when compared to sourcing the WWF materials from existing, more distant quarries. The Project will also avoid diesel emissions associated with these alternative longer haulage routes.

Based on this assessment, it has been concluded that the Project is a relatively remote and temporary operation that is unlikely to cause any adverse air quality impacts at sensitive locations.

# 1 Introduction

## 1.1 Background

The Proponent is seeking State Significant Development (SSD) approval to construct and operate the Winterbourne Wind Farm (WWF) near Walcha, New South Wales (NSW). Construction materials will be required to support the development of the WWF and the Proponent is proposing the development of an on-site quarry (WWF Quarry) for this purpose. This report represents an air quality and greenhouse gas (GHG) assessment of the WWF Quarry to support the SSD application.

## 1.2 Project Description

The Proponent has identified an opportunity to establish a temporary hard rock quarry for the sole purpose of producing and supplying quarry products to support the construction of the WWF Project. Approval for the WWF Project is being sought under State Significant Development (SSD) 10471.

Australian Resource Development Group Pty Limited (ARDG) has undertaken detailed site geological investigations which indicate that the quarry resource is suitable for the production of a range of products (e.g. roadbase, concrete aggregates, drainage rock) required for construction of the public road upgrades, wind farm access tracks, hardstand areas, turbine foundations and other associated civil works associated with the Project.

Approval for the quarry is being sought development that is ancillary to the SSD, while a separate Environmental Protection Licence (EPL) would also be sought for the quarry operation. The WWF Quarry site (the quarry site) is located on Lot 95 DP1128816. Figure 1 shows the proposed location of the WWF Quarry, surrounding features and nearest properties.

Given it is located within the WWF Project Site Boundary on 'Bark Hut', with direct access from the quarry site to Bark Hut Road (part of the WWF construction haulage route), sourcing of construction materials from the proposed WWF Quarry (compared to sourcing from commercial quarries in the broader region) would significantly reduce WWF construction traffic on the local and regional road network. This would result in very significant, tangible benefits for the local and broader community by:

- reducing construction traffic noise amenity impacts for residents and road users, in particular those along the construction traffic haul route;
- improving road safety (by substantially reducing heavy/light vehicle interactions); and
- reducing heavy vehicle wear and potential damage to the local and regional road network by significantly reducing total distance travelled on the local and regional road network.

Supply of quarry products from this on-site quarry would also reduce the carbon footprint of the WWF Project (via substantially reduced fuel consumption associated with haulage), and would also provide significant construction cost savings, by significantly reducing the haulage distance for construction materials supplied to the Project.

It is estimated that the WWF Project may require approximately 1 million tonnes (Mt) of quarry materials to support the construction of the Project over an estimated period of 3 to 4 years, with peak production / transport from the site not exceeding 500,000 tonnes per annum (tpa). Construction and operation would be undertaken during daytime hours, being Monday to Friday 7 am to 6 pm and Saturday 8 am to 6 pm, with minor non-audible works to be undertaken outside of these hours (e.g. maintenance activities).

Key features of the WWF Quarry are illustrated on Figure 2 and summarised as follows:

- Extraction pit ("pit") covering an area of approximately 4.45 hectares (ha) from where a greywacke resource would be drilled, blasted and extracted, prior to processing. The Pit would be developed to a floor level of approximately 1170 m AHD, with extraction undertaken as two benches with nominal height of 15 m.
- Main processing and stockpiling area covering an area of approximately 2.13 ha adjacent to the western edge of the Pit. Processing of extracted rock would be undertaken in this area using mobile crushing and screening equipment, with finished quarry products transferred to discrete stockpiles. As the pit face progresses, processing / stockpiling may also occur in pit (i.e. below the ground surface), further shielding operations.
- Secondary processing and operational areas (peripheral to the above areas) covering an area of approximately 3.88 ha. These areas would accommodate, for example, additional stockpiling (if required), internal temporary administration (mobile crib room/toilet facilities), peripheral topsoil bunds, access tracks, light vehicle parking, and surface water management controls.

- Internal access track linking the stockpile / operational areas with Bark Hut Road (approximately 8 m wide surface with 1 m wide shoulders). The access track would be approximately 0.15 km long. Transport of processed quarry material on the approved haul route of the WWF, which would be managed by the appointed civil contractor for the WWF on an 'as needs' basis during quarry operations.
- Surface water management / sediment basin area (0.67 ha).
- Annual production from the Project will not exceed 500,000 tpa during construction phases.
- It is not proposed to construct a weighbridge, as extraction quantities will be calculated by belt / loader scales and cross referenced with topographic survey taking account of rock density. All materials produced by the quarry will supply the WWF Project only.
- At the completion of quarry operations, the site will be rehabilitated in consultation with the landowner to determine an appropriate, safe and stable landform(s) that can facilitate ongoing rural activities.
- Stabilisation of the processing and stockpiling area. To be returned to pre-disturbance existing condition in consultation with the landowner (e.g. re-seeded with appropriate pasture grass).

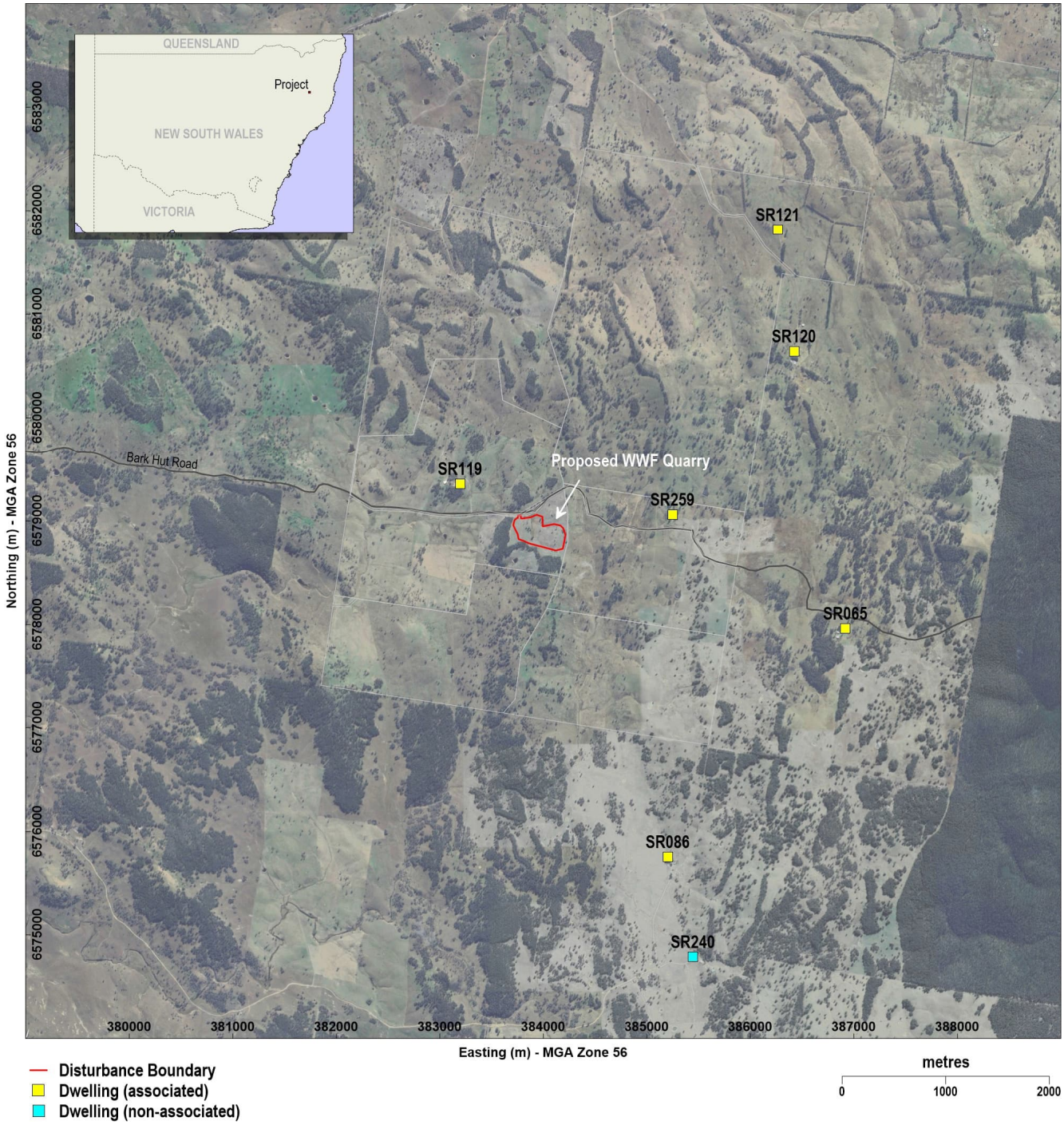



Figure 1 Proposed location for the WWF Quarry

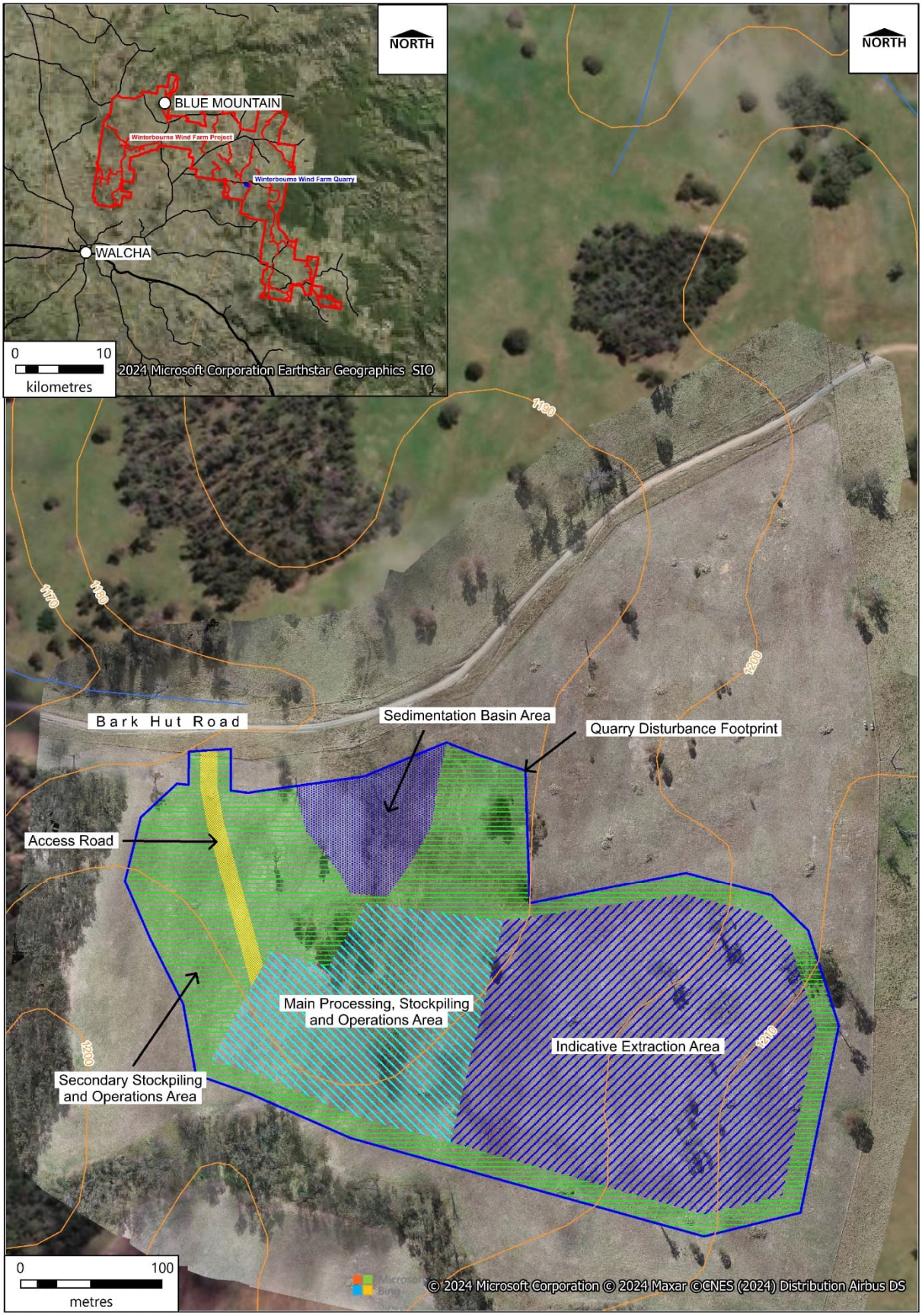



Figure 2 Proposed site layout

## 1.3 Assessment Requirements

This assessment has been prepared in accordance with requirements of the NSW Department of Planning, Housing and Industry (DPHI). While the Secretary's Environmental Assessment Requirements (SEARs) for the WWF did not include specific requirements for air quality impact assessment (AQIA) for the WWF Quarry, Table 1 outlines typical SEARs relevant to this assessment along with a reference to where these are addressed.

Table 1 Assessment requirements relevant to air quality and greenhouse gas

| Secretary's requirements | Where addressed in this report |
|---|---|
| Air Quality - including:<br>- a detailed assessment of potential construction and operational air quality impacts of the development, in accordance with the Approved Methods for the Modelling and Assessment of Air Pollutants in NSW, and with a particular focus on dust emissions including $PM_{2.5}$ and $PM_{10}$, and having regard to the Voluntary Land Acquisition and Mitigation Policy;<br>- an assessment of potential dust and other emissions generated from processing, operational activities and transportation of quarry products;<br>- an assessment of the likely greenhouse gas emissions and impacts of the development;<br>- reasonable and feasible mitigation measures to minimise dust and other emissions; and<br>- proposed monitoring and management measures. | Section 5 describes the methodology for assessment, as per the Approved Methods for the Modelling and Assessment of Air Pollutants in NSW<br>Section 6 provides an assessment of predicted impacts.<br>Section 7 provides estimates of greenhouse gas emissions.<br>Section 8 outlines monitoring and management measures, commensurate with the predicted impacts. |

The EPA has also released a draft Climate Change Assessment Requirements and draft Guide for Large Emitters. The assessment has also had regard to this draft policy and Guide however, as noted in the assessment below, the Project does not trigger the threshold for a Large Emitter.

## 1.4 Report Structure

The report is structured as follows:

- Section 1 introduces the project with a summary of the background and description.
- Section 2 identifies the key air quality and GHG issues to be addressed.
- Section 3 outlines the key legislative and policy assessment requirements for air quality and greenhouse gas.
- Section 4 discusses key features of the existing environment including surrounding land uses, sensitive receptors, and local meteorological and air quality conditions.
- Section 5 provides an overview of the methods used to assess the potential for air quality and GHG impacts.
- Section 6 provides an assessment of the potential construction and operational air quality impacts.
- Section 7 provides an assessment of the potential GHG emissions.
- Section 8 outlines the measures to mitigate or otherwise effectively manage potential impacts.
- Section 9 provides the conclusions of the assessment.

# 2 Key Issues

Air quality issues can arise when emissions from an industry or activity lead to a deterioration in the ambient air quality. Potential air quality issues have been identified from a review of the Project and associated activities. This identification process has considered the types of emissions to air and proximity of these emission sources to sensitive receptors.

Emissions to air from the Project could occur from a variety of activities including material handling, material transport, processing, and wind erosion from exposed areas. These emissions will primarily occur during the operational phase, as limited construction works will be required. The main emission to air from quarry activities is dust, also referred to as particulate matter.

Key classifications of particulate matter include:

- Total suspended particulates (TSP)
- Particulate matter with equivalent aerodynamic diameter of 10 microns or less ($PM_{10}$)
- Particulate matter with equivalent aerodynamic diameter of 2.5 microns or less ($PM_{2.5}$)
- Deposited dust

Plant and equipment engine exhausts also have the potential to generate emissions that include carbon monoxide (CO), oxides of nitrogen ($NO_x$) and particulate matter, and to a lesser extent sulphur dioxide ($SO_2$). Post-blast fume has the potential to generate nitric oxide (NO) emissions which, in turn, can oxidise to the more harmful nitrogen dioxide ($NO_2$).

The key issues which were identified for the Project for consideration in this assessment included:

- Quarry dust i.e. particulate matter in the form of TSP, $PM_{10}$, $PM_{2.5}$ and deposited dust
- Post-blast fume ($NO_2$)
- Diesel exhaust ($PM_{10}$, $PM_{2.5}$ and $NO_2$)
- Greenhouse gas emissions e.g. carbon dioxide equivalent gases ($CO_2$-e)

# 3 Policy Setting

## 3.1 Air Quality Criteria

Air quality is typically quantified by the concentrations of substances in the ambient air. Air pollution occurs when the concentration (or some other measure of intensity) of one or more substances known to cause health, nuisance and/or environmental effects, exceeds a certain level. With regard to human health and nuisance effects, the substances most relevant to the Project have been identified, from Section 2, as particulate matter and $NO_2$.

The EPA has developed assessment criteria for a range of air quality indicators including particulate matter and $NO_2$. These criteria are outlined in the "Approved Methods for the Modelling and Assessment of Air Pollutants in NSW" (EPA, 2022), hereafter referred to as the Approved Methods. Most of the EPA criteria referred to in this report have been drawn from national standards for air quality set by the National Environmental Protection Council of Australia (NEPC) as part of the National Environment Protection Measures (NEPMs) (NEPC, 1998 and updates).

The Project has been assessed in terms of its ability to comply with the relevant air quality criteria set by the EPA as part of the Approved Methods. These criteria are outlined in Table 2 and apply to existing and potentially sensitive receptors, where the Approved Methods defines a sensitive receptor as including "a location where people are likely to work or reside; this may include a dwelling, school, hospital, office or public recreational area".

Table 2 EPA air quality assessment criteria

| Air quality indicator | Averaging time | Criterion | Application |
|---|---|---|---|
| Particulate matter ($PM_{10}$) | 24-hour | 50 µg/m$^3$ | Cumulative, at sensitive receptors |
| | Annual | 25 µg/m$^3$ | Cumulative, at sensitive receptors |
| Particulate matter ($PM_{2.5}$) | 24-hour | 25 µg/m$^3$ | Cumulative, at sensitive receptors |
| | Annual | 8 µg/m$^3$ | Cumulative, at sensitive receptors |
| Particulate matter (TSP) | Annual | 90 µg/m$^3$ | Cumulative, at sensitive receptors |
| Deposited dust | Annual (maximum increase) | 2 g/m$^2$/month | Incremental, at sensitive receptors |
| | Annual (maximum total) | 4 g/m$^2$/month | Cumulative, at sensitive receptors |
| Nitrogen dioxide ($NO_2$) | 1-hour | 164 µg/m$^3$ | Cumulative, at sensitive receptors |
| | Annual | 31 µg/m$^3$ | Cumulative, at sensitive receptors |

**Source: Table 11 of the Approved Methods.*

The EPA air quality assessment criteria relate to the total concentration of pollutants in the air (that is, cumulative) and not just the contribution from project-specific sources. Therefore, some consideration of background levels needs to be made when using these criteria to assess the potential impacts. In situations where background levels are elevated the proponent must "demonstrate that no additional exceedances of the impact assessment criteria will occur as a result of the proposed activity and that best management practices will be implemented to minimise emissions of air pollutants as far as is practical" (EPA, 2022). Section 4 provides further discussion on background levels.

## 3.2 Greenhouse Gas

### 3.2.1 Overview

GHG is a collective term for a range of gases that are known to trap radiation in the upper atmosphere, where they have the potential to contribute to the greenhouse effect (global warming). GHGs include:

- Carbon dioxide ($CO_2$); by far the most abundant GHG, primarily released during fuel combustion.
- Methane ($CH_4$); generated from the anaerobic decomposition of carbon-based material (including enteric fermentation and waste disposal in landfills).
- Nitrous oxide ($N_2O$); generated from industrial activity, fertiliser use and production.
- Hydrofluorocarbons (HFCs); commonly used as refrigerant gases in cooling systems.
- Perfluorocarbons (PFCs); used in a range of applications including solvents, medical treatments and insulators.

- Sulphur hexafluoride ($SF_6$); used as a cover gas in magnesium smelting and as an insulator in heavy duty switch gear.

It is common practice to aggregate the emissions of these gases to the equivalent emission of carbon dioxide. This provides a simple figure for comparison of emissions against targets. Aggregation is based on the potential of each gas to contribute to global warming relative to carbon dioxide and is known as the global warming potential (GWP). The resulting number is expressed as carbon dioxide equivalents (or $CO_2$-e).

GHG emissions that form an inventory can be split into three categories known as 'Scopes'. Scopes 1, 2 and 3 are defined by the Greenhouse Gas Protocol (WRI, 2004) and can be summarised as follows:

- Scope 1 – Direct emissions from sources that are owned or operated by the organisation (examples include combustion of diesel in company owned vehicles or used in on-site generators).
- Scope 2 – Indirect emissions associated with the import of energy from another source (examples include importation of electricity or heat).
- Scope 3 – Other indirect emissions (other than Scope 2 energy imports) which are a direct result of the operations of the organisation but from sources not owned or operated by them (examples include business travel, by air or rail, and product usage).

The purpose of differentiating between the scopes of emissions is to avoid the potential for double counting, where two or more organisations assume responsibility for the same emissions.

### 3.2.2 Federal Policy

The 21st yearly session of the Conference of Parties (COP), held in Paris in 2015, was pivotal for developing an international treaty on climate change. It resulted in "The Paris Agreement", an agreement 'to achieve a balance between anthropogenic (human induced) emissions by sources and removals by sinks of greenhouse in the second half of this century'. Subsequent COPs have sought to develop policy architecture to deliver on the commitments of COP21. In particular, following COP21, international agreements were made to:

- Keep global warming well below 2.0 degrees Celsius, with an aspirational goal of 1.5 degrees Celsius (based on temperature pre-industrial levels).
- From 2018, countries are to submit revised emission reduction targets every five years, with the first being effective from 2020, and goals set to 2050.
- Define a pathway to improve transparency and disclosure of emissions.
- Make provisions for financing the commitments beyond 2020.

Australia has a *Climate Change Act 2022*. This Act operates as 'umbrella' legislation to implement Australia's net-zero commitments and codifies Australia's net 2030 and 2050 GHG emissions reductions targets under the Paris Agreement including targets to cut emissions by 43% by 2030 from 2005 levels, and achieve net zero emissions by 2050.

The Federal Government uses the *National Greenhouse and Energy Reporting Act 2007* (NGER Act) for the measurement, reporting and verification of GHG emissions in Australia. This legislation is used for a range of purposes, including international GHG reporting. Under the NGER Act, constitutional corporations in Australia which exceed thresholds for GHG emissions or energy production or consumption are required to measure and report data to the Clean Energy Regulator on an annual basis. The *National Greenhouse and Energy Reporting (Measurement) Determination 2008* (Measurement Determination) identifies several methodologies to account for GHGs from specific sources relevant to the Project. This includes emissions of GHGs from direct fuel combustion (fuels for transport energy purposes), emissions associated with consumption of power from direct combustion of fuel (e.g. diesel generators used during construction), and from consumption of electricity from the grid.

The Measurement Determination provides methods, criteria, and measurement standards for calculating and reporting greenhouse gas emissions and energy data under the NGER Act. It covers scope 1 and scope 2 emissions and energy production and consumption. The Measurement Determination is primarily used for historical reporting of activities. The calculation methodologies for the Project have been based on the National Greenhouse Accounts (NGA) Factors as the NGA Factors are referred to in, for example, the SEARs where relevant, for the purposes of project assessment. The NGA Factors is not published for the purposes of reporting under the NGER Act.

### 3.2.3 State Policy

The NSW government has developed a Climate Change Policy Framework which sets the objective of achieving net-zero emissions by 2050. The policy does not impose any specific requirements on developments undertaken by private companies but intends to achieve net-zero emissions through a combination of policy development, leading by example and advocacy. Specific directions and emission reduction initiatives arising from or aligned to the Framework include:

- An electricity infrastructure roadmap
- A net zero industry and innovation program
- An electric vehicle strategy
- A hydrogen strategy
- A waste and sustainable materials strategy
- A primary industries productivity and abatement program.

In May 2024, the EPA issued a draft policy on climate change assessment requirements for large emitters (EPA, 2024a) (draft CCARs) and a draft NSW EPA Guide for Large Emitters (EPA 2024b). Under the draft CCARs, an SSD project that is likely to emit 25,000 t $CO_2$-e or more Scope 1 and 2 must apply the requirements of the EPA Guide for Large Emitters as part of the assessment of GHG emissions for a project. As detailed in Section 7, this threshold is not exceeded by the Project and the draft CCARs and NSW EPA Guide for Large Emitters therefore do not apply to the assessment processes for the Project.

# 4 Existing Environment

This section provides a description of the environmental characteristics in the area, including a review of recent and historical meteorological and ambient air quality conditions.

## 4.1 Local Setting

The Project is located on privately-owned rural land approximately 20 km northeast of Walcha. There are several isolated rural residences to the northwest, northeast, and southeast, with the closest residence located 1 km to the northwest of the proposed extraction area (Figure 1) – all these residences are associated with the WWF Project. The Project is located on a ridgeline at an elevation of around 1,200 m above mean sea level with areas of rugged terrain. Figure 3 shows a three-dimensional representation of the local terrain. This topographical environment has the potential to influence local wind conditions, discussed in Section 4.2.

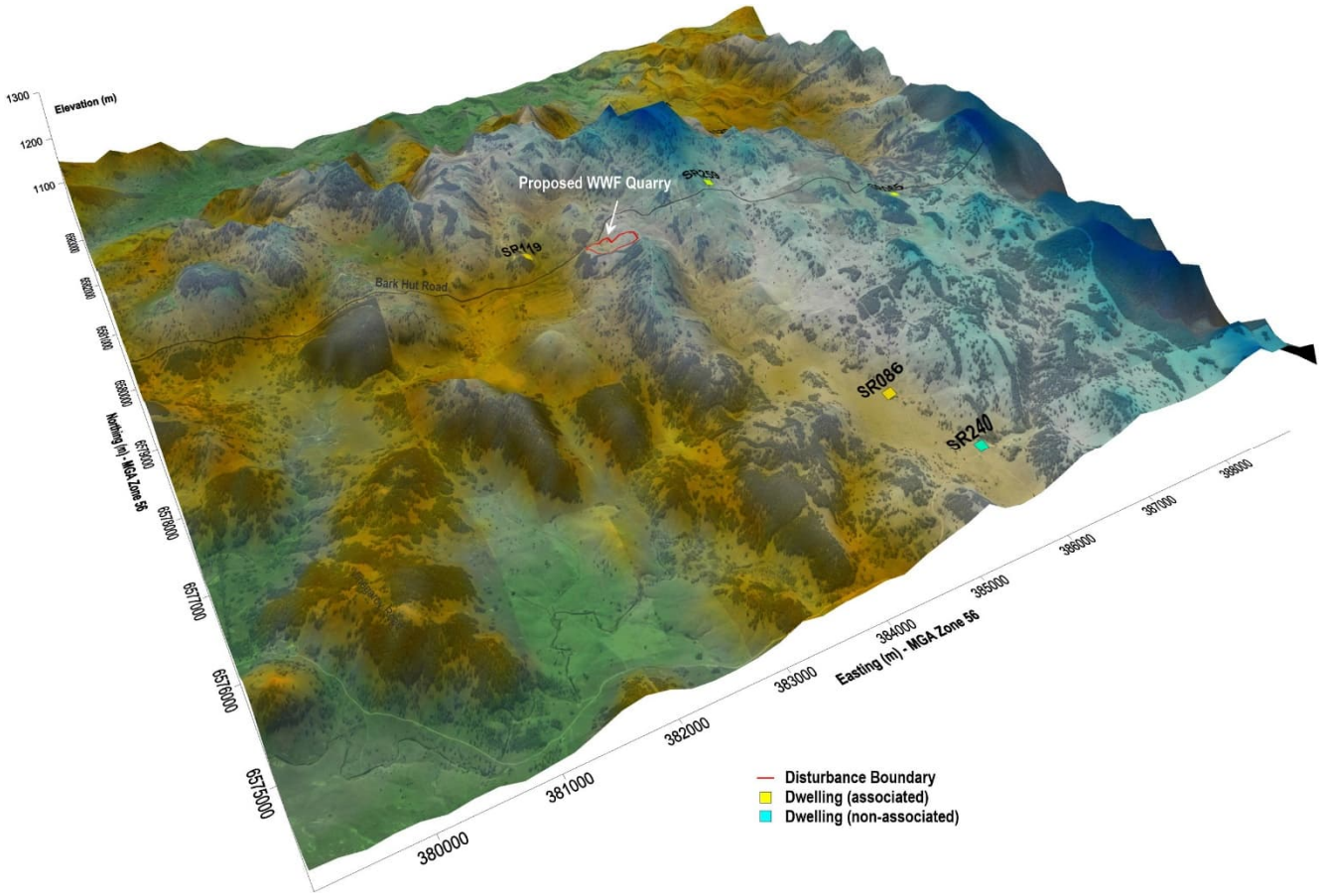



Figure 3 Three-dimensional representation of the local terrain

## 4.2 Meteorology

Meteorological conditions are important for determining the transport of emissions, and the potential influences on air quality. In addition, meteorological data are often used with concurrent air quality data to determine potential contributions from sources of interest. This section provides an analysis of the meteorological conditions around the Project and identifies the datasets that are representative of the long term, local conditions.

The EPA prescribes the minimum requirements for meteorological data that are to be used for air quality assessments. These requirements are outlined in the Approved Methods and include minimum data capture rates, siting and operation, and data preparation. Meteorological stations that are used for the purposes of air quality assessments can be classified (EPA, 2022) as either “site specific” or “site representative”. Data from site-specific meteorological stations are preferred however site representative data are also acceptable where site-specific meteorological data are not available provided that the data adequately describe the expected meteorological conditions at the site of interest. Air quality assessments that involve modelling are usually carried out using at least one year of site-specific or site-representative meteorological data that is over 90% complete.

There are no known meteorological stations in the Walcha region (suitable for use in air quality modelling) however the DPHI operates a network of meteorological monitoring stations across NSW including several stations in the Northern Tablelands region. The closest DPHI station to the Project is at Armidale, over 50 km away. This station is unlikely to collect data that accurately represent conditions in the Project area, primarily due to terrain effects. Meteorological modelling has therefore been used to derive conditions near the Project.

As noted above, the meteorological data from Armidale are unlikely to accurately represent conditions in the Project area however these data can be used to identify a representative year for the meteorological modelling. Figure 4 shows the hourly wind speeds from data collected at the Armidale between 2019 and 2023. These data show that maximum hourly wind speeds typically reached around 10 metres per second (m/s) and the strongest winds can occur at any time of year. There were no periods that might be considered as unusual or extraordinary.

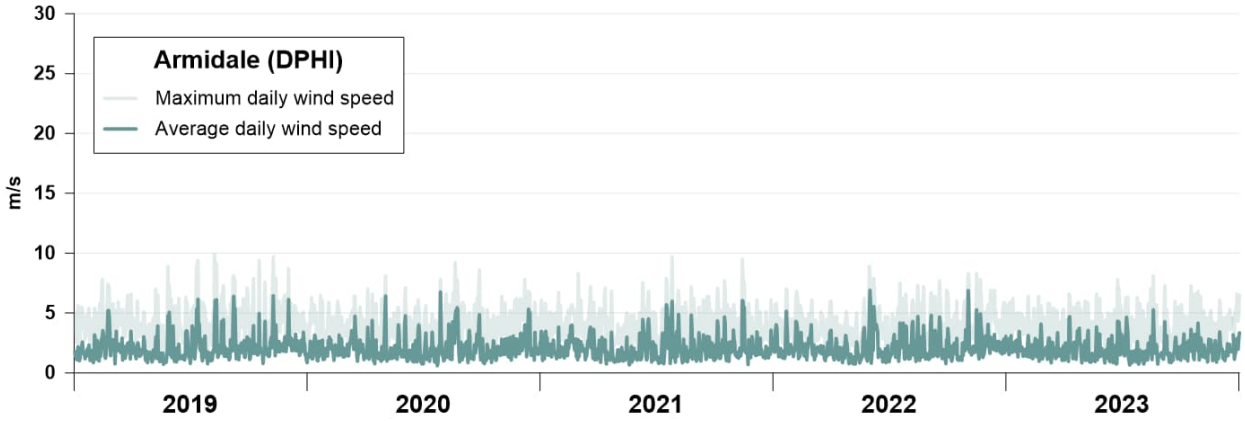



Figure 4 Wind speed data collected at Armidale between 2019 and 2023

Table 3 provides annual statistics from the Armidale wind speed data. These statistics do not highlight any unusual or extraordinary years in terms of wind speeds.

Table 3 Wind speed statistics from data collected at Armidale between 2019 and 2023

| Statistic | 2019 | 2020 | 2021 | 2022 | 2023 |
|---|---|---|---|---|---|
| Percentage complete (%) | 100 | 100 | 100 | 100 | 99 |
| Mean wind speed (m/s) | 2.2 | 2.0 | 2.0 | 2.2 | 1.9 |
| 99$^{th}$ percentile wind speed (m/s) | 7.5 | 6.4 | 6.5 | 6.8 | 6.0 |
| Percentage of calms (<= 0.5 m/s) (%) | 12 | 13 | 13 | 10 | 12 |

Wind-roses have also been prepared from the Armidale data (Figure 5). The wind-roses show the frequency of wind speeds and wind directions based on hourly records. The circular format of the wind rose shows the direction from which the wind blew and the length of each “spoke” around the circle shows how often the wind blew from that direction. The different colours of each spoke provide details on the speed of the wind from each direction.

Figure 5 shows that the winds in the Armidale area are most commonly from the east-southeast or northwest and that the proportion of calm conditions is in the order of 10 to 15%. This pattern of winds is evident in all periods of data and shows that wind patterns do not vary significantly from year to year. It also suggests that the data from any of the years presented could be considered as representative of the longer-term conditions.

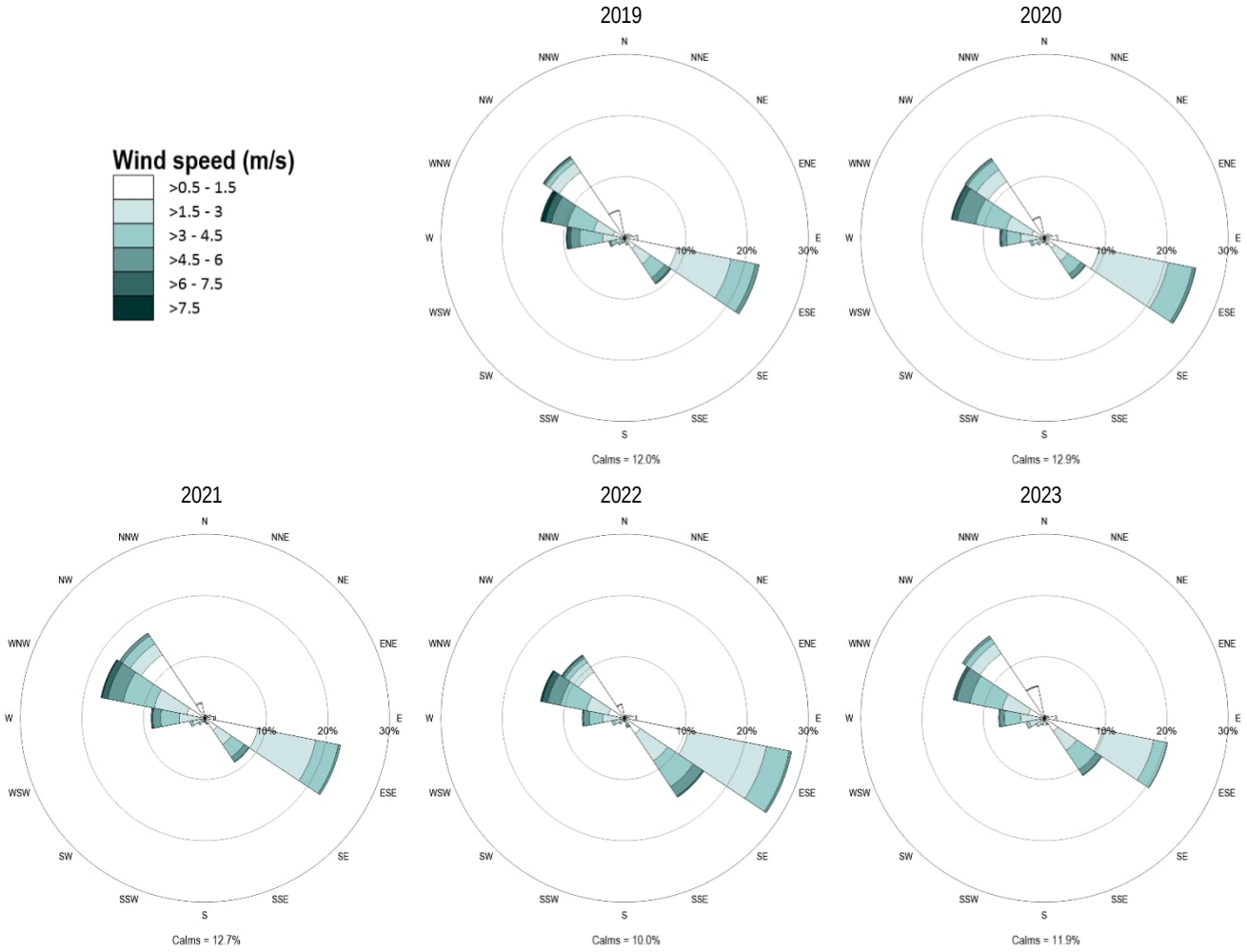



Figure 5 Wind-roses from data collected at Armidale

Meteorological modelling has been carried out to simulate conditions at the Project site for the 2023 calendar year. Details of the modelling are provided in Appendix A. Figure 6 shows annual and seasonal wind-roses from modelled data. These data show that the prevailing winds at the Project site are likely to be stronger than at Armidale and from the east and west, with a relatively low proportion of calm conditions. The differences between the Armidale data and modelled site data can be explained by the higher elevation and more undulating terrain of the Project site. Methods used for generating and incorporating the 2023 meteorological data into the dispersion modelling for the Project are discussed in Section 5.

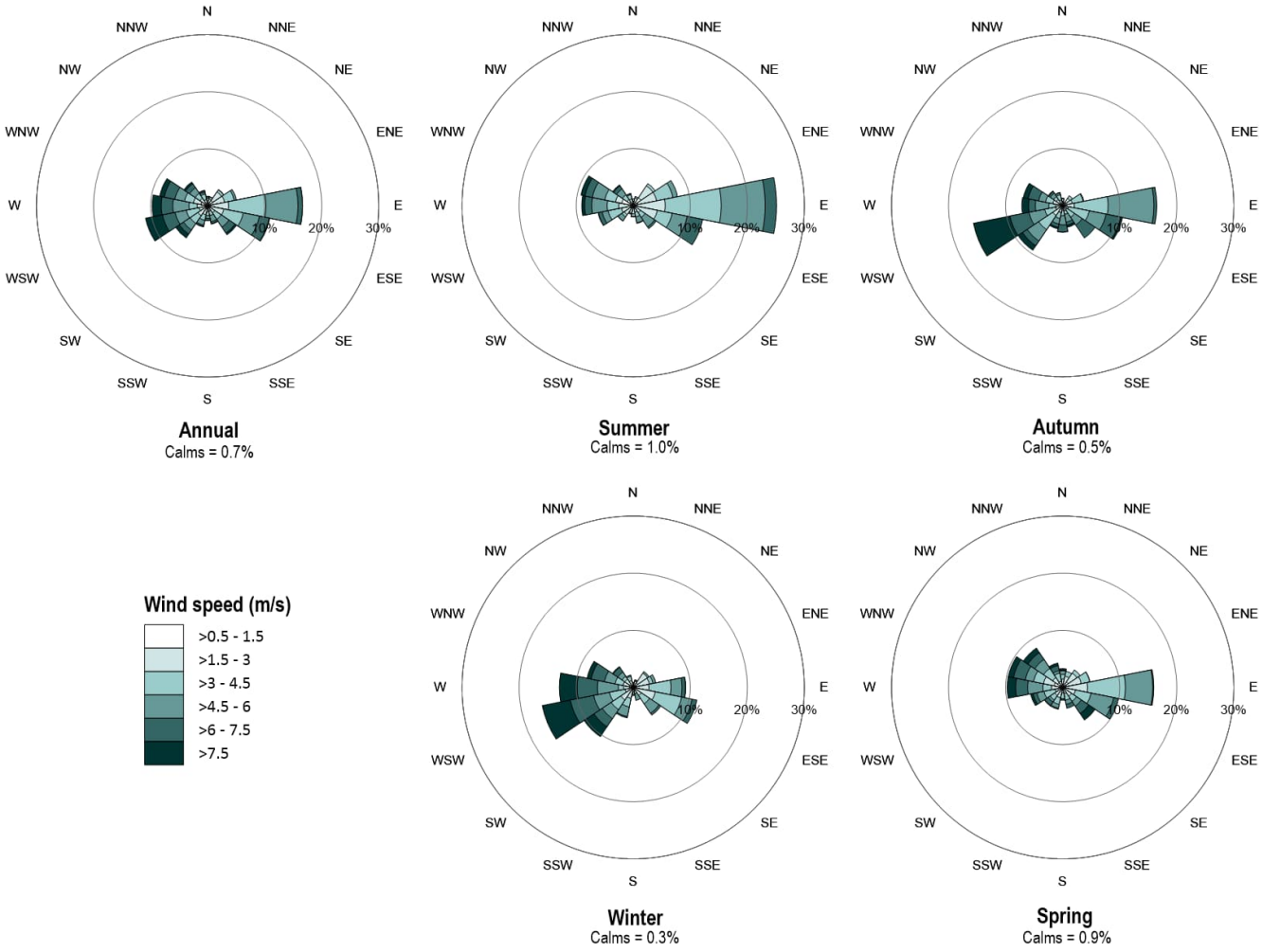



Figure 6 Annual and seasonal wind-roses from modelled data for the Project site in 2023

## 4.3 Air Quality

The DPHI monitors air quality at various locations across NSW including in the Northern Tablelands. The network includes over 90 air quality monitoring stations. Over 50 stations use compliance methods to monitor air quality in areas of the State's highest populations, near industrial activities, and at locations with special interest or research purposes. Over 35 stations, supported by rural communities, use indicative instrumentation methods to monitor particles across the NSW rural air quality monitoring network.

This section examines the historical air quality conditions of the region and establishes the appropriate background levels to be considered for assessment of the Project. It should be noted that air quality monitoring data represent the contributions from all sources that have at some stage been upwind of each monitor. In the case of particulate matter (as $PM_{10}$) for example, a measurement may contain contributions from many sources such as from construction works, bushfires and 'burning off', agricultural activities, industry, vehicles, roads, wind-blown dust from nearby and remote areas, fragments of pollens, moulds, and so on.

### 4.3.1 Extraordinary Events

Air quality in many parts of NSW, including the Northern Tablelands, was adversely influenced by drought conditions between 2017 to 2019 and lower than average rainfall. A deterioration in air quality conditions over these years was not unique to the Northern Tablelands and extraordinary events, beyond normal conditions, have been identified as part of annual reviews of monitoring data.

In its "Annual Air Quality Statement 2018", the DPHI concluded that particle levels increased across NSW due to dust from the widespread, intense drought and smoke from bushfires and hazard reduction burning (OEH, 2019). The DPHI subsequently concluded, from their "Annual Air Quality Statement 2019", that air quality in NSW was greatly affected by the continuing intense drought conditions and unprecedented extensive bushfires during 2019. In addition, the continued "intense drought has led to an increase in widespread dust events throughout the year" (DPE, 2020).

The influence of drought conditions on air quality is evident in the DPHI's monitoring data. Figure 7 shows the rolling annual average $PM_{10}$ concentrations from data collected at various rural and urban air quality monitoring sites since 2011. These data clearly show an increase in $PM_{10}$ concentrations at all rural and urban locations from 2017 onwards, reflecting the onset of drought conditions, and increased bushfire activity in 2019. The rolling annual average $PM_{10}$ concentrations decreased rapidly from 2020 to 2022 as rainfall increased.

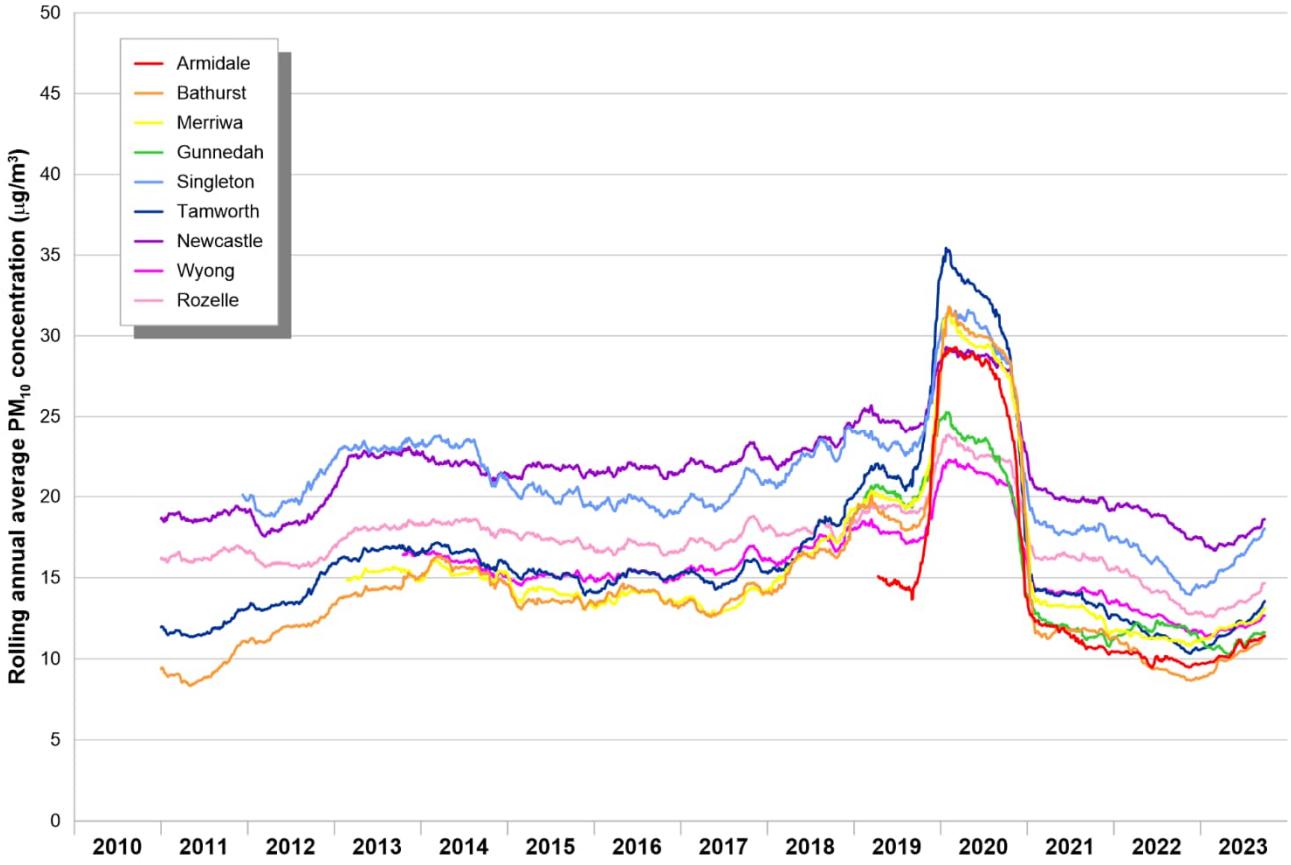



Figure 7 Rolling annual average $PM_{10}$ concentrations at various NSW air quality monitoring sites

The use of years with elevated air quality levels, largely driven by extraordinary events or extreme climatic conditions (or both) are avoided in modelling studies primarily because they do not address the definition of representative. In addition, extraordinary events cannot be reliably simulated in air dispersion models as it is not possible to identify all possible factors that led to these events, for example, the factors that influence the time, location, and intensity of bushfires. This context has been considered in the analysis below.

### 4.3.2 Particulate Matter (as $PM_{10}$)

Air quality criteria for $PM_{10}$ are set to protect against adverse health impacts. The closest known monitoring of $PM_{10}$ occurs at Armidale, approximately 50 km to the north of the Project location. Table 4 provides a summary of the Armidale $PM_{10}$ data. The data show elevated $PM_{10}$ concentrations in 2019 and 2020 coinciding with drought conditions and lower than average rainfall. These conditions led to increases in the number of days when the 24-hour average $PM_{10}$ concentration exceeded 50 µg/m³ and increases in the annual average $PM_{10}$ concentrations. The increases in $PM_{10}$ concentrations were observed across many locations in NSW and were not unique to the Northern Tablelands. Concentrations decreased from mid-2020, coinciding with increased rainfall. Concentrations of $PM_{10}$ near the Project would be much lower than at Armidale due to the absence of any significant sources of particulate matter.

Table 4 Summary of measured $PM_{10}$ concentrations at Armidale

| Statistic | 2019 | 2020 | 2021 | 2022 | 2023 | EPA criterion |
|---|---|---|---|---|---|---|
| Maximum 24-hour average (µg/m³) | 310 | 113 | 41 | 51 | 38 | 50 |
| Number of days above 50 µg/m³ (days) | 41 | 4 | 0 | 1 | 0 | - |
| Annual average (µg/m³) | 28 | 14 | 10 | 10 | 12 | 25 |

### 4.3.3 Particulate Matter (as $PM_{2.5}$)

Air quality criteria for $PM_{2.5}$ are set to protect against adverse health impacts. The closest known monitoring of $PM_{2.5}$ occurs at Armidale. Table 5 provides a summary of the Armidale $PM_{2.5}$ data. Concentrations of $PM_{2.5}$ near the Project would, again, be much lower than at Armidale due to the absence of any significant sources of particulate matter.

Table 5 Summary of measured $PM_{2.5}$ concentrations at Armidale

| Statistic | 2019 | 2020 | 2021 | 2022 | 2023 | EPA criterion |
|---|---|---|---|---|---|---|
| Maximum 24-hour average (µg/m³) | 267 | 54 | 35 | 45 | 32 | 25 |
| Number of days above 25 µg/m³ (days) | 60 | 27 | 3 | 11 | 7 | - |
| Annual average (µg/m³) | 17.2 | 9.2 | 7.2 | 7.1 | 8.6 | 8 |

### 4.3.4 Particulate Matter (as TSP)

TSP is not monitored in the vicinity of the Project. The NSW Minerals Council (2000) estimated that, for rural environments in NSW, the average $PM_{10}$ concentrations are typically 40% of the TSP concentrations. For this assessment it has therefore been assumed that $PM_{10}$ concentrations would be 40% of the TSP concentrations, an assumption that yields an estimated annual average TSP concentration of 30 µg/m³ at Armidale based on the measured annual average $PM_{10}$ concentration of 12 µg/m³ in 2023. Table 6 shows the estimated annual average TSP concentrations at Armidale for data collected between 2019 and 2023.

Table 6 Summary of estimated TSP concentrations at Armidale

| Statistic | 2019 | 2020 | 2021 | 2022 | 2023 | EPA criterion |
|---|---|---|---|---|---|---|
| Annual average (µg/m³) | 70 | 34 | 26 | 24 | 30 | 90 |

### 4.3.5 Deposited Dust

Air quality criteria for deposited dust are set to protect against nuisance amenity impacts. Deposited dust is not monitored in the vicinity of the Project, so it was necessary to estimate levels from the Armidale data on the assumption that 90 µg/m³ TSP is equivalent to a deposited dust level of 4 g/m²/month. Table 7 shows the estimated annual average deposited dust levels at Armidale. These estimates show that deposited dust levels are unlikely to have exceeded the 4 g/m²/month criterion in the past five years.

Table 7 Summary of estimated deposited dust at Armidale

| Statistic | 2019 | 2020 | 2021 | 2022 | 2023 | EPA criterion |
|---|---|---|---|---|---|---|
| Annual average (g/m²/month) | 3.1 | 1.5 | 1.2 | 1.1 | 1.3 | 4 |

### 4.3.6 Nitrogen Dioxide ($NO_2$)

The closest DPHI monitoring station that measures $NO_2$ concentrations is at Gunnedah. Table 8 provides a summary of the measured $NO_2$ concentrations from Gunnedah. As expected for this rural location, these data show that the maximum $NO_2$ concentrations have not exceeded the EPA's 1-hour average criterion of 164 µg/m³. Annual averages have not exceeded the EPA's annual average criterion of 31 µg/m³.

Table 8 Summary of measured $NO_2$ concentrations at Gunnedah

| Statistic | 2019 | 2020 | 2021 | 2022 | 2023 | EPA criterion |
|---|---|---|---|---|---|---|
| Maximum 1-hour average (µg/m³) | 74 | 57 | 105 | 53 | 53 | 164 |
| Annual average (µg/m³) | 9.6 | 7.1 | 6.0 | 4.5 | 5.4 | 31 |

## 4.4 Background Levels

The Approved Methods requires the determination of background concentrations of relevant air quality indicators to assess the total impact of the Project. Section 4.3 presented air quality monitoring data from the nearest DPHI monitoring stations. These stations are located at least 50 km from the site, near larger population centres and with more potential sources of air pollution. In addition, the sources of air pollution near the closest monitoring stations would not resemble the existing sources at the Project site. This means that

the DPHI data will not accurately reflect air quality conditions near the Project site, and it would be not appropriate to assume that the DPHI data represent background levels near the Project. It was therefore necessary to make estimates of background levels that may apply at sensitive receptors. This was done using reasonable percentiles or statistics from the available data. Table 9 shows the assumed background levels that would apply to sensitive receptors near the Project. These levels have been added to project contributions to determine the potential cumulative impacts.

Table 9 Assumed background levels that apply at sensitive receptors

| Air quality indicator | Averaging time | Assumed background level | Notes |
|---|---|---|---|
| Particulate matter ($PM_{10}$) | 24-hour | 15 µg/m$^3$ | 70$^{th}$ percentile of $PM_{10}$ concentrations from Armidale in 2023 |
| | Annual | 10 µg/m$^3$ | 50$^{th}$ percentile of $PM_{10}$ concentrations from Armidale in 2023 |
| Particulate matter ($PM_{2.5}$) | 24-hour | 10 µg/m$^3$ | 70$^{th}$ percentile of $PM_{2.5}$ concentrations from Armidale in 2023 |
| | Annual | 5.9 µg/m$^3$ | 50$^{th}$ percentile of $PM_{2.5}$ concentrations from Armidale in 2023 |
| Particulate matter (TSP) | Annual | 24 µg/m$^3$ | Estimated annual average TSP from annual $PM_{10}$ above |
| Deposited dust | Annual | 1.1 g/m$^2$/month | Estimated annual average deposited dust from TSP above |
| Nitrogen dioxide ($NO_2$) | 1-hour | 53 µg/m$^3$ | Maximum 1-hour average $NO_2$ from Gunnedah in 2023 |
| | Annual | 5.4 µg/m$^3$ | Annual average $NO_2$ from Gunnedah in 2023 |

# 5 Assessment Methodology

This assessment has followed the procedures outlined in the Approved Methods (EPA, 2022). The Approved Methods include guidelines for the preparation of meteorological data, reporting requirements and air quality assessment criteria to assess the significance of expected impacts. Specific methodologies for each of the identified key issues (from Section 2) are described below.

## 5.1 Operational Dust

Operational dust has been quantified by modelling. The choice of model has considered the expected transport distances for the emissions, as well as the potential for temporally and spatially varying flow fields due to influences of the locally complex terrain, non-uniform land use, and potential for stagnation conditions characterised by calm or very low wind speeds with variable wind directions. The CALPUFF model was selected for this purpose. This model is listed in the Approved Methods and has been used to predict ground-level particulate matter concentrations and deposition levels due to the Project and other sources. Concentrations and deposition levels have been simulated for every hour of the representative year and results at local communities and sensitive receptors have then been compared to the relevant air quality assessment criteria.

Figure 8 shows an overview of the model inputs and outputs. Appendix A provides details of all model settings.

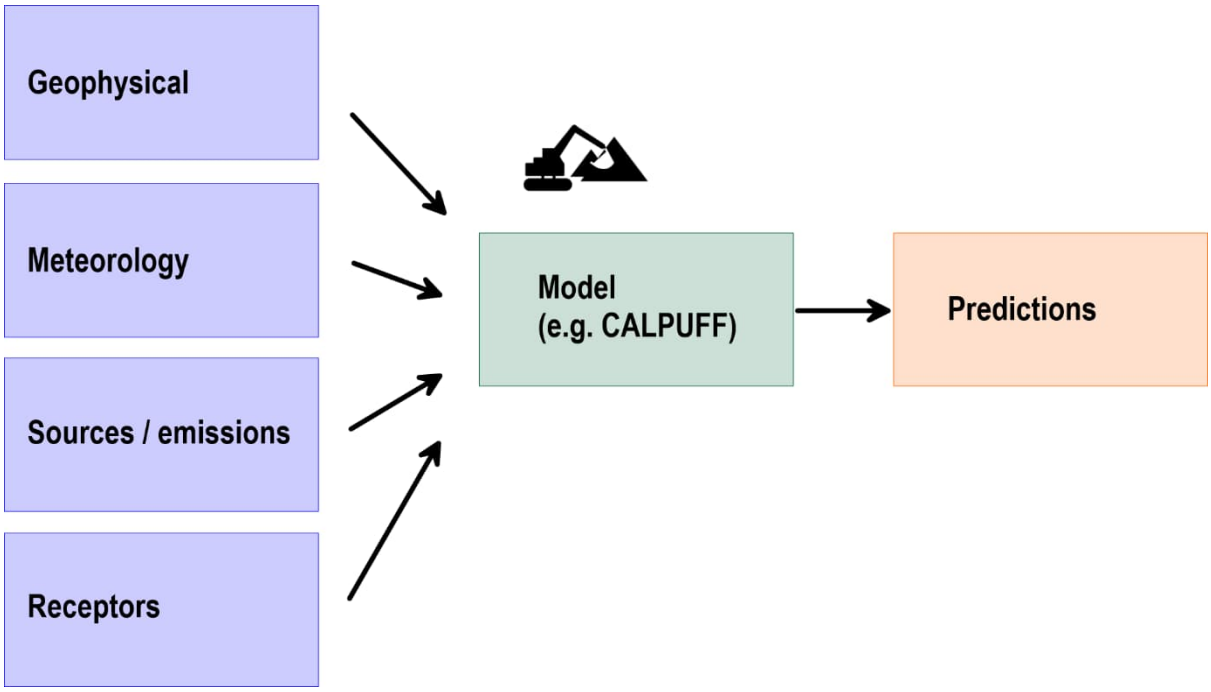



Figure 8 Overview of model inputs and outputs

Dust (particulate matter) is the most significant emission to air from the operations and estimates of these emissions are required by the dispersion model. Total dust emissions have been estimated for the proposed operations using the material handling schedule, equipment listing, and site layout plans combined with emission factors from:

- "Emission Estimation Technique Manual for Mining" (NPI, 2012); and
- AP 42 (US EPA 1985 and updates).

Table 10 summarises the estimated annual TSP, $PM_{10}$ and $PM_{2.5}$ emissions, respectively, due to the Project, as well as the assumed emission controls for the assessment. Full details on the emission calculations, including assumptions, emission controls and allocation of emissions to modelled locations are provided in Appendix A.

Table 10 Estimated annual dust emissions from operational activities

| Activity | Annual emissions (kg/y) | | | Assumed emission controls for the assessment |
|---|---|---|---|---|
| | TSP | $PM_{10}$ | $PM_{2.5}$ | |
| Dozer working | 48,867 | 11,897 | 5,131 | Nil. |
| Drilling rock | 35 | 19 | 2 | Water sprays, 70% control. |
| Blasting rock | 173 | 90 | 9 | Nil. |
| Loading to trucks | 1,462 | 692 | 73 | Nil. |
| Hauling to processing area | 2,778 | 529 | 132 | Level 2 watering, 75% control. |
| Unloading from trucks | 1,462 | 692 | 73 | Nil. |
| Loading rock to mobile crusher by FEL | 1,462 | 692 | 73 | Nil. |
| Crushing (mobile jaw crusher) | 2,775 | 1,088 | 139 | Water sprays, 50% control. |
| Screening (mobile screen 1) | 7,500 | 2,500 | 375 | Water sprays, 50% control. |
| Crushing (mobile cone crusher) | 2,775 | 1,088 | 139 | Water sprays, 50% control. |
| Screening (mobile screen 2) | 7,500 | 2,500 | 375 | Water sprays, 50% control. |
| Loading product stockpiles | 731 | 346 | 37 | Water sprays, 50% control. |
| Wind erosion from exposed areas | 3,504 | 1,752 | 263 | Nil. |
| Wind erosion from product stockpiles | 438 | 219 | 33 | Water sprays, 50% control. |
| Loading product to trucks | 1,462 | 692 | 73 | Nil. |
| Hauling product off-site | 7,813 | 1,488 | 372 | Level 2 watering, 75% control. |
| Total | 90,738 | 26,280 | 7,298 | - |

The quarry operations were represented by a series of volume sources located according to the location of activities for each modelled scenario. Emissions from the dust generating activities were assigned to one or more of source location (refer to Appendix A for details of the allocations).

Dust emissions for all modelled construction-related sources have been considered to fit in one of three categories, as follows:

- Wind insensitive sources, where emissions are relatively insensitive to wind speed (for example, dozers).
- Wind sensitive sources, where emissions vary with the hourly wind speed, raised to the power of 1.3, a generic relationship published by the US EPA (1987). This relationship has been applied to sources such as loading and unloading of material to/from trucks and results in increased emissions with increased wind speed.
- Wind sensitive sources, where emissions also vary with the hourly wind speed, but raised to the power of 3, a generic relationship published by Skidmore (1998). This relationship has been applied to sources including wind erosion from stockpiles or emplacement areas, and results in increased emissions with increased wind speed.

Emissions from each volume source were developed on an hourly time step, taking into account the level of activity at that location and, in some cases, the hourly wind speed. This approach ensured that light winds corresponded with lower dust generation and higher winds, with higher dust generation. Blasting activities and associated emissions were assumed to take place only during daylight hours (12 pm to 3 pm for the purposes of the modelling) while all other activities have been modelled between 7 am and 6 pm, except wind erosion which was modelled for 24 hours per day.

Finally, the model results at identified sensitive receptors were then compared with the EPA air quality assessment criteria, previously discussed in Section 3.1. Contour plots have also been created to show the spatial distribution of model results. Section 6.1 provides the assessment of operational dust.

## 5.2 Post Blast Fume

Blasting activities have the potential to result in fume and particulate matter emissions. Particulate matter emissions from blasting are included in the operational dust modelling discussed in Section 5.1. Post-blast fume has also been quantified by modelling.

Post-blast fume can be produced in non-ideal explosive conditions of the ammonium nitrate/fuel oil (ANFO) and is visible as an orange / brown plume. The fumes comprise of $NO_x$ including nitric oxide (NO) and $NO_2$. In general, at the point of emission, NO will comprise the

greatest proportion of the total $NO_x$ emission. Typically, this is 90% by volume of the NOx. The remaining 10% will comprise mostly $NO_2$. Ultimately however, much of the NO emitted into the atmosphere is oxidised to $NO_2$. The rate at which this oxidisation takes place depends on prevailing atmospheric conditions including temperature, humidity, and the presence of other substances in the atmosphere such as ozone. It can vary from a few minutes to many hours. The rate of conversion is important because from the point of emission to the point of maximum ground-level concentration there will be an interval of time during which some oxidation will take place. If the dispersion is sufficient to have diluted the plume to the point where the concentration is very low, then the level of oxidation is unimportant. However, if the oxidation is rapid and the dispersion is slow then high concentrations of $NO_2$ can occur.

The $NO_x$ monitoring data from Gunndeah (DPHI data from 2023) show that the percentage of $NO_2$ in the $NO_x$ is inversely proportional to the total $NO_x$ concentration, and when $NO_x$ concentrations increase, the percentage of $NO_2$ in the $NO_x$ generally decreases to 20% or less. This is demonstrated by Figure 9 which shows that, for higher $NO_x$ concentrations, the $NO_2$ to $NO_x$ ratio reduces to less than 20%.

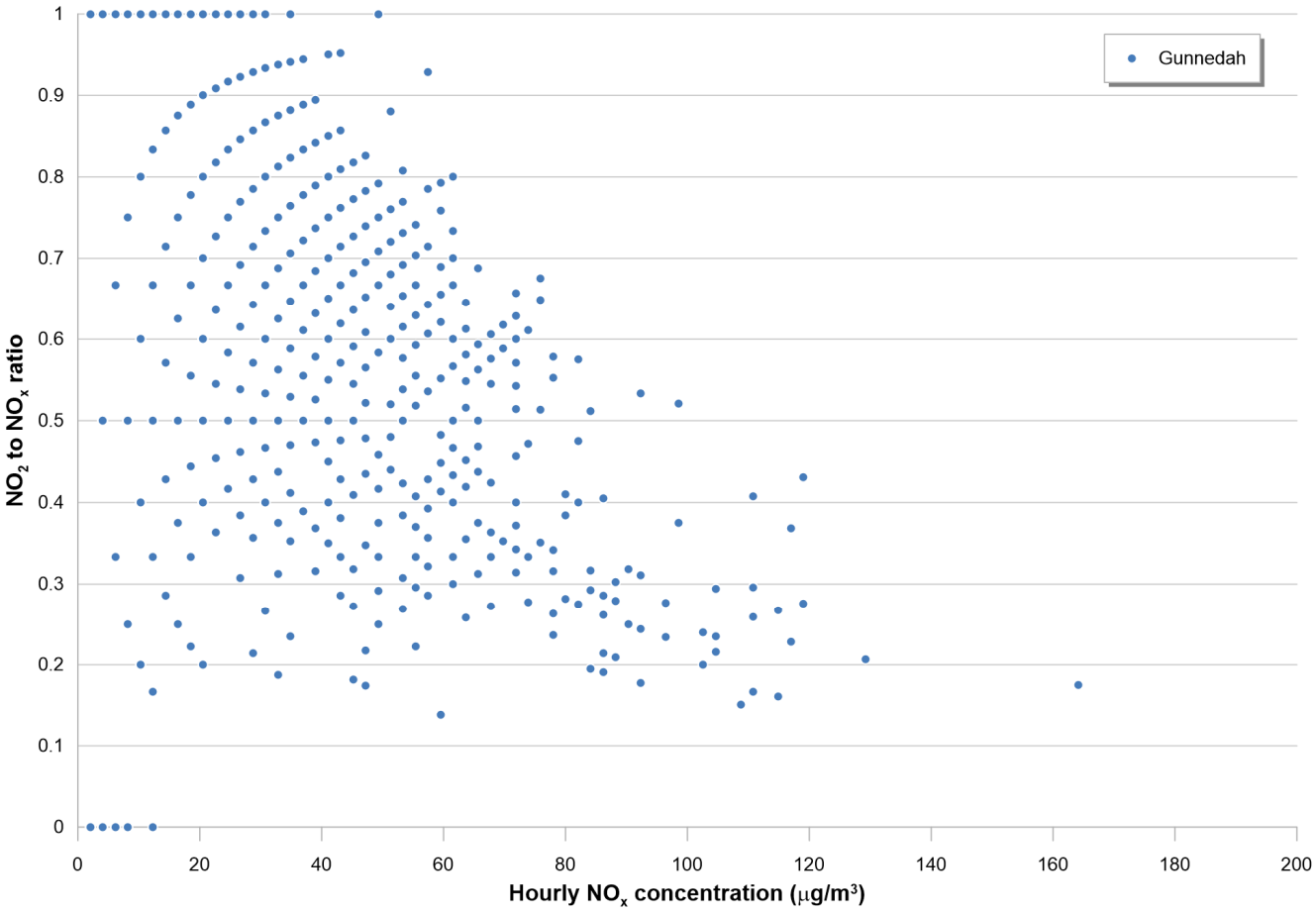



Figure 9 Measured $NO_2$ to $NO_x$ ratios from hourly average data collected at Gunnedah

The methodology for the operational post-blast fume modelling is outlined below:

- Blast modelled as a single volume source in a location indicative of the centre of the quarry.
- Release height of 10 m, effective plume height of 20 m, initial horizontal spread (sigma y) of 10 m and initial vertical spread (sigma z) of 5 m.
- Emissions assumed to occur every hour between 9 am and 5 pm, and on any day of the week. These are conservative assumptions as the Project does not propose operations every day of the week, and approximately 8 blasts per year, with each blast most likely to occur between 12 pm and 3 pm.
- $NO_x$ emissions based on data presented in the Queensland Guidance Note for the management of oxides in open cut blasting (DEEDI, 2011). It was conservatively assumed that the initial $NO_2$ concentration in the plume would be 17 ppm (34.9 mg/m$^3$) based on the Rating 3 Fume Category in the Queensland Guidance Note.
- The initial $NO_2$ concentration in the plume was converted to a total $NO_x$ emission rate based on a detailed measurement program of $NO_x$ in blast plumes in the Hunter Valley made by Attalla et al. (2008) which found that the NO:$NO_2$ ratio was typically 27:1, giving a $NO_x$:$NO_2$ ratio of approximately 18.6 g $NO_x$/g $NO_2$.

- Calculated emission of 92.2 g/s of $NO_x$ per blast and an emission release time of 5 minutes.
- 20% of the $NO_x$ is $NO_2$ at the points of maximum 1-hour average concentrations and at sensitive receptors.

Model results for post-blast fume have been compared to the applicable EPA air quality criterion for $NO_2$; that is 164 µg/m$^3$ as a 1-hour average and taking background levels into account. Section 6.2 provides the assessment of operational post blast fume.

## 5.3 Diesel Exhaust

The most significant emissions from diesel exhausts are products of combustion including CO, $NO_x$, $PM_{10}$ and $PM_{2.5}$. It is the $NO_x$, or more specifically $NO_2$, and $PM_{10}$ (including $PM_{2.5}$) which have been assessed. DPHI monitoring data have shown that CO concentrations have not exceeded relevant air quality criteria at rural or urban monitoring stations in NSW, indicating that this substance represents a much lower air quality risk.

The modelling for operational dust (Section 5.1) has considered emission factors that represent the contribution from both wheel generated particulates and the exhaust particulates. These emission factors, including with control factors, are based on measured emissions which included diesel particulates in the form of both $PM_{10}$ and $PM_{2.5}$.

Table 11 provides the explicit estimates of $PM_{10}$ and $PM_{2.5}$ emissions due only to diesel plant and equipment exhausts. Emission factors for "Industrial off-road vehicles and equipment" from the EPA's 2008 Air Emissions Inventory (EPA, 2012) were used for the calculations and it has been assumed that there will be no reduction to emissions in the future; a conservative approach. These factors relate to diesel exhaust and evaporative emissions.

Table 11 Estimated $PM_{10}$ and $PM_{2.5}$ emissions from diesel engines

| Parameter | Value |
|---|---|
| Estimated fuel usage (kL/y) | 765.120 |
| $PM_{10}$ calculations | |
| Diesel exhaust emission factor (kg/kL) | 2.84 |
| Diesel exhaust emission (all equipment) (kg/y) | 2,173 |
| $PM_{2.5}$ calculations | |
| Diesel exhaust emission factor (kg/kL) | 2.75 |
| Diesel exhaust emission (all equipment) (kg/y) | 2,108 |

Emissions of $NO_x$ from diesel exhausts have been estimated using fuel consumption data, provided by ARDG, and an emission factor from the EPA's Air Emissions Inventory for 2008 (EPA, 2012). Table 12 shows the calculations. Again, it has been assumed that there will be no reduction to emissions in the future, a conservative approach.

Table 12 Estimated $NO_x$ emissions from diesel engines

| Parameter | Value |
|---|---|
| Estimated fuel usage (kL/y) | 765.120 |
| $NO_x$ calculations | |
| Diesel exhaust emission factor (kg/kL) | 40.77 |
| Diesel exhaust emission (all equipment) (kg/y) | 31,194 |

The $NO_x$ emission estimates from Table 12 have been explicitly modelled to provide an indication of the off-site $NO_2$ concentrations due to diesel exhaust emissions. Section 6.3 provides the assessment of operational diesel exhaust.

## 5.4 Greenhouse Gas

The GHG inventory in this document has been calculated in accordance with the principles of the GHG Protocol and the "Technical Guidelines for the Estimation of Greenhouse Gas Emissions by Facilities in Australia" (DEE, 2017). The initial actions for a GHG inventory are to determine the sources of GHG emissions, assess their likely significance and set a boundary for the assessment. Creating an inventory of the likely GHG emissions associated with the Project has the benefit of determining the scale of the emissions and providing a baseline from which to develop and deliver GHG reduction options.

The results of this assessment are presented in terms of the previously mentioned 'Scopes' to help understand the direct and indirect impacts of the project. The GHG Protocol (and similar reporting schemes) dictates that reporting Scope 1 and 2 sources is mandatory, whilst reporting Scope 3 sources is optional. Reporting significant Scope 3 sources is recommended. Scope 3 emissions are a consequence of the activities of the company, but from sources not owned or controlled by the company. Some examples of Scope 3 activities include the extraction and production of purchased materials, transportation of purchased fuels, and use of sold products and services. The inventory for this assessment includes all significant sources of GHGs (Scopes 1, 2 and 3) associated with the Project.

Future projections of fuel usage, provided by ARDG, were used to determine the greenhouse gas emissions from the Project. Estimated emissions will be conservative as the calculations do not consider the likelihood of increased renewable energy usage or potential improvements to vehicle efficiency in the future (for example, through electrification or alternative fuel sources). Table 13 shows the key emission sources that have been considered in this assessment as well as the estimation methodologies.

Table 13 GHG emission sources and estimation methodologies

| Activity | Description | Scope(s) | Emission estimation methodology |
|---|---|---|---|
| Diesel usage (on-site equipment) | Combustion of diesel fuel from on-site mobile and stationary plant and equipment | 1, 3 | Emission factors from NGA Factors (DCCEEW, 2023) |
| Diesel usage (trucks transporting product) | Combustion of diesel fuel from trucks transporting product off-site | 1, 3 | Emission factors from NGA Factors (DCCEEW, 2023) |

Section 7 provides the assessment of GHG emissions.

# 6 Air Quality Assessment

## 6.1 Operational Dust

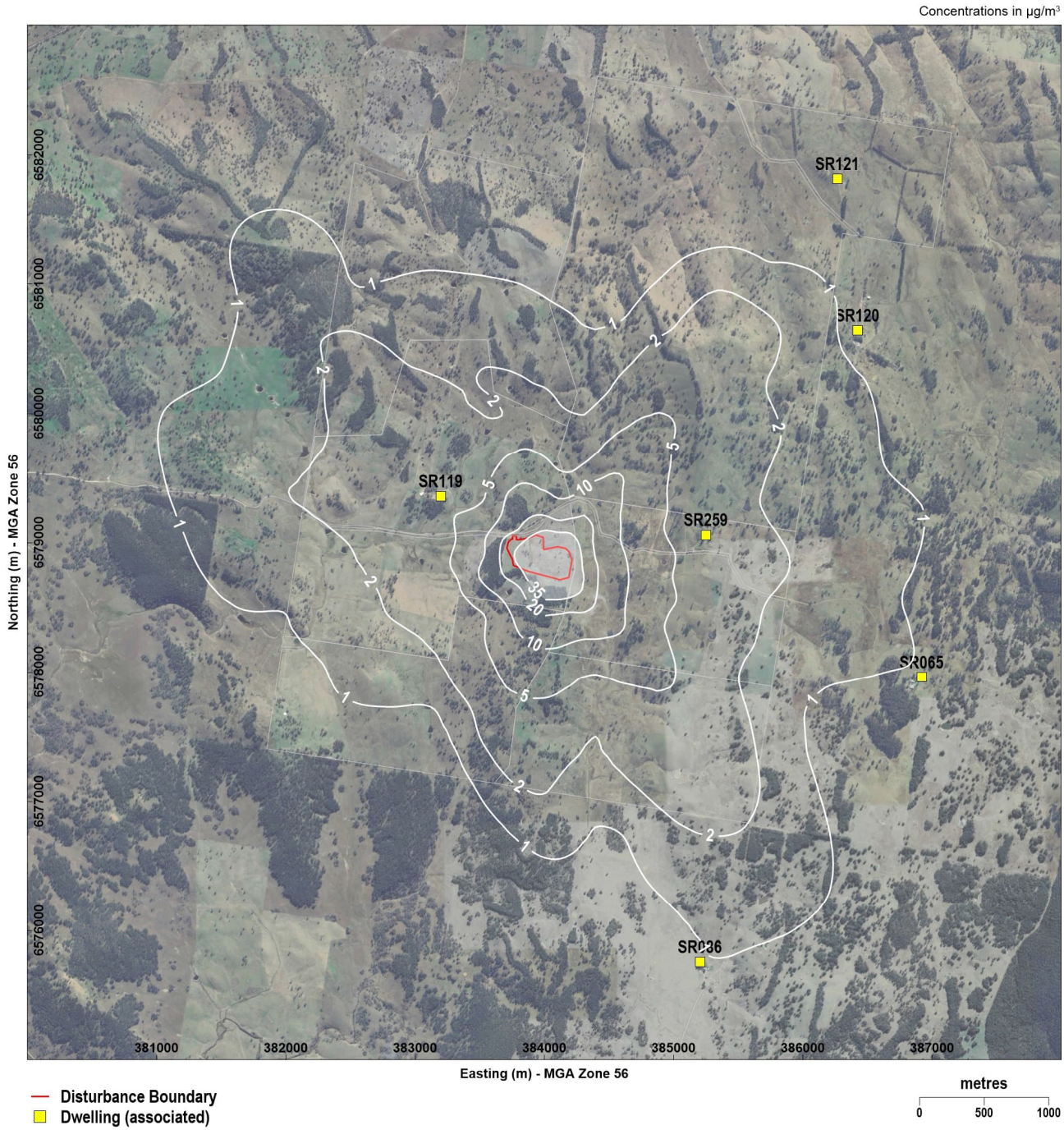
This section provides an assessment of the Project in terms of operational dust, based on the methodology described in Section 5.1. Model results have been assessed for each of the key particulate matter classifications.

### 6.1.1 Particulate Matter (as $PM_{10}$)

Figure 10 shows the modelled maximum 24-hour average $PM_{10}$ concentrations due to the Project. These results have been assessed against the EPA's 24-hour average $PM_{10}$ criterion of 50 µg/m$^3$. This criterion relates to the total concentration in the air (that is, cumulative) and not just the contribution from the Project. Therefore, the extent of 50 µg/m$^3$ has been represented by the 35 µg/m$^3$ contour which considers the estimated maximum background level of 15 µg/m$^3$ (from Table 9). The modelling shows that the Project would not cause exceedances of the EPA assessment criterion for 24-hour average $PM_{10}$ at any sensitive receptor nor on more than 25% of any lot of land on which a dwelling could be constructed.

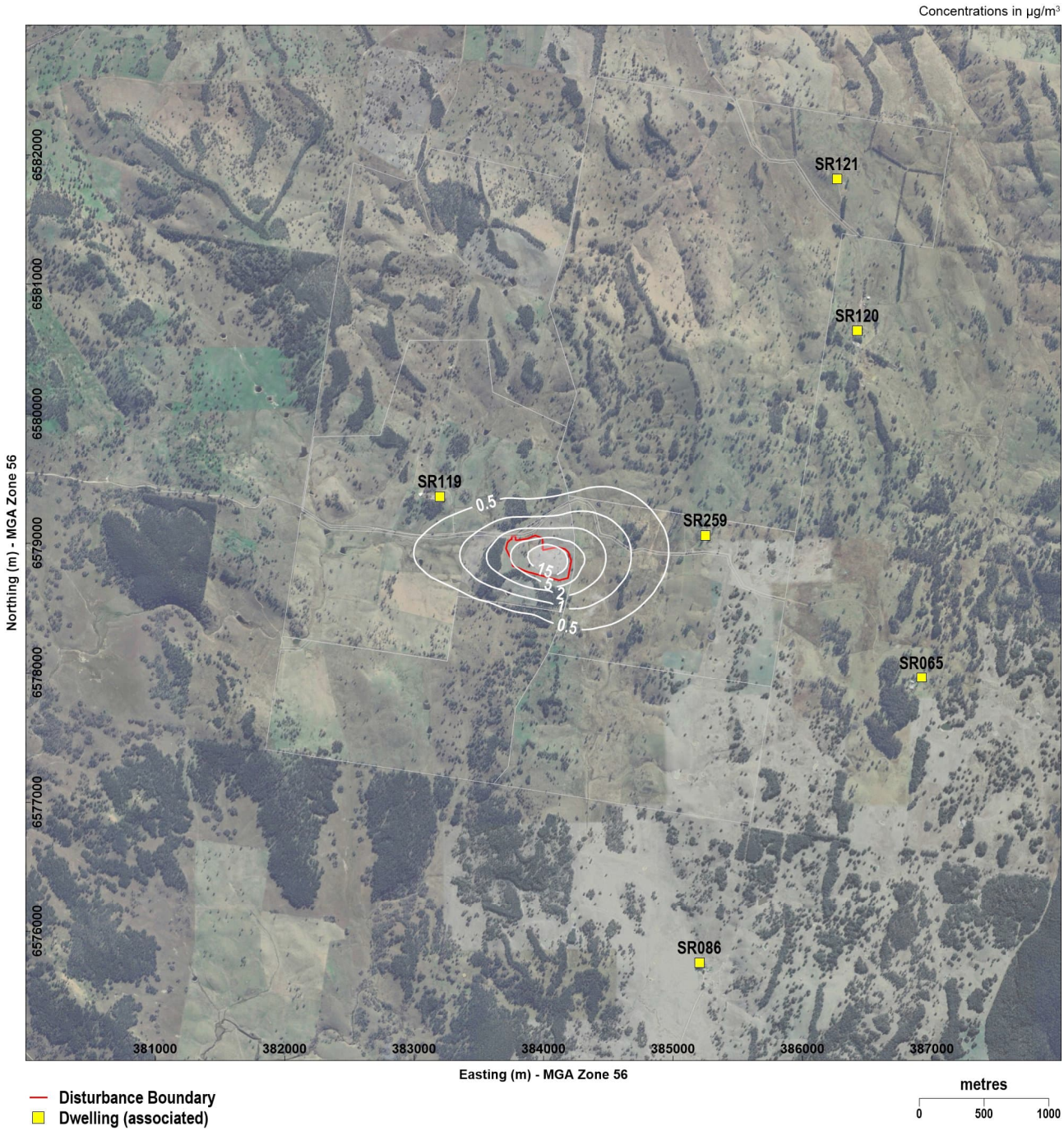
Figure 11 shows the modelled annual average $PM_{10}$ concentrations due to the Project. These results have been assessed against the EPA's annual average $PM_{10}$ criterion of 25 µg/m$^3$. These results indicate compliance with the EPA's assessment criterion for annual average $PM_{10}$ (25 µg/m$^3$) at all sensitive receptors, even when adding the estimated background level of 10 µg/m$^3$ (from Table 9).

The results indicate that the Project would not cause adverse impacts with respect to $PM_{10}$.




Note: assessment criterion = 50 µg/m³, which is equivalent to 35 µg/m³ when background levels are considered

Figure 10 Modelled maximum 24-hour average $PM_{10}$ concentrations due to the Project

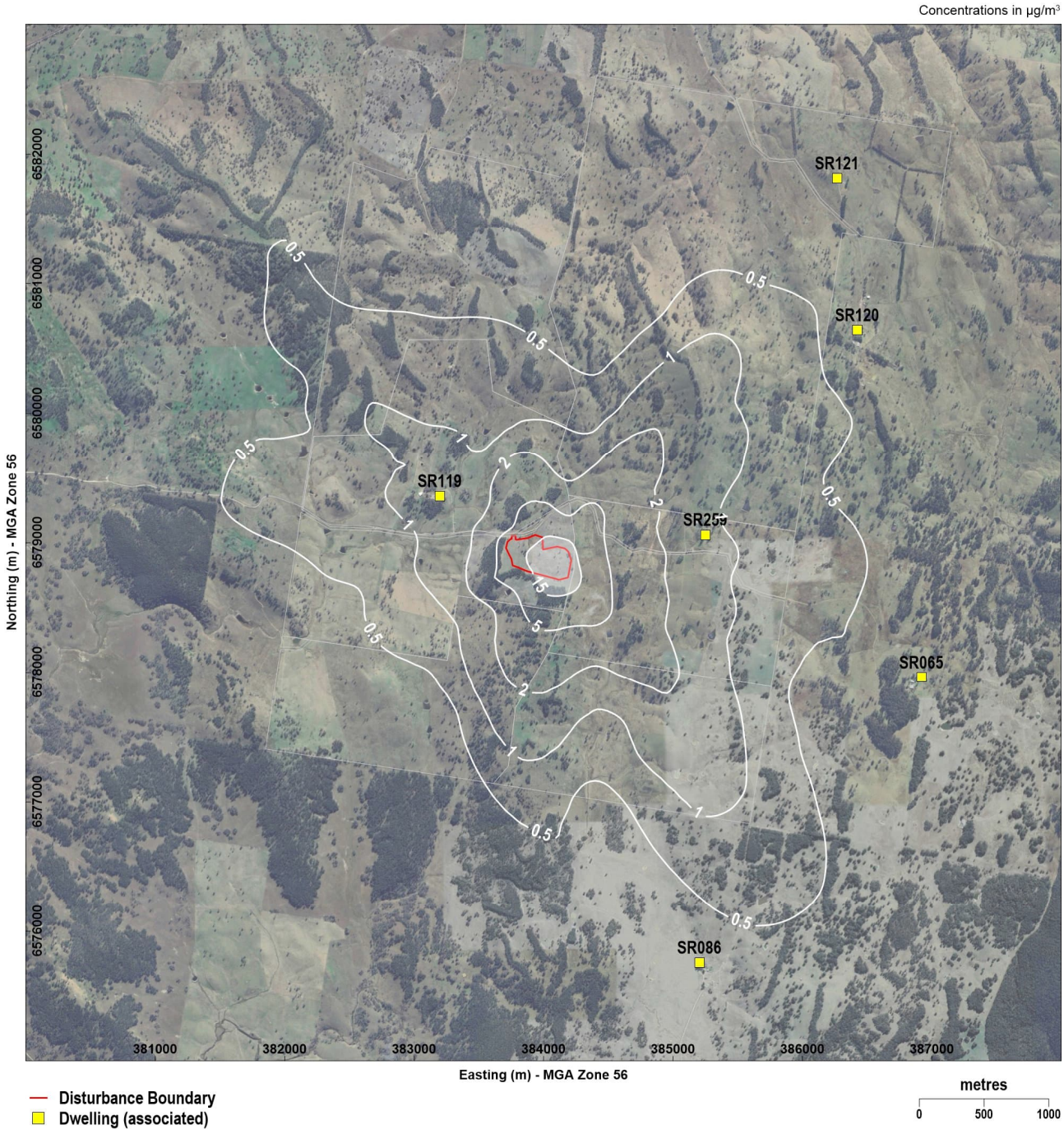



Note: assessment criterion = 25 µg/m³, which is equivalent to 15 µg/m³ when background levels are considered

Figure 11 Modelled annual average $PM_{10}$ concentrations due to the Project

### 6.1.2 Particulate Matter (as $PM_{2.5}$)

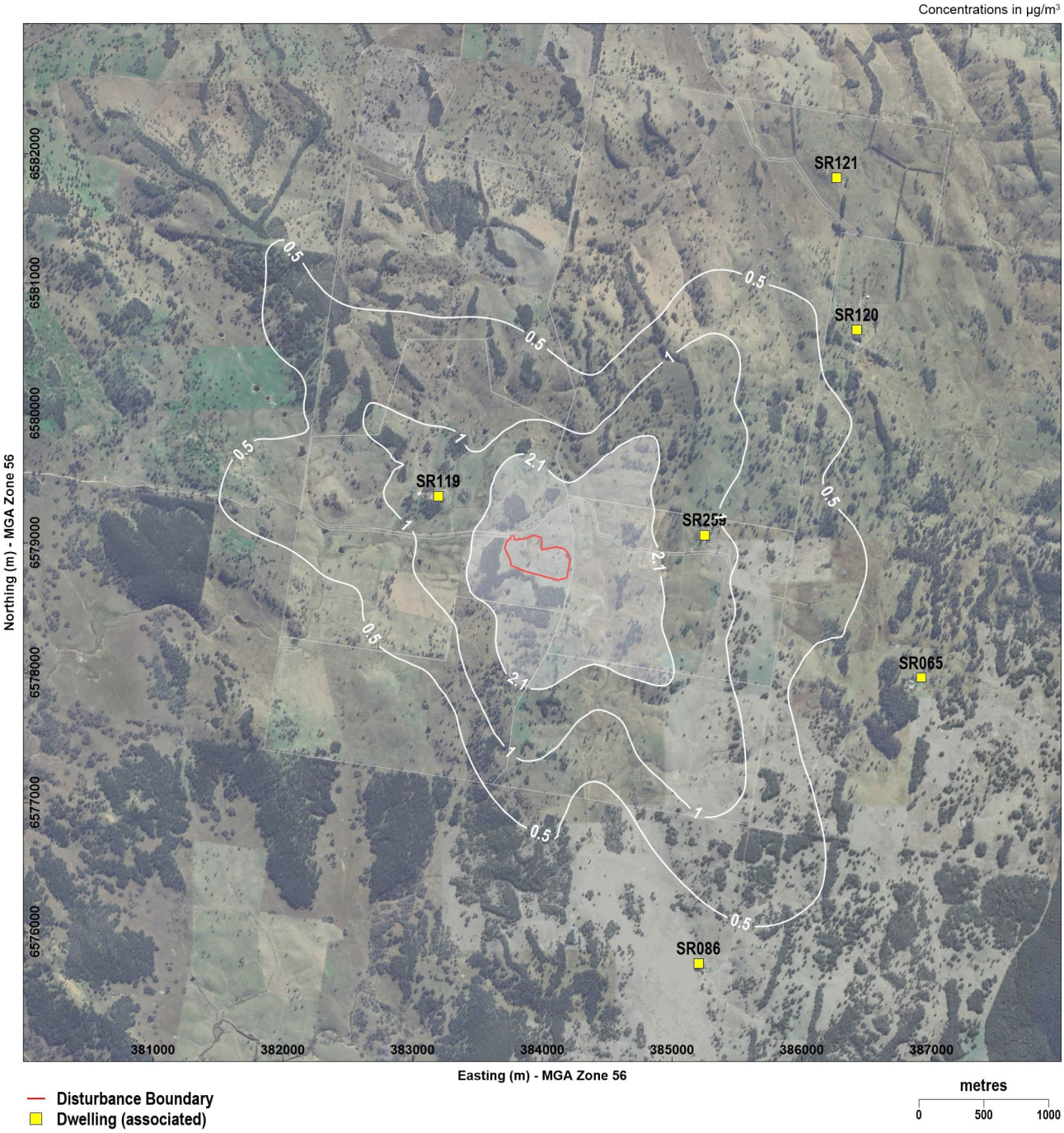
Figure 12 shows the modelled maximum 24-hour average $PM_{2.5}$ concentrations due to the Project. These results have been assessed against the EPA's 24-hour average $PM_{2.5}$ criterion of 25 µg/m³. These results indicate compliance with the EPA's assessment criterion at all sensitive receptors, even when adding the estimated background level of 10 µg/m³ (from Table 9).




Note: assessment criterion = 25 µg/m³, which is equivalent to 15 µg/m³ when background levels are considered

Figure 12 Modelled maximum 24-hour average $PM_{2.5}$ concentrations due to the Project

Figure 13 shows the modelled annual average $PM_{2.5}$ concentrations due to the Project. These results indicate compliance with the EPA's assessment criterion (8 µg/m³) at all sensitive receptors, even when adding the estimated background level of 5.9 µg/m³ (from Table 9). The results indicate that the Project would not cause adverse impacts with respect to $PM_{2.5}$.

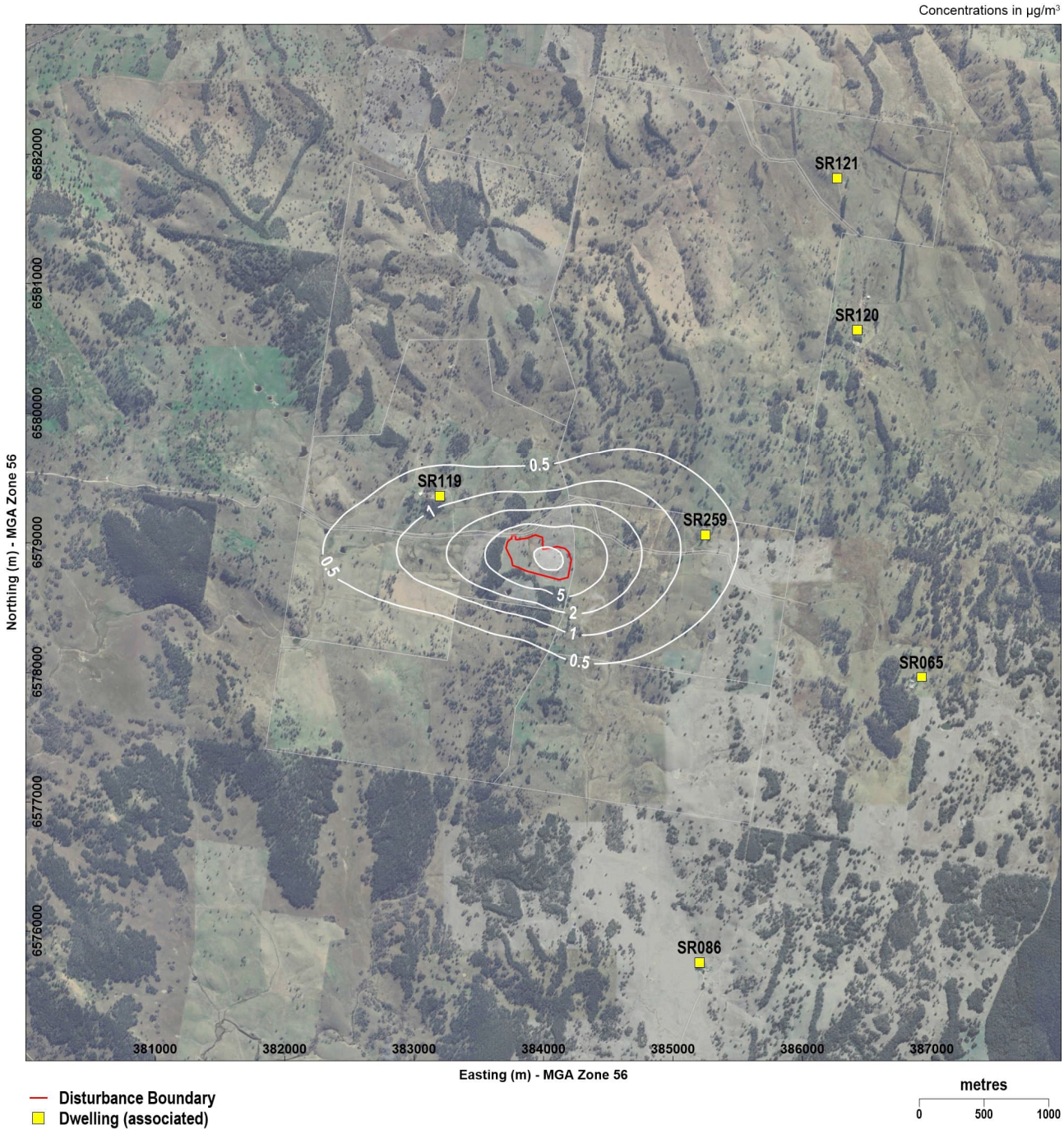



Note: assessment criterion = 8 µg/m³, which is equivalent to 2.1 µg/m³ when background levels are considered

Figure 13 Modelled annual average $PM_{2.5}$ concentrations due to the Project

### 6.1.3 Particulate Matter (as TSP)

Figure 14 shows the modelled annual average TSP concentrations due to the Project. These results have been assessed against the EPA's annual average TSP criterion of 90 µg/m³. These results indicate compliance with the EPA's assessment criterion at all sensitive receptors, even when adding the estimated background level of 24 µg/m³ (from Table 9).

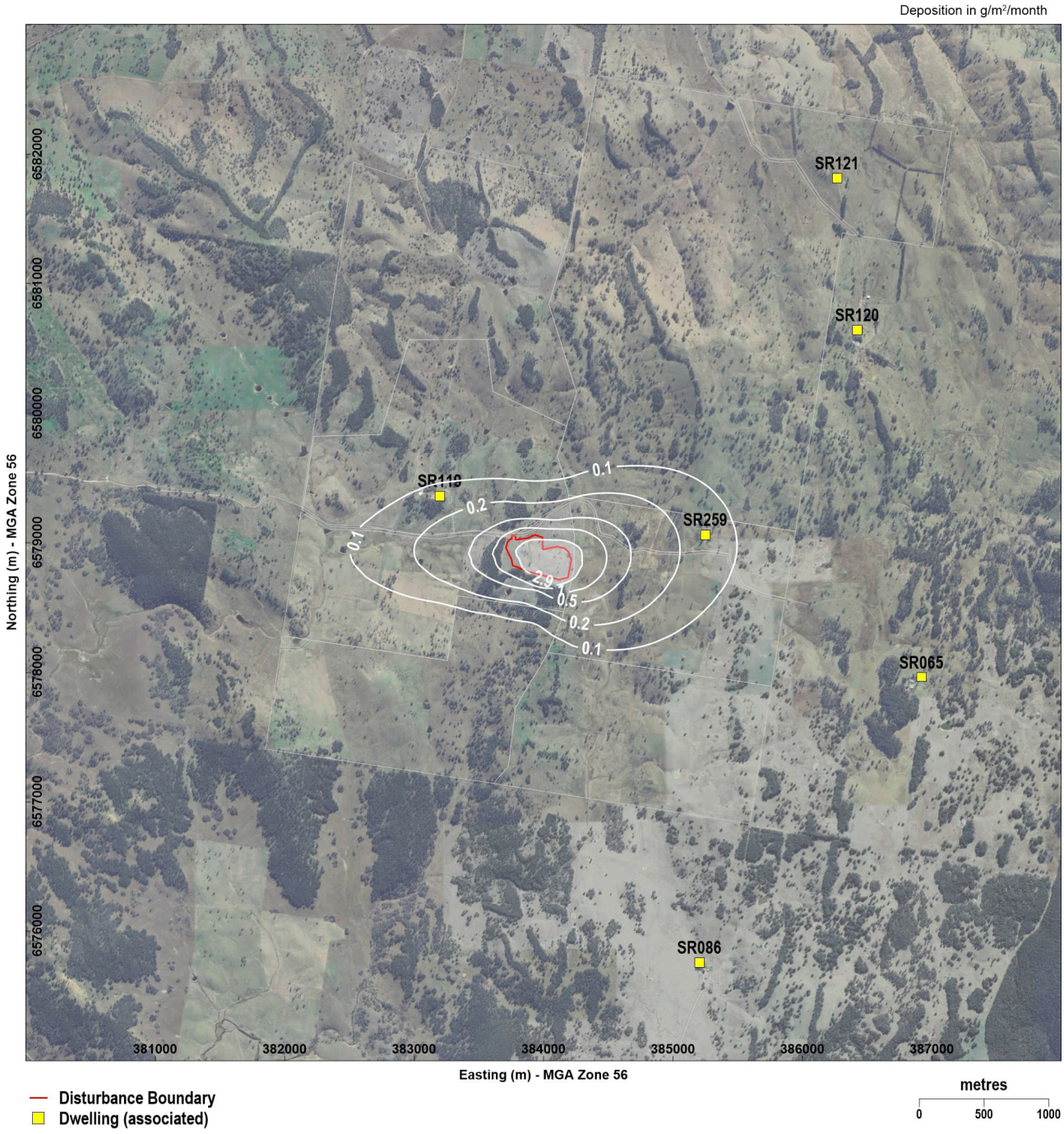



Note: assessment criterion = 90 µg/m³, which is equivalent to 66 µg/m³ when background levels are considered

Figure 14 Modelled annual average TSP concentrations due to the Project

### 6.1.4 Deposited Dust

Figure 15 shows the modelled annual average deposited dust levels due to the Project. These results have been assessed against the EPA's criteria of 2 g/m²/month (incremental) and 4 g/m²/month (cumulative). These results indicate compliance with the EPA's assessment criteria at all sensitive receptors.

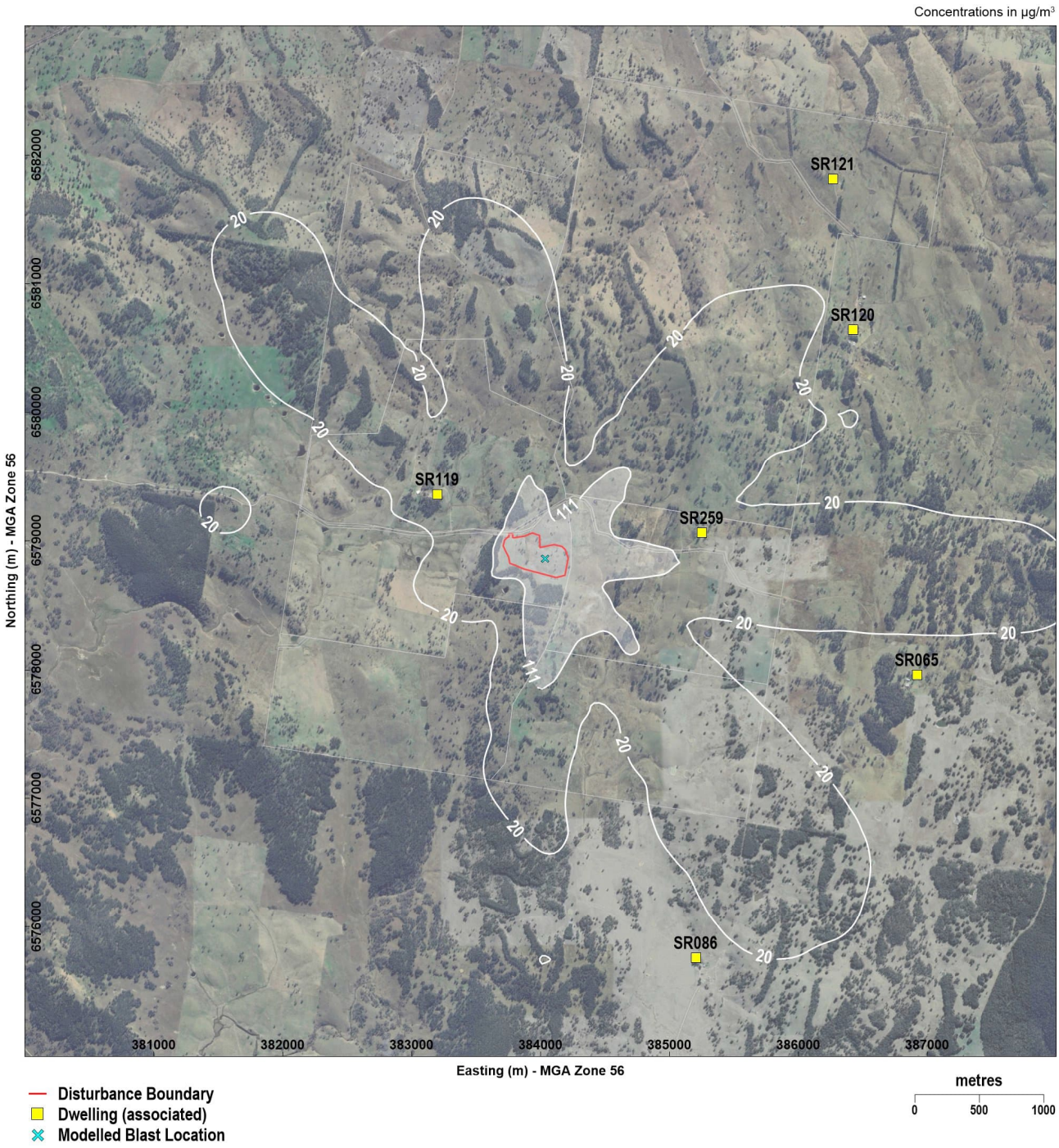



Note: assessment criterion = 4 g/m²/month, which is equivalent to 2.9 g/m²/month when background levels are considered

Figure 15 Modelled annual average deposited dust levels due to the Project

## 6.2 Post Blast Fume

Figure 16 shows the modelled maximum 1-hour average $NO_2$ concentrations due to post-blast fume, based on the methodology outlined in Section 5.2. The 111 µg/m³ contour represents the extent of the EPA's 164 µg/m³ assessment criterion with the inclusion of maximum background levels (53 µg/m³ from Table 9). These results show that, under worst-case meteorological conditions with a rated 3 fume, blasting every day between 9 am and 5 pm and maximum background concentrations (noting that in reality blasting would occur once every 4 to 6 weeks), the maximum 1-hour average $NO_2$ concentrations will not exceed the EPA's criterion at any off-site sensitive receptor.

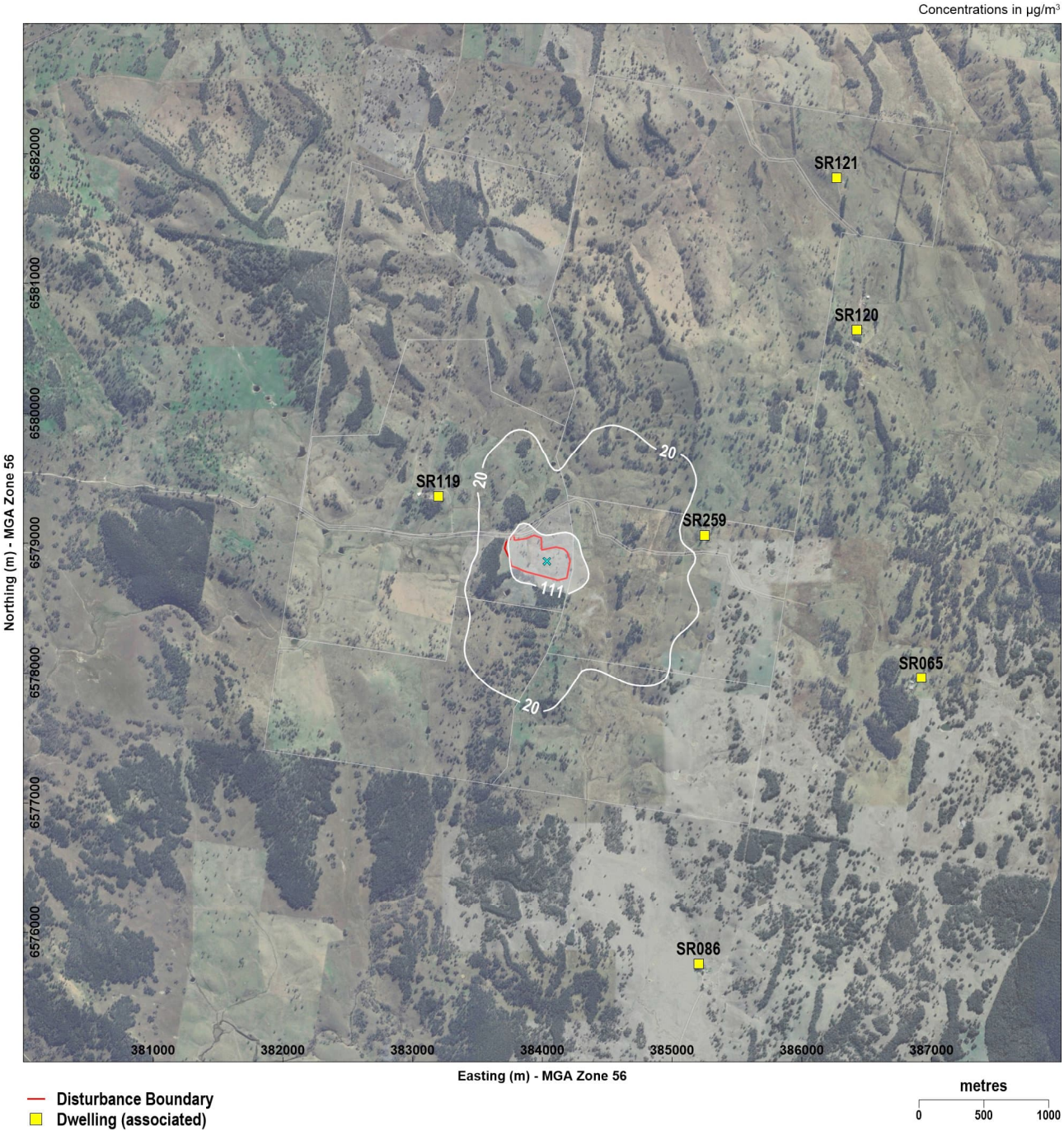



Note: assessment criterion = 164 µg/m³, which is equivalent to 111 µg/m³ when background levels are considered

Figure 16 Modelled 1-hour average $NO_2$ concentrations due to blasting

## 6.3 Diesel Exhaust

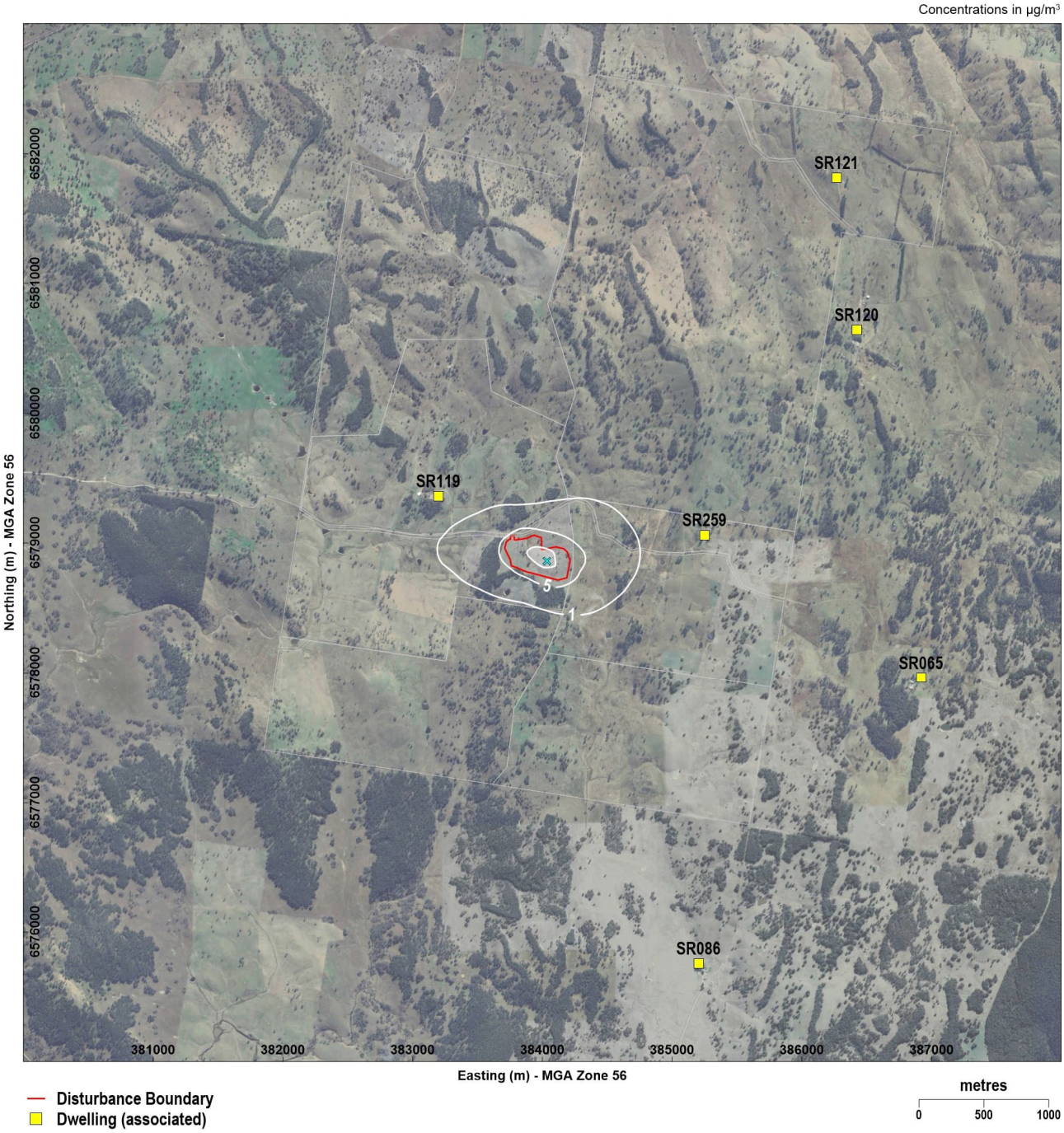
Figure 17 shows the modelled maximum 1-hour average $NO_2$ concentrations due to diesel exhaust emissions, based on the methodology outlined in Section 5.3. The results assume that 20% of the $NO_x$ is $NO_2$ at the locations of maximum ground-level concentrations. Compliance with the EPA's 164 µg/m³ criterion is expected at all sensitive receptors, including with consideration of a maximum background concentration of 53 µg/m³.




Note: assessment criterion = 164 µg/m³, which is equivalent to 111 µg/m³ when background levels are considered

Figure 17 Modelled maximum 1-hour average $NO_2$ concentrations due to diesel exhausts

Figure 18 shows the modelled annual average $NO_2$ concentrations. These results assume that 100% of the $NO_x$ is $NO_2$. Compliance with the EPA's 31 µg/m³ criterion is expected at all sensitive receptors, including with consideration of a background concentration of 5.4 µg/m³.




Note: assessment criterion = 31 µg/m³, which is equivalent to 25.6 µg/m³ when background levels are considered

Figure 18 Modelled annual average $NO_2$ concentrations due to diesel exhausts

# 7 Greenhouse Gas Assessment

This section provides estimates of the greenhouse gas emissions from the Project. It should be noted that there are no specific criteria for which to assess the significance of projected greenhouse gas emissions from individual projects. The convention is to compare estimated emissions with national and state figures for consideration in achieving state, territory, or federal emission targets.

Table 14 shows the estimated emissions of GHGs due to all identified GHG generating activities associated with the Project. The direct emissions from the Project (i.e. Scope 1) are estimated to average 2,186 t $CO_2$-e per year.

### Table 14 Estimated GHG emissions

| Activity | Usage (kL/y) | Emission factor (kg $CO_2$-e/kL) | | | Emission (t $CO_2$-e/y) | | | |
|---|---|---|---|---|---|---|---|---|
| | | Scope 1 | Scope 2 | Scope 3 | Scope 1 | Scope 2 | Scope 3 | Total |
| Fuel (diesel) usage (on site) | 765 | 2,709.72 | 0 | 667.78 | 2,073 | 0 | 511 | 2,584 |
| Fuel (diesel) usage (transporting product) | 42* | 2717.40 | 0 | 667.78 | 113 | 0 | 28 | 141 |
| Total | 807 | - | - | - | 2,186 | 0 | 539 | 2,725 |

* Estimated based on 10 km return distance to WWF sites, fuel consumption of 40 L/100 km, and average of 29 return trips per day (every day of the year).

Table 15 shows the calculated greenhouse gas emissions from the Project in the State and National context, using the DPHI Net Zero Emissions Dashboard data and DCCEEW (2024) projections. The comparisons show that the Project emissions would be in the order of:

- 0.0020% of NSW emissions, and
- 0.0005% of Australia's emissions.

The predicted Scope 1 and 2 emissions are well below the 25,000 t $CO_2$-e threshold for a large emitter under the EPA draft Guide for Large Emitters and the requirement under this guide for a GHG Mitigation Plan and Climate Change Mitigation and Adaptation Plan do not apply to the Project.

### Table 15 Comparison of GHG emissions in the State and National context

| Project emissions (Scope 1) (Mt $CO_2$-e) | Emissions (Mt $CO_2$-e) (with Project proportion as a percentage) | |
|---|---|---|
| | NSW | Australia |
| 0.0022 | 111.00 (0.0020%) | 432.62 (0.0005%) |

It is also relevant to note that the Project will provide a more efficient option for supplying materials to the WWF, compared to sourcing materials from more distant, existing quarries. Specifically, the Project is located approximately 5 km from the closest WWF sites whereas materials from existing quarries would need to be transported a distance of 150 km or more. From these distances, the transport of a notional 1 Mt of construction materials from the Project is estimated to avoid in the order of 10,747 t $CO_2$-e.

# 8 Monitoring and Management

The modelling showed that off-site dust concentrations and deposition levels would be well below the relevant EPA assessment criteria. Therefore, an appropriate air quality management strategy would include standard mitigation measures such as:

- Minimising the area of disturbed land at any one time
- Adopting controls for unsealed haul road dust emissions
- Use of water sprays when drilling if / as required
- Use of water sprays on stockpile areas if / as required
- Visual monitoring to identify excessive dust generation

Due to the low predicted levels of all assessed emissions at the nearest sensitive receptors, particulate and depositional dust monitoring is not considered to be warranted. The implementation of reactive controls such as additional watering or sprays in the event of visible dust emissions from activities which can be controlled (e.g. haulage emissions and crushing / processing operations) is considered sufficient to manage potential impacts.

Mitigation of GHG emissions will be inherent in the development of the quarry plan. The mitigation measures to minimise the level of GHG emissions from the Project will include:

- Planning and designing of operations to minimise fuel usage and to maximise energy efficiency
- Maintenance of plant and equipment to minimise fuel consumption and associated emissions
- Training staff on improvement strategies to minimise fuel usage and maximise energy efficiency

# 9 Conclusions

This report has provided an assessment of the potential air quality impacts of the WWF Quarry. The assessment involved identifying the key air quality issues, characterising the existing environment, quantifying emissions to air and modelling the potential impact of the Project on local air quality. The key air quality issues were identified as operational dust, post-blast fume and diesel exhaust. These issues were the focus of the assessment. GHG emissions were also estimated in accordance with recognised methodologies.

A detailed review of the existing environment was carried out including an analysis of historically measured concentrations of key quality indicators from regional monitoring stations. The review showed that air quality in many parts of NSW, including the Northern Tablelands, is heavily influenced by climatic conditions such as drought. However, due to the absence of any significant sources of air pollution, the concentrations of key air quality indicators near the Project are expected to be very low and well within acceptable (EPA) levels.

The key outcomes of the modelling and subsequent assessment were as follows:

- The Project would not cause adverse impacts with respect to dust concentrations or deposition levels, based on modelling which showed compliance with air quality assessment criteria at all sensitive receptors.
- Post blast fume emissions are not expected to result in any adverse air quality impacts (as $NO_2$), based on modelling which showed compliance with air quality assessment criteria at all sensitive receptors.
- Emissions from diesel exhausts associated with off-road vehicles and equipment are not expected to result in any adverse air quality impacts, based on modelling which showed compliance with air quality assessment criteria at all sensitive receptors.
- The direct GHG emissions from the Project (i.e. Scope 1) are estimated to average 2,186 t $CO_2$-e per year. These emissions represent a very small fraction of Australia's emissions. In addition, the Project is estimated to reduce GHG emissions relative to the currently approved source of quarry materials for the WWF which would require haulage of quarry material over approximately 300 km return. These reductions in travel distances are estimated to avoid in the order of 10,747 t $CO_2$-e when compared to sourcing the WWF materials from existing, more distant quarries. The Project will also avoid diesel emissions associated with these alternative longer haulage routes.

Based on this assessment, it has been concluded that the Project is a relatively remote and temporary operation that is unlikely to cause any adverse air quality impacts at sensitive locations. The Project will have significant benefits in terms of avoided GHG and diesel particulate emissions relative to alternate sources of quarry material for the WWF.

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# Appendix A. Model settings

## Geophysical

Figure A1 shows the model grid, land-use and terrain information, as used by CALMET.

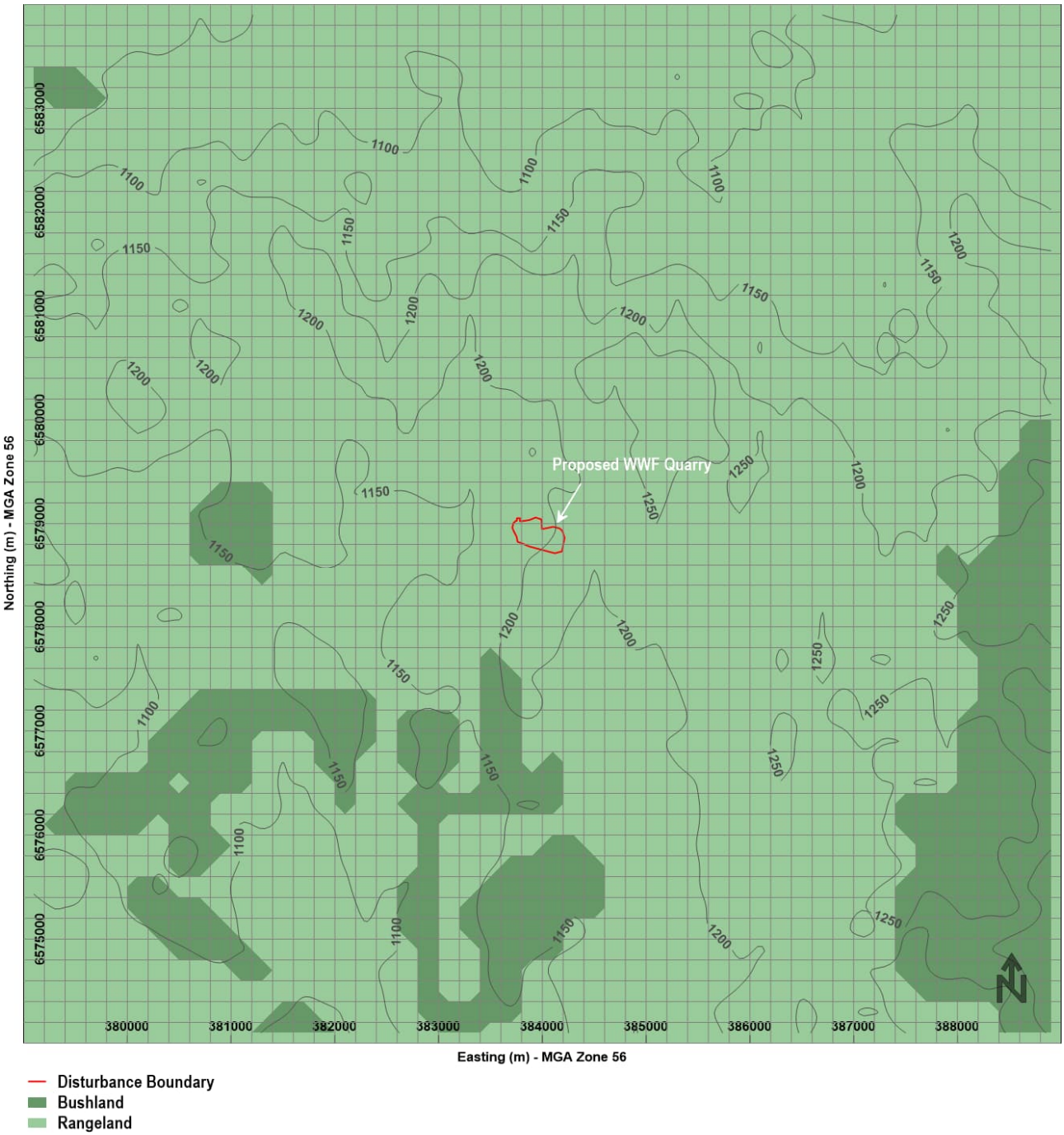


Figure A1 Model domain, grid, land use and terrain information

## Meteorology

The CALPUFF model, through the CALMET meteorological pre-processor, simulates complex meteorological patterns that exist in a particular region. The necessary surface and upper air data for CALMET were generated by the CSIRO's prognostic model, TAPM. CALMET was used to produce a year-long, three-dimensional output of meteorological conditions for input to the CALPUFF air dispersion model. The meteorological modelling followed the guidance of TRC (2011) and adopted the "no-observations" mode.

### Table A1 Model settings and inputs for TAPM

| Parameter | Value(s) |
|---|---|
| Model version | 4.0.5 |
| Number of grids (spacing) | 4 (30 km, 10 km, 3 km, 1 km) |
| Number of grids point | 35 x 35 x 25 |
| Year(s) of analysis | 2023 |
| Centre of analysis | 30°55' S, 151°47' E |
| Terrain data source | 30 m Shuttle Research Topography Mission (SRTM) |
| Land use data source | Default |
| Meteorological data assimilation | None |

### Table A2 Model settings and inputs for CALMET

| Parameter | Value(s) |
|---|---|
| Model version | 6.334 |
| Terrain data source(s) | 30 m SRTM |
| Land use data source(s) | Digitised from aerial imagery |
| Meteorological grid domain | 10 km x 10 km |
| Meteorological grid resolution | 0.2 km |
| Meteorological grid dimensions | 50 x 50 x 9 grid points |
| Meteorological grid origin | 379000 mE, 6574000 mN. MGA Zone 56 |
| Surface meteorological stations | No observations mode |
| Upper air meteorological stations | No observations mode |
| Simulation length | 8760 hours (1 Jan 2023 to 31 Dec 2023) |
| R1, R2 | 0.5, 1 |
| RMAX1, RMAX2 | 5, 20 |
| TERRAD | 5 |

Figure A2 shows a snapshot of winds at 10 metres above ground-level as simulated by the CALMET model under stable conditions. This plot shows the effect of the topography on local winds, for this particular hour, and highlights the non-uniform wind patterns in the area, further supporting the use of a non-steady-state model such as CALPUFF.

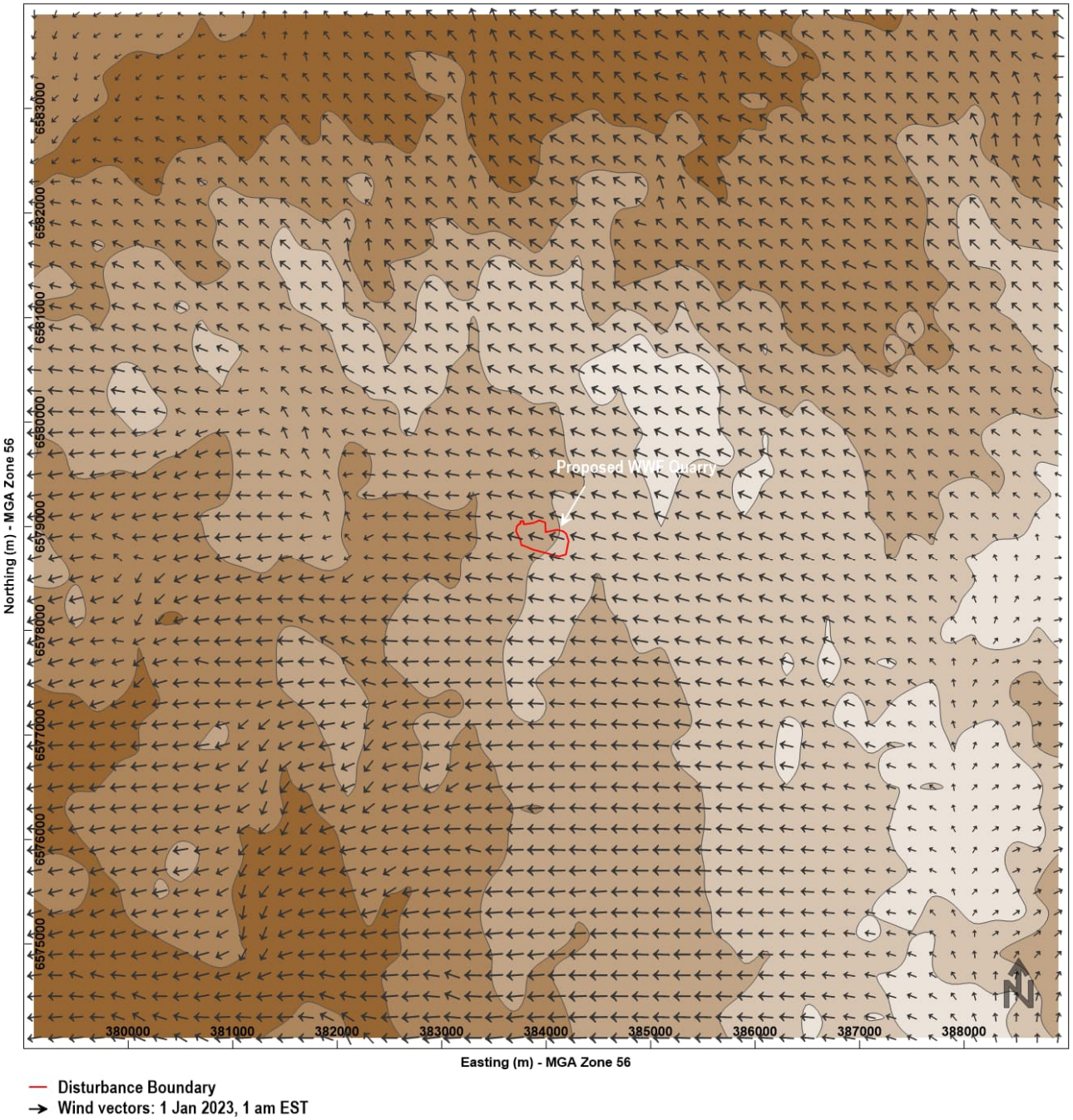


Figure A2 Example of CALMET simulated ground-level wind flows

Table A3 shows the model settings and input for the dispersion model, CALPUFF.

Table A3 Model settings and inputs for CALPUFF

| Parameter | Value(s) |
|---|---|
| Model version | 6.42 |
| Computational grid domain | 50 x 50 |
| Chemical transformation | None |
| Dry deposition | Yes |
| Wind speed profile | ISC rural |
| Puff element | Puff |

| Parameter | Value(s) |
|---|---|
| Dispersion option | Turbulence from micrometeorology |
| Time step | 3600 seconds (1 hour) |
| Terrain adjustment | Partial plume path |
| Number of volume sources | See below. Height = 5 m, SY = 20 m, SZ = 10 m. |
| Number of discrete receptors | 533. See below. |

## Sources


Figure A3 Modelled source locations

## Receptors

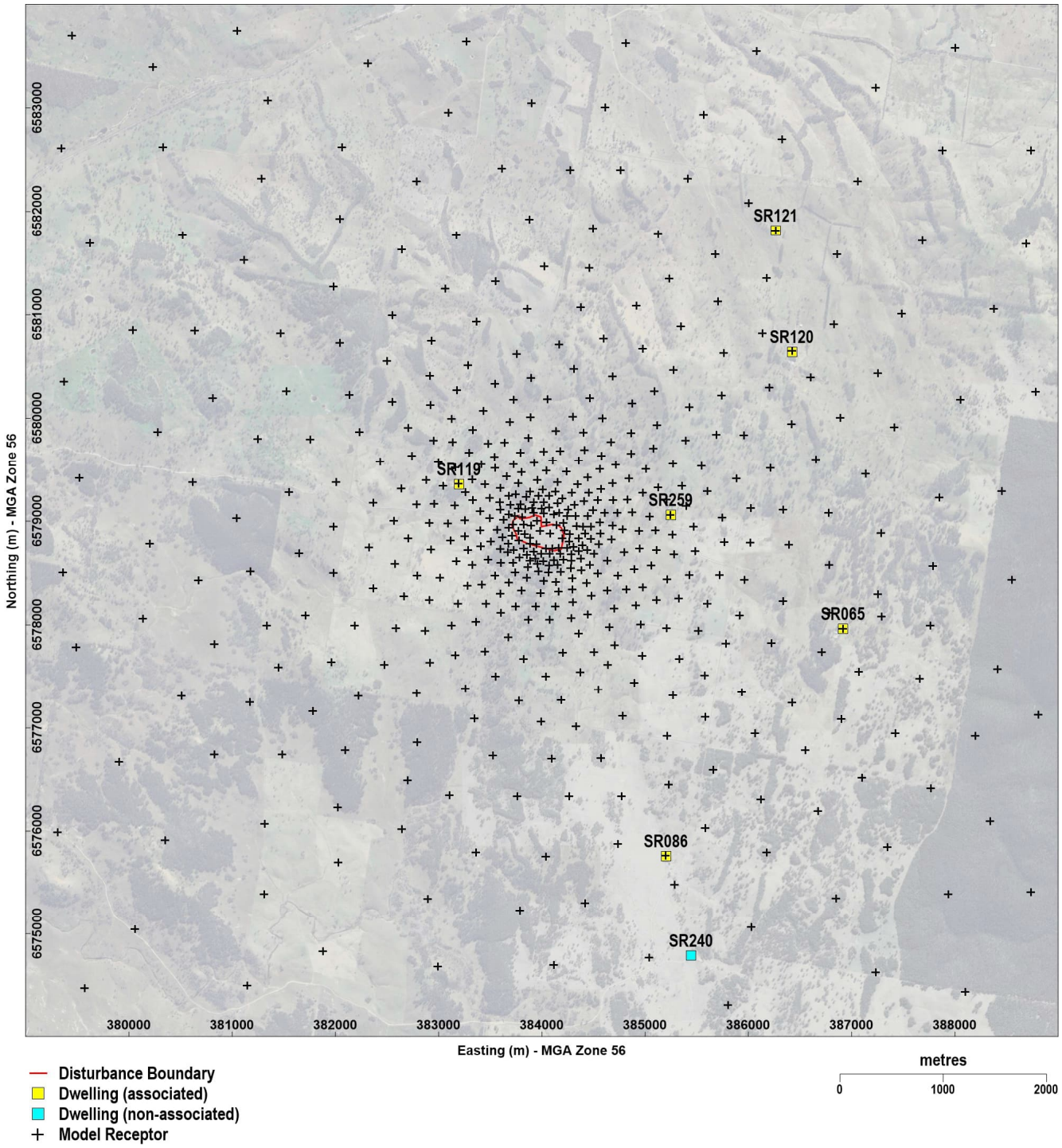


Figure A4 Model receptor locations

# Appendix B. Emission calculations

| | Annual emissions (kg/y) | | | | | | TSP | | PM10 | | PM2.5 | | Variables | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Activity | TSP | PM10 | PM2.5 | Control (%) | Intensity | Units | Factor | Units | Factor | Units | Factor | Units | Area (m2) | (ws/2.2)^1.3 | Moisture (%) | kg/VKT | t/truck | km/trip | Silt (%) |
| Drilling overburden | 0 | 0 | 0 | 0 | 0 | holes/y | 0.59 | kg/hole | 0.31 | kg/hole | 0.030 | kg/hole | - | - | - | - | - | - | - |
| Blasting overburden | 0 | 0 | 0 | 0 | 0 | blasts/y | 21.6 | kg/blast | 11.2 | kg/blast | 1.081 | kg/blast | 2130 | - | - | - | - | - | - |
| Dozer working | 48867 | 11897 | 5131 | 0 | 2920 | h/y | 16.7 | kg/h | 4.07 | kg/h | 1.757 | kg/h | - | - | 2 | - | - | - | 10 |
| Drilling rock | 35 | 19 | 2 | 70 | 200 | holes/y | 0.59 | kg/hole | 0.31 | kg/hole | 0.030 | kg/hole | - | - | - | - | - | - | - |
| Blasting rock | 173 | 90 | 9 | 0 | 8 | blasts/y | 21.6 | kg/blast | 11.2 | kg/blast | 1.081 | kg/blast | 2130 | - | - | - | - | - | - |
| Loading to trucks | 1462 | 692 | 73 | 0 | 500000 | t/y | 0.00292 | kg/t | 0.00138 | kg/t | 0.000 | kg/t | - | 2.47 | 2 | - | - | - | - |
| Hauling to processing area | 2778 | 529 | 132 | 75 | 500000 | t/y | 0.02222 | kg/t | 0.00423 | kg/t | 0.001 | kg/t | - | - | - | 4.0 | 36 | 0.2 | - |
| Unloading from trucks | 1462 | 692 | 73 | 0 | 500000 | t/y | 0.00292 | kg/t | 0.00138 | kg/t | 0.000 | kg/t | - | 2.47 | 2 | - | - | - | - |
| Loading rock to mobile crusher by FEL | 1462 | 692 | 73 | 0 | 500000 | t/y | 0.00292 | kg/t | 0.00138 | kg/t | 0.000 | kg/t | - | 2.47 | 2 | - | - | - | - |
| Crushing (mobile jaw crusher) | 2775 | 1088 | 139 | 50 | 500000 | t/y | 0.01 | kg/t | 0.004 | kg/t | 0.001 | kg/t | - | - | - | - | - | - | - |
| Screening (mobile screen 1) | 7500 | 2500 | 375 | 50 | 500000 | t/y | 0.03 | kg/t | 0.01 | kg/t | 0.002 | kg/t | - | - | - | - | - | - | - |
| Crushing (mobile cone crusher) | 2775 | 1088 | 139 | 50 | 500000 | t/y | 0.01 | kg/t | 0.004 | kg/t | 0.001 | kg/t | - | - | - | - | - | - | - |
| Screening (mobile screen 2) | 7500 | 2500 | 375 | 50 | 500000 | t/y | 0.03 | kg/t | 0.01 | kg/t | 0.002 | kg/t | - | - | - | - | - | - | - |
| Loading product stockpiles | 731 | 346 | 37 | 50 | 500000 | t/y | 0.00292 | kg/t | 0.00138 | kg/t | 0.000 | kg/t | - | 2.47 | 2 | - | - | - | - |
| Wind erosion from exposed areas | 3504 | 1752 | 263 | 0 | 4 | ha | 876.0 | kg/ha/y | 438.0 | kg/ha/y | 65.7 | kg/ha/y | - | - | - | - | - | - | - |
| Wind erosion from product stockpiles | 438 | 219 | 33 | 50 | 1 | ha | 876.0 | kg/ha/y | 438.0 | kg/ha/y | 65.7 | kg/ha/y | - | - | - | - | - | - | - |
| Loading product to trucks | 1462 | 692 | 73 | 0 | 500000 | t/y | 0.00292 | kg/t | 0.00138 | kg/t | 0.000 | kg/t | - | 2.47 | 2 | - | - | - | - |
| Hauling product off-site | 7813 | 1488 | 372 | 75 | 500000 | t/y | 0.06250 | kg/t | 0.0119 | kg/t | 0.003 | kg/t | - | - | - | 4.0 | 32 | 0.5 | - |
| | | | | | | | | | | | | | | | | | | | |
| | | | | | | | | | | | | | | | | | | | |
| | 90738 | 26280 | 7298 | | | | | | | | | | | | | | | | |

```
  -----ACTIVITY SUMMARY-----
 ACTIVITY NAME : Dozer working
 ACTIVITY TYPE : Wind insensitive
 DUST EMISSION : 48867 kg/y TSP  11897 kg/y PM10  5131 kg/y PM2.5
 FROM SOURCES  : 9
1 2 3 4 5 6 7 8 9
 HOURS OF DAY  :
0 0 0 0 0 0 0 1 1 1 1 1 1 1 1 1 1 0 0 0 0 0 0

 ACTIVITY NAME : Drilling rock
 ACTIVITY TYPE : Wind insensitive
 DUST EMISSION : 35 kg/y TSP  19 kg/y PM10  2 kg/y PM2.5
 FROM SOURCES  : 9
1 2 3 4 5 6 7 8 9
 HOURS OF DAY  :
0 0 0 0 0 0 0 1 1 1 1 1 1 1 1 1 1 0 0 0 0 0 0

 ACTIVITY NAME : Blasting rock
 ACTIVITY TYPE : Wind insensitive
 DUST EMISSION : 173 kg/y TSP  90 kg/y PM10  9 kg/y PM2.5
 FROM SOURCES  : 9
1 2 3 4 5 6 7 8 9
 HOURS OF DAY  :
0 0 0 0 0 0 0 0 0 0 0 1 1 1 0 0 0 0 0 0 0 0 0

 ACTIVITY NAME : Loading to trucks
 ACTIVITY TYPE : Wind sensitive
 DUST EMISSION : 1462 kg/y TSP  692 kg/y PM10  73 kg/y PM2.5
 FROM SOURCES  : 9
1 2 3 4 5 6 7 8 9
 HOURS OF DAY  :
0 0 0 0 0 0 0 1 1 1 1 1 1 1 1 1 1 0 0 0 0 0 0

 ACTIVITY NAME : Hauling to processing area
 ACTIVITY TYPE : Wind insensitive
 DUST EMISSION : 2778 kg/y TSP  529 kg/y PM10  132 kg/y PM2.5
 FROM SOURCES  : 9
1 2 3 4 5 6 7 8 9
 HOURS OF DAY  :
0 0 0 0 0 0 0 1 1 1 1 1 1 1 1 1 1 0 0 0 0 0 0

 ACTIVITY NAME : Unloading from trucks
 ACTIVITY TYPE : Wind sensitive
 DUST EMISSION : 1462 kg/y TSP  692 kg/y PM10  73 kg/y PM2.5
 FROM SOURCES  : 9
1 2 3 4 5 6 7 8 9
 HOURS OF DAY  :
0 0 0 0 0 0 0 1 1 1 1 1 1 1 1 1 1 0 0 0 0 0 0

 ACTIVITY NAME : Loading rock to mobile crusher by FEL
 ACTIVITY TYPE : Wind sensitive
 DUST EMISSION : 1462 kg/y TSP  692 kg/y PM10  73 kg/y PM2.5
 FROM SOURCES  : 9
1 2 3 4 5 6 7 8 9
 HOURS OF DAY  :
0 0 0 0 0 0 0 1 1 1 1 1 1 1 1 1 1 0 0 0 0 0 0

 ACTIVITY NAME : Crushing (mobile jaw crusher)
```

```
 ACTIVITY TYPE : Wind insensitive
 DUST EMISSION : 2775 kg/y TSP  1088 kg/y PM10  139 kg/y PM2.5
 FROM SOURCES  : 3
10 11 12
 HOURS OF DAY  :
0 0 0 0 0 0 0 1 1 1 1 1 1 1 1 1 1 0 0 0 0 0 0

 ACTIVITY NAME : Screening (mobile screen 1)
 ACTIVITY TYPE : Wind insensitive
 DUST EMISSION : 7500 kg/y TSP  2500 kg/y PM10  375 kg/y PM2.5
 FROM SOURCES  : 3
10 11 12
 HOURS OF DAY  :
0 0 0 0 0 0 0 1 1 1 1 1 1 1 1 1 1 0 0 0 0 0 0

 ACTIVITY NAME : Crushing (mobile cone crusher)
 ACTIVITY TYPE : Wind insensitive
 DUST EMISSION : 2775 kg/y TSP  1088 kg/y PM10  139 kg/y PM2.5
 FROM SOURCES  : 3
10 11 12
 HOURS OF DAY  :
0 0 0 0 0 0 0 1 1 1 1 1 1 1 1 1 1 0 0 0 0 0 0

 ACTIVITY NAME : Screening (mobile screen 2)
 ACTIVITY TYPE : Wind insensitive
 DUST EMISSION : 7500 kg/y TSP  2500 kg/y PM10  375 kg/y PM2.5
 FROM SOURCES  : 3
10 11 12
 HOURS OF DAY  :
0 0 0 0 0 0 0 1 1 1 1 1 1 1 1 1 1 0 0 0 0 0 0

 ACTIVITY NAME : Loading product stockpiles
 ACTIVITY TYPE : Wind sensitive
 DUST EMISSION : 731 kg/y TSP  346 kg/y PM10  37 kg/y PM2.5
 FROM SOURCES  : 3
13 14 15
 HOURS OF DAY  :
0 0 0 0 0 0 0 1 1 1 1 1 1 1 1 1 1 0 0 0 0 0 0

 ACTIVITY NAME : Wind erosion from exposed areas
 ACTIVITY TYPE : Wind erosion
 DUST EMISSION : 3504 kg/y TSP  1752 kg/y PM10  263 kg/y PM2.5
 FROM SOURCES  : 11
1 2 3 4 5 6 7 8 9 10 11
 HOURS OF DAY  :
1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1

 ACTIVITY NAME : Wind erosion from product stockpiles
 ACTIVITY TYPE : Wind erosion
 DUST EMISSION : 438 kg/y TSP  219 kg/y PM10  33 kg/y PM2.5
 FROM SOURCES  : 3
13 14 15
 HOURS OF DAY  :
1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1

 ACTIVITY NAME : Loading product to trucks
 ACTIVITY TYPE : Wind sensitive
 DUST EMISSION : 1462 kg/y TSP  692 kg/y PM10  73 kg/y PM2.5
 FROM SOURCES  : 3
13 14 15
 HOURS OF DAY  :
0 0 0 0 0 0 0 1 1 1 1 1 1 1 1 1 1 0 0 0 0 0 0

 ACTIVITY NAME : Hauling product off-site
 ACTIVITY TYPE : Wind insensitive
 DUST EMISSION : 7813 kg/y TSP  1488 kg/y PM10  372 kg/y PM2.5
 FROM SOURCES  : 5
15 16 17 18 19
 HOURS OF DAY  :
0 0 0 0 0 0 0 1 1 1 1 1 1 1 1 1 1 0 0 0 0 0 0
```