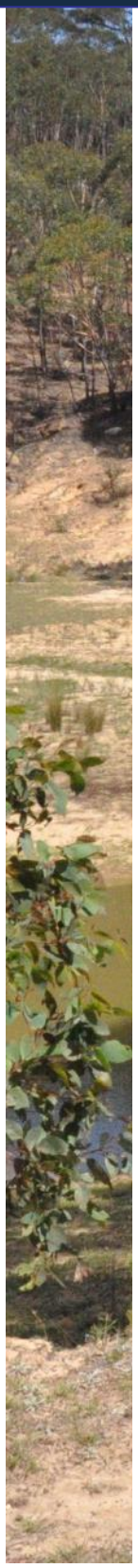
Section 5



Environmental Features, Safeguards and Impacts

Preamble

This section describes the specific environmental features of the Site and its surrounds that would or may be affected by the Proposal. Information on existing conditions, proposed safeguards and controls and potential impacts the Proposal may have following the implementation of these measures is presented for all relevant issues. The various issues in this section are addressed generally in the order prioritised in Section 3.3.

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5.1 TRAFFIC AND TRANSPORT

5.1.1 Introduction

The DGRs for the Proposal identified "*Traffic and Transport*" as a key issue, requiring that the "*EIS include:*

- *accurate predictions of project-related traffic and a detailed assessment of the potential impacts of project-related traffic on the capacity, safety and efficiency of road networks, including modelling to predict queue lengths and intersection performance; and*
- *a detailed description of the measures that would be implemented to maintain and/or improve the capacity, efficiency and safety of effected roads and intersections over the life of the project, including concept plans for any proposed works.*

The DGRs also made reference to the need to take into account two RTA documents entitled "Guide to Traffic Generating Developments" (RTA, 2002) and the "Road Design Guide" (RTA, 1989).

Additional matters for consideration in preparing the EIS were also provided in the correspondence attached to the DGRs from the NSW Roads and Maritime Services (RMS) Division of Resources & Energy (DRE) now Division of Resources and Geoscience (DRG), and Wingecarribee Shire Council (WSC). Discussions have also been held with RMS regarding the design of access to and from the Hume Highway via a proposed Quarry Interchange. A consolidated list of the identified requirements relating to traffic and transport and where each is addressed is presented in **Appendix 2**.

Based on the risk assessment undertaken for the Proposal (**Appendix 4**), the potential impacts relating to traffic and transport, and their risk rankings (in parenthesis) after the adoption of pre-existing or standard mitigation measures are as follows.

- Ongoing truck traffic and possible congestion leading to:
  - inconvenience to commuters (medium); and
  - increased risk of accidents occurring (medium).
- Accelerated road pavement deterioration (low).
- Reduced amenity of local area due to ongoing truck traffic and vehicle noise/emissions (medium).
- Loss of species in local area due to death or injury to native animals on the road network (low).

The traffic assessment of the Proposal was undertaken by Transport and Urban Planning Pty Ltd. The full assessment is presented in Part 1 of the *Specialist Consultant Studies Compendium* and is referenced throughout this section as TUP (2018), with a summary of the assessment presented in the following subsections.

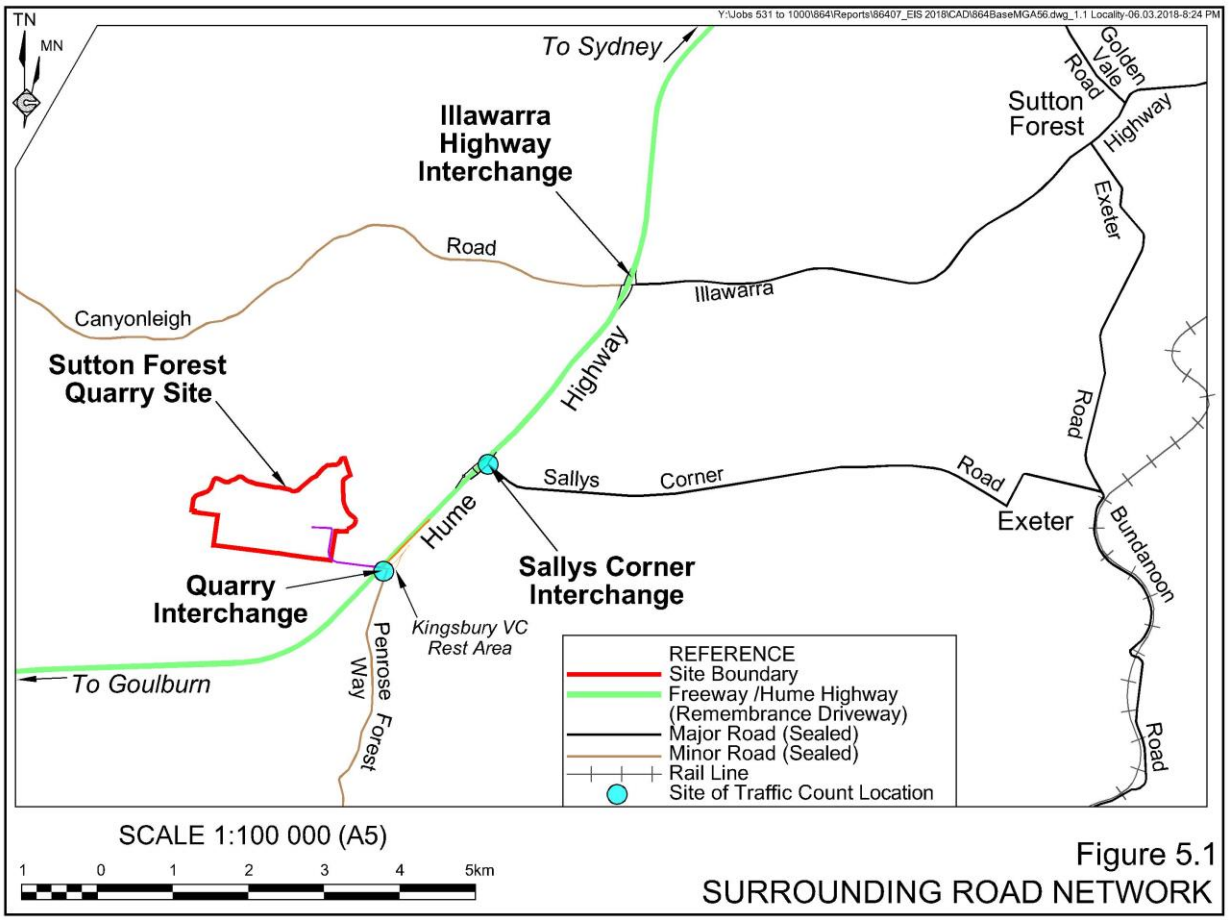
5.1.2 Existing Traffic Conditions

5.1.2.1 Description of the Existing Road Network

The key roads, interchanges and other transport infrastructure that are either in the vicinity of the Site or would provide access to and from the Site include:

- the Hume Highway;
- the Sallys Corner Interchange
- the Illawarra Highway;
- the Illawarra Highway Interchange;
- Penrose Forest Way; and
- Kingsbury VC Rest Area.

Figure 5.1 displays the locations of these key roads, interchanges and other transport infrastructure.



Hume Highway

The Hume Highway is the principal transport route that provides access to the Site which is a State Road and a National Route under the control of the RMS.

The Hume Highway is a high standard four lane divided road with dual carriageways. The Highway is the main road corridor between Sydney and Melbourne, as well as servicing those towns/communities in the Southern Highlands, southwestern NSW and the ACT.

In the Sutton Forest area, the Hume Highway provides two through lanes in each direction plus additional turning and/or diverging/merging lanes at the at-grade intersections for vehicles entering or leaving the highway.

The speed limit on the section of the Hume Highway near the Quarry Interchange is 110km/h. A high level of traffic management is provided in the Hume Highway including separate carriageways with wide shoulders, delineation and signage. The Hume Highway has a theoretical capacity of 3 600 vehicles per hour (vph) in each direction. The carriageways are separated by a wide median and storage/holding areas provided at intersections and cross-overs to queue/store turning traffic.

Sallys Corner Interchange

Sallys Corner Interchange is a grade separated interchange located approximately 3.2km south of Illawarra Highway and approximately 1.7km northeast of the Site. The Interchange provides access to Sallys Corner Road as well as to the service centres (i.e. petrol and food outlets) which are located on both the eastern and western sides of the Hume Highway.

The eastern service centre (i.e. located on the eastern side of Hume Highway) incorporates a fuel station, convenience store, three food outlets and truck parking. The eastern service centre generally accommodates motorists arriving from the north and travelling southwards on the Hume Highway.

The western service centre (i.e. located on the western side of Hume Highway), which accommodates northbound motorists, incorporates a fuel station, convenience store, one food outlet and truck parking. The western service centre generally accommodates materials arriving from the south and travelling northwards on the Hume Highway.

Illawarra Highway

The Illawarra Highway is a 65km transport route linking the Illawarra region with the Hume Highway and Southern Highlands at the Illawarra Highway Interchange. The Illawarra Highway is a State Road under the control of the RMS. The speed limit on the section of the Illawarra Highway near the Illawarra Highway Interchange is 100km/h.

Illawarra Highway Interchange

The Illawarra Highway Interchange is located 3.2km to the north of Sallys Corner Road. The Interchange, which is constructed to a high standard, provides for vehicles travelling between the Hume Highway and Illawarra Highway (to the east) and Canyonleigh Road (to the west). Illawarra Highway and Canyonleigh Road are grade separated with a dual lane bridge structure over the Hume Highway.

Penrose Forest Way

Penrose Forest Way is an unsealed road, approximately 5.7km in length that provides the principal access to Penrose State Forest. The at-grade intersection of Penrose Forest Way and the Hume Highway is located approximately 1.7km southwest of the Sallys Corner Interchange and incorporates vehicle access to Penrose Forest Way and the Kingsbury VC Rest Area, as well as other access for Penrose State Forest (Webber [Stingray] Road and Burnt Cottage Road). Penrose Forest Way is maintained by the Forestry Corporation of NSW (FCNSW) from the intersection with the Hume Highway to Paddys River, Penrose. From Paddys River to Old Argyle Road, Penrose, the responsibility for road maintenance lies with Wingecarribee Shire Council. Penrose Forest Way is utilised for the transport of timber raw materials from Belanglo and Penrose State Forests to the Penrose Pine Sawmill, Old Argyle Road Penrose. Penrose Forest Way is also used as a local route for vehicles travelling from Penrose and intending to travel north on the Hume Highway.

Kingsbury VC Rest Area

Kingsbury VC Rest Area is a road side rest area that forms part of the Remembrance Driveway between Sydney and Canberra. Parking for light vehicles, caravans and trailers is provided as are picnic areas and toilet facilities. Access and egress from the rest area is provided by the at grade intersection of the Hume Highway and Penrose Forest Way.

5.1.2.2 Existing Traffic Volumes

Traffic counts on the Hume Highway, Sallys Corner Interchange road network and the intersection of the Hume Highway and Penrose Forest Way (refer **Figure 5.1**) were undertaken as part of the traffic assessment to establish traffic volumes and vehicle types using the highway and interchange road network.

This included:

- hourly volume and vehicle classification counts in the Hume Highway at Sallys Corner Interchange which were undertaken on Thursday 12 May 2016 over a 24 hour period;
- daily volume and vehicle classification counts in the Northbound and southbound off-ramps from the Hume Highway to Sallys Corner Interchange which were undertaken in week 12-18 May 2016; and
- intersection and turning volume counts at the intersections of Sallys Corner Interchange which were undertaken on Thursday 12 May 2016 between 4:00am and 9:00am, at the following intersections;
  - Eastern Service Road/Overbridge/southbound on-ramp and Driveway from Service Centre (priority control); NB: an additional count was also undertaken between 2:00pm and 6:00pm on Wednesday 28 February 2018.
  - northbound off-ramp/Western Service Road and Driveway to Service Centre and private access to Lot 2 (roundabout control);
  - Western Service Road/Overbridge and Driveway from Service Centre (priority control);

In addition, an intersection and turning volume count in the Hume Highway at Penrose Forest Way was undertaken Tuesday 27 February 2018 between 5:30am and 9:30am and 3:30pm and 6:30pm.

Table 5.1 lists the total daily through traffic volumes and vehicle classifications for the northbound and southbound lanes of the Hume Highway, while **Table 5.2** lists the typical weekday (5-day average) and 7 day average traffic volume for the northbound and southbound off-ramps at Sallys Corner Interchange.

Table 5.1
Daily through Traffic Volume – Hume Highway at Sallys Corner Interchange – 12 May 2016

Direction of Travel	Kerbside Lane		Median Lane		Total Volume
	Light Vehicles[1]	Heavy Vehicles[2]	Light Vehicles[1]	Heavy Vehicles[2]	
Northbound	4 610	2 435	1 715	120	8 880
Southbound	3 783	2 388	1 419	124	7 714
Total	**8 393**	**4 823**	**3 134**	**244**	**16 594**
[1] Light vehicles – Austroads 1 and 2 vehicle classification and motorbikes [2] Heavy vehicles – Austroads 3-12 vehicle classification					
Source: TUP (2018) – modified after Tables 3.1 and 3.2					

Table 5.2
Average Daily Traffic Volumes – Sallys Corner Interchange

Direction of Travel	5 – Day Average (Weekday)				7 – Day Average (AADT)			
	Light Vehicles[1]	Heavy Vehicles[2]	Unclassified	Total Volume	Light Vehicles[1]	Heavy Vehicles[2]	Unclassified	Total Volume
Northbound	1 511	326	16	1 853	1 689	271	14	1 973
Southbound	2 329	400	8	2 738	2 599	326	6	2 930
Total	**3 840**	**726**	**24**	**4 591**	**4 288**	**597**	**20**	**4 903**
%	83.6%	15.8%	0.6%	100%	87.5%	12.2%	0.3%	100%
[1] Light vehicles – Austroads 1 and 2 vehicle classification and motorbikes [2] Heavy vehicles – Austroads 3-12 vehicle classification								
Source: TUP (2018) – modified after Tables 3.3 to 3.6								

Over the 24 hour period on 12 May 2016 presented in **Table 5.1**, a total of 16 594 vehicles travelled the Hume Highway through the Sallys Corner Interchange (i.e. without stopping or entering the interchange) of which 5 067 (or 31%) were heavy vehicles. During the weekday am period between 4:00am and 9:00am, the total hourly northbound through traffic volumes on the Hume Highway ranged between 155vph to 440vph whilst the total hourly southbound through traffic volumes on the Hume Highway for the same period ranged between 106vph and 488vph, i.e. levels well below the theoretical capacity of 3 600vph in each direction. The peak hour for traffic in the northbound direction generally occurred between 4:00pm and 5:00pm with a total of 756vph whilst the southbound peak hour occurred between 3:00pm and 4:00pm with a traffic volume of 568vph.

As noted in **Table 5.2,** the volume of vehicles using the northbound off-ramp to Sallys Corner Interchange on an average weekday (5 day average) was 1 853 vehicles (ranging between 13vph and 136vph) whilst the average daily volume over a full week, (7 day average) was marginally higher with 1 973 vehicles (ranging between 11vph and 147vph). The average daily volumes of vehicles using the southbound off-ramp on an average weekday (5 day average) was 2 738 vehicles (ranging between 13vph and 213vph) with average daily volumes over a full week (7 day average) also marginally higher with 2 930 vehicles (ranging between 12vph to 207vph).

For the weekday am period between 4:00am and 9:00am, hourly volumes using the northbound off-ramp ranged between 22vph and 104vph whilst the hourly volumes for the southbound off-ramp for the same period ranged between 30vph and 213vph.

The overall volumes of traffic travelling on the Hume Highway north and south of the Sallys Corner Interchange can be approximated by combining the through traffic levels (**Table 5.1**) with the number of vehicles departing the highway at the interchange (**Table 5.2**)[1]. By combining these traffic levels, the 2016 Hume Highway northbound weekday volumes, north of Sallys Corner Interchange were calculated to be a total of 10 730vpd with 2 881 of these vehicles estimated to be heavy vehicles. The 2016 Southbound Hume Highway weekday volumes, north of Sallys Corner Interchange are calculated to be a total of 10 452vpd with 2 912 of these vehicles, estimated to be heavy vehicles.

The intersections on the eastern side of Sallys Corner Interchange, which generally accommodate southbound vehicle movements from the Hume Highway as well as Sallys Corner Road, exhibits higher traffic volumes, as compared to the intersections on the western side of the interchange which accommodates the northbound vehicle movements from the Hume Highway. The overall traffic volumes using the intersections between 4:00am and 6:00am are very low and increase between 6:00am to 9:00am. The am peak one hour occurred at the intersections between 7.15am – 8.15am. Observations undertaken at the intersections during the weekday am period indicate that all the intersections operate at a very good level of service (equivalent to Level of Service A operation) with low vehicle delays for all movements. RMS Guidelines indicate that a Level of Service D or better (i.e. A, B, C or D) represents a satisfactory operation.

Table 5.3 lists the hourly traffic volumes between the periods 5:30am and 9:30am and 3:30pm and 6:30pm on 27 February 2018 using the Hume Highway/Penrose Forest Way intersection that also provides access to the Kingsbury VC Rest Area.

The two way traffic volumes using the Hume Highway/Penrose Forest Way Intersection between 5:30am and 9:30am presented in **Table 5.3** range between 1vph and 8vph, which represent low hourly volumes.

[1] This approach recognises that the proportion of traffic travelling on Sallys Corner Road between the interchange and Exeter is comparatively small.

Table 5.3
Hourly Traffic Volumes – Hume Highway/Penrose Forest Way Intersection

	Southbound		Northbound	
Time Period	**Left turn in[1]**	**Left turn out[2]**	**Right turn in[1]**	**Right turn out[2]**
5:30am-6:00am	2	0	0	0
6:00am-7:00am	1	0	0	3
7:00am-8:00am	8	0	5	1
8:00am-9:00am	7	0	3	2
9:00am-9:30am	4	0	1	1
3:30pm-4:00pm	4	0	2	0
4:00pm-5:00pm	7	1	3	12
5:00pm-6:00pm	7	1	4	0
6:00pm-6:30pm	6	0	1	1
[1] Vehicles entering Penrose Forest Way from the Hume Highway [2] Vehicles entering the Hume Highway from the Penrose Forest Way				
Source: TUP (2018) – Modified after Table 3.7				

5.1.2.3 Existing Road Safety Record

Road crash statistics for the 5 year period between 1 July 2010 and 30 June 2015 for the section of Hume Highway 1km north and south of the Sallys Corner Interchange including the interchange itself were obtained from the RMS. During this period, there were a total of 18 crashes including one fatal crash, seven injury crashes (either minor or uncategorised injury) and ten non casualty crashes.

With respect to the accident locations, the following summary is provided.

- The fatal crash occurred on the Hume Highway 1km south of the Sallys Corner Interchange and was a single vehicle crash.
- An additional eight crashes occurred on the Hume Highway, four of which were non-casualty crashes and four that were injury crashes.
- A total of nine crashes occurred within the Sallys Corner Interchange Road network.
  - Five of the crashes occurred at/adjacent to the roundabout intersection at the end of northbound off-ramp, one of which was an injury crash and four non-casualty crashes. All of these were single vehicle crashes, with the vehicles crashing into objects on the side of the road or within the roundabout. Speed was a contributing factor in these crashes.
  - One non-casualty crash at the intersection of the Overbridge/Western Side Interchange Road, which was a right angle type crash.
  - Three crashes at or near the roundabout at the intersection of the southbound off-ramp/Sallys Corner Road, two of which were injury crashes. Two of these crashes involved a southbound vehicle running off the road (single vehicle crash) and speed and fatigue were contributing factors. The other crash occurred just east of the roundabout in Sallys Corner Road and was an injury crash involving two vehicles travelling in unknown directions.

5.1.3 Proposed Changes to the Public Road Network

As discussed in Section 2.8, the Applicant proposes to undertake roadworks immediately north of the current Penrose Forest way intersection with the Hume Highway which also provides access to the Kingsbury VC Rest Area. This roadwork would involve the construction of the Quarry Interchange (refer **Figure 5.2**) which would comprise the following.

- A single lane, grade separated exit from the southbound lanes of the Hume Highway for vehicles accessing the Site, the residences situated on Lot 12 DP241054 and Lots 3 and 4 DP253435, Penrose Forest Way and the Kingsbury VC Rest Area. The entry to the southbound off-ramp would be located 1.1km from the end of the acceleration lane of the southbound exit from the Sallys Corner Interchange and approximately 350m south of the truck layout stop in the Hume Highway (southbound). Vehicles entering the southbound off-ramp exit lane would diverge into either the at-grade entry (right) to the Kingsbury VC Rest Area and Penrose Forest Way or the grade separated ramp (left) to the overbridge for those vehicles continuing onto the Site. The grade of the off-ramp entry to the overbridge is 3.5% with a 40km/h entry speed to the overbridge.
- A single lane, two span overbridge over the Hume Highway for southbound vehicles entering the Site and accessing Lot 12 DP241054 and Lots 3 and 4 DP253435. The overbridge would also comprise supporting piers and abutments and provide a minimum 7.5m clearance over the Hume Highway carriageways.
- A single lane, at-grade northbound on-ramp and acceleration lane linking the Quarry Access Road to the Hume Highway. The design entry speed to the on ramp from the Quarry Access Road is 35km/h whilst the acceleration lane is 890m long. This distance would be of sufficient length to allow for trucks and other vehicles to accelerate to a suitable speed in order to safely merge with traffic using the northbound kerbside lane in the Hume Highway. The northbound on-ramp would also be used by the vehicles exiting the properties situated on Lot 12 DP241054 and Lots 1, 2, 3 and 4 DP253435. Vehicles entering the properties on Lots 1 and 2 DP253435 would retain their current entry arrangements.

Transport Routes

After the construction of the Quarry Interchange is completed, the Applicant anticipates that all laden trucks departing the Site would travel northwards from the northbound on-ramp and enter the northbound lanes of the Hume Highway (see **Figure 5.2**). **Figure 5.3** displays the proposed transport routes for the delivery of sand products from the Site. The Applicant proposes that, on average, approximately 95% of laden trucks would travel north towards the Sydney market with fewer numbers of trucks destined for the Illawarra, Southern Highlands, Goulburn and Canberra. These vehicles would use the northbound lanes of the Hume Highway prior to using the Hume Highway/Illawarra Highway grade separated interchange to either undertake a "U" turn and return southwards along the Hume Highway or continue east on the Illawarra Highway.

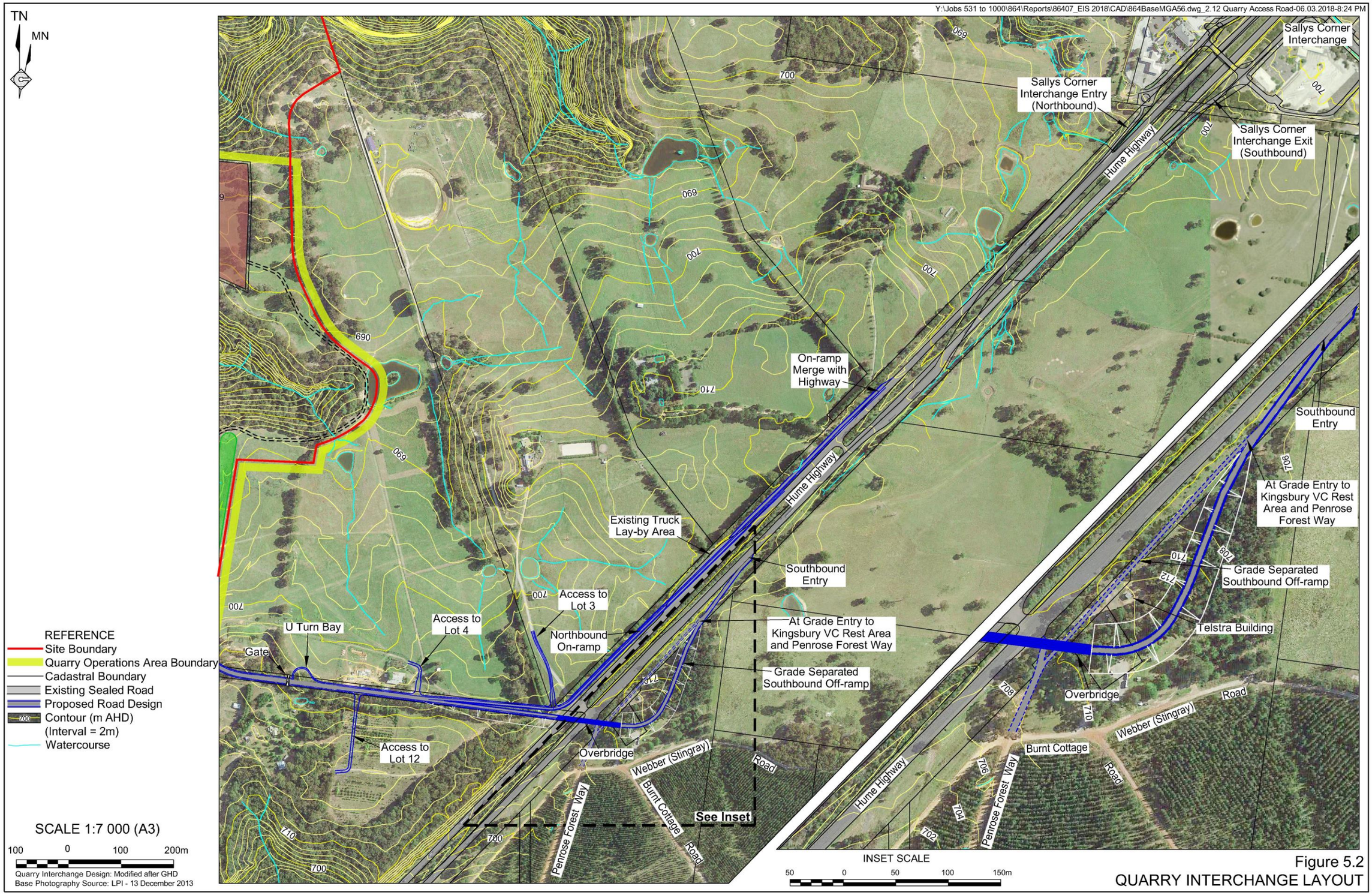


Figure 5.2
QUARRY INTERCHANGE LAYOUT

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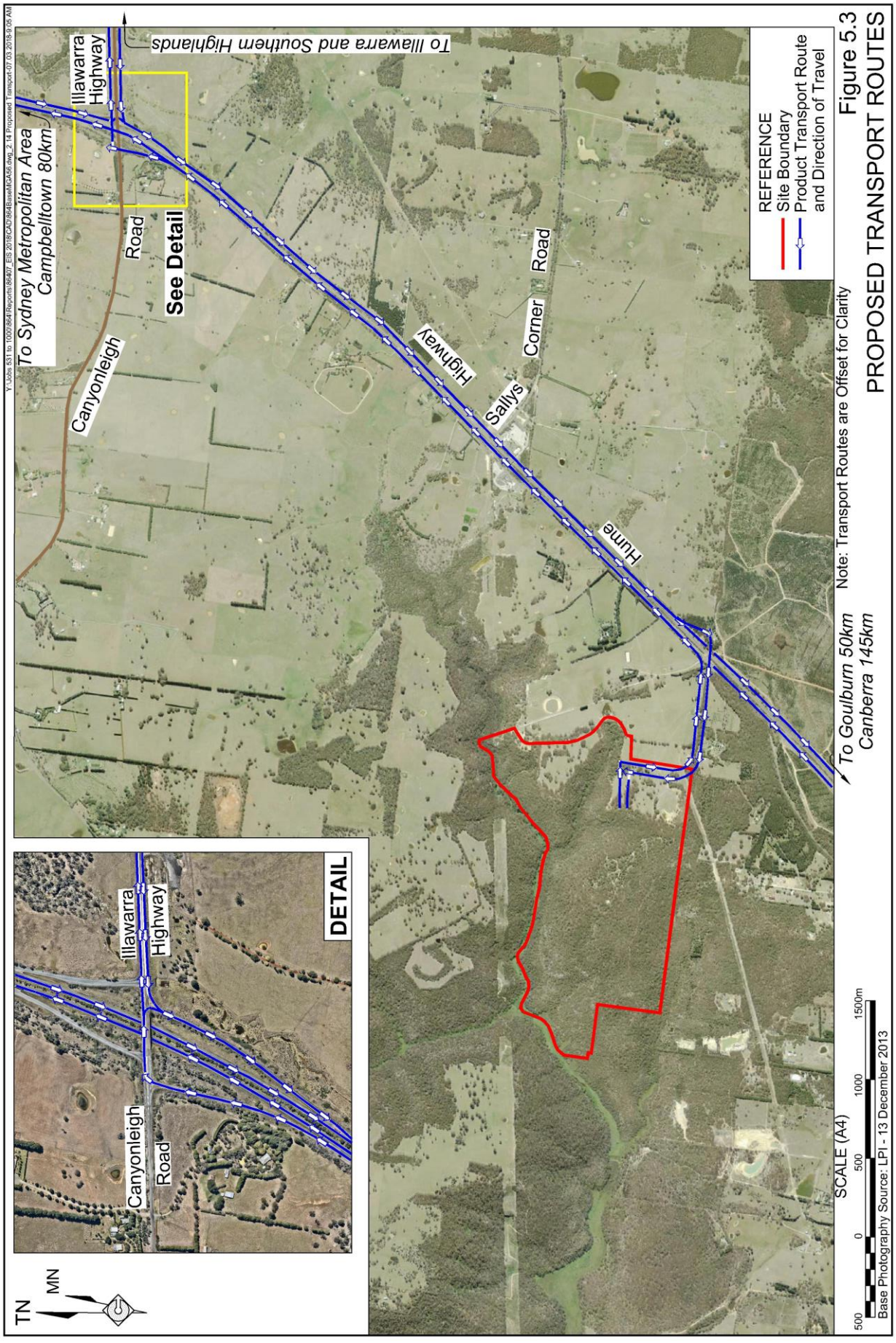

PROPOSED TRANSPORT ROUTES
Figure 5.3
REFERENCE
Site Boundary
Product Transport Route and Direction of Travel
To Sydney Metropolitan Area Campbelltown 80km
To Illawarra and Southern Highlands
To Goulburn 50km Canberra 145km
Illawarra Highway
Canyonleigh Road
See Detail
Sallys Corner Road
Hume Highway
Note: Transport Routes are Offset for Clarity
DETAIL
TN MN
SCALE (A4)
500 0 500 1000 1500m
Base Photography Source: LPI - 13 December 2013

5.1.4 Proposed Internal Roads

Site Establishment and Construction Stage

Access for all vehicles during the bulk of the site establishment and construction stage would be via the existing entrance Lot 4 DP 253435 directly from the Hume Highway. From the entrance to Lot 4, all vehicles would travel via a new all-weather unsealed road to be constructed across Lot 4. The Construction Access Road would include a suitably engineered crossing of the high pressure gas (Moomba – Sydney (natural gas), Moomba – Wilton (ethane)) and water pipelines (Goulburn – Wingecarribee) easement. A temporary wheel wash would be installed approaching the gate to Lot 4 to prevent the tracking of mud onto the Hume Highway by heavy vehicles departing the Site.

The majority of the construction traffic is expected to arrive and depart from/to the north along the Hume Highway. Traffic entering from the Hume Highway would do so via an existing 240m long auxiliary lane that is provided in the southbound carriageway of the Hume Highway for right turn vehicles from the highway into the Construction Access Road. The holding area between the northbound and southbound carriageways in the Hume Highway is approximately 22m in width and can accommodate heavy vehicles, without impacting on the through lanes. Minor works are proposed to the Construction Access Road at its entrance to the Hume Highway to accommodate trucks turning left from the Construction Access Road into the northbound kerbside lane of the Hume Highway.

Quarry Access Road

The despatch of laden trucks from the Site would occur via a specially constructed Quarry Access Road between the Quarry Operations Area and the Quarry Interchange, with all trucks accessing the Hume Highway via the northbound on-ramp.

The dual lane Quarry Access Road would be the sole access between the Quarry Interchange and the Quarry Operations Area throughout the operational life of the Quarry (see **Figure 5.4**). The Quarry Access Road would extend from the Quarry Interchange to the weighbridge within the Quarry Operations Area, a distance of approximately 1.4km. The Quarry Access Road would be constructed with a 7.5m wide sealed pavement with 0.75m wide unsealed shoulders. Local widening would be used approaching the gentle corners along the route. The Quarry Access Road would traverse a 0.7km long section of the Crown Road Reserve between Lot 4 DP253435 and Lot 12 DP241054.

The Quarry Access Road would be constructed to carry trucks up to 26.5m in length. The Quarry Access Road would also be used by the owners of Lot 12 DP241054 and Lots 3 and 4 DP253435. Due to the inbound and outbound lane separation on the Quarry Access Road, access to the residence on Lot 3 DP253435 would be via a U-turn bay (refer **Figure 5.4**) near the entrance to the Site that would be constructed for this purpose as well as to provide recourse for those vehicles mistakenly entering the Quarry Access Road. The Quarry Access Road would also include a range of mitigation works such as cattle grids, fencing and planting part of its construction. This is considered an improvement for these owners and occupiers as they currently access their properties directly from the Hume Highway.

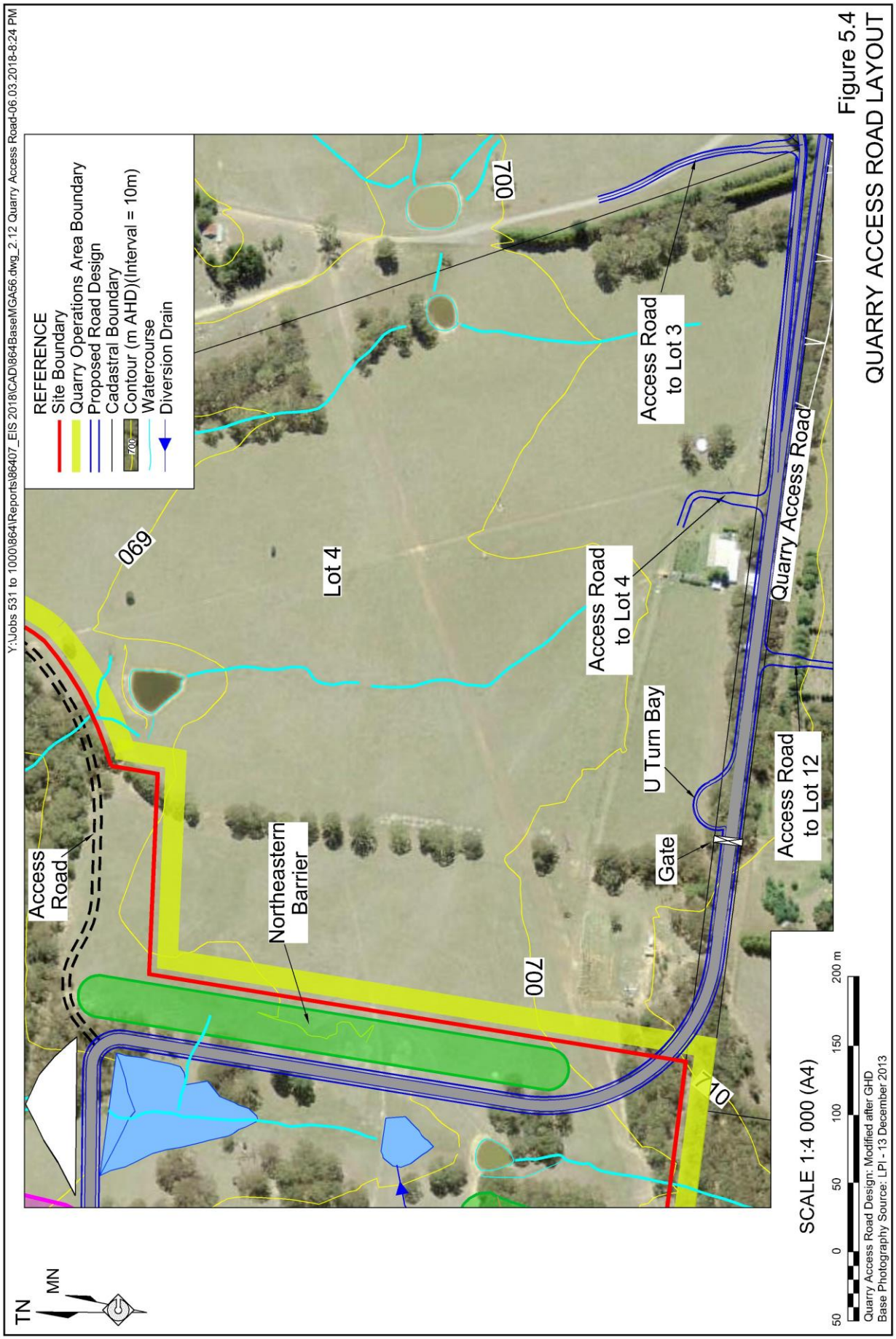


Figure 5.4
QUARRY ACCESS ROAD LAYOUT
Y:\Jobs 531 to 1000\864\Reports\86407_EIS 2018\CAD\864BaseMGA56.dwg_2.12 Quarry Access Road-06.03.2018-8:24 PM
REFERENCE
Site Boundary
Quarry Operations Area Boundary
Proposed Road Design
Cadastral Boundary
Contour (m AHD)(Interval = 10m)
Watercourse
Diversion Drain
700
069
Lot 4
Access Road to Lot 3
Access Road to Lot 4
Quarry Access Road
U Turn Bay
Access Road to Lot 12
Gate
Access Road
Northeastern Barrier
700
700
10
TN
MN
SCALE 1:4 000 (A4)
50 0 50 100 150 200 m
Quarry Access Road Design: Modified after GHD
Base Photography Source: LPI - 13 December 2013

5.1.5 Proposed Traffic Generation

5.1.5.1 Traffic Generation during Site Establishment and Construction Stage

The Proposal would generate a range of traffic during the 12 month site establishment and construction stage. Traffic travelling to and from the Site during this period would include the following.

- Low loaders delivering earthmoving equipment and equipment for use in assembling the processing plant (0 to 4 movements per day).
- Various semi-trailers/truck and dog vehicles delivering construction materials and a range of equipment required on site (6 to 30 movements per day).
- Various concrete agitator trucks delivering concrete for equipment foundations, etc. (0 to 20 movements per day).
- Occasional trucks delivering fuel for on-site earthmoving equipment and temporary generators (0 to 2 movements per day).
- A range of light vehicles used by the Applicant's employees, contractors, couriers, visitors, etc. (20 to 40 movements per day).

5.1.5.2 Traffic Generation and Transport Routes during Operational Phase

As the majority of the Applicant's products would be destined for the Sydney market, the product trucks would travel northwards towards Sydney. Those product trucks destined towards Goulburn or Canberra would travel southwards along the Hume Highway whilst those for the Southern Highlands and Illawarra would travel east via the Illawarra Highway. Minor quantities of sand products would be occasionally supplied to other regional areas, which would require product trucks to use local roads.

Although it is proposed that products would be despatched 24 hours per day, the bulk of the despatch trucks would be planned during periods that avoid the Sydney Metropolitan Area peak traffic periods. It is proposed that the maximum rate of laden trucks departing the Site would not exceed 25 per hour throughout any hour of the day. The maximum hourly rate of despatch may also be required for large scale local deliveries when smaller capacity trucks are used.

Furthermore, whilst it is proposed that products would be despatched 7 days per week, it is considered unlikely that sales and delivery to customers on Sundays and Public Holidays would be a regular occurrence.

There would also be occasional trucks delivering fuel and larger items of equipment. Periodically, low loaders may be used to transport mobile equipment to and from the Site as the production level changes. There would also be a number of staff, visitor and supplier's light vehicles.

Truck Types and Traffic Generation

It is anticipated that at least 70% of the sand products would ultimately be despatched from the Site using 19m truck and dog trailers (quad axle, 37 tonne capacity) with the remainder being truck and dog trailers (tri axle, 33 tonne capacity) occasional rigid trucks (12 to 18 tonne

capacity) or higher mass limit (HML) vehicles (e.g. 26.5m B-Double, 44 tonne capacity). For the purposes of calculating daily truck movements, an average of 35t has been used and an average of sales on 300 days per year.

On a day of maximum sales, the transport route would require 172 one way heavy vehicle movements into the Site plus the return trip (i.e. 172 in/172 out). This includes 166 product trucks and 6 delivery / maintenance vehicles plus return trip entering and exiting the Site. Light vehicle trips are expected to number 28 inbound trips and 28 outbound trips per day. The Applicant estimates 95% of the heavy vehicle trips would be to and from the north along the Hume Highway, with 5% of heavy vehicle trips to and from the south.

Hourly Truck Movements

The majority of truck movements would occur during periods aimed at avoiding the Sydney Metropolitan Area peak traffic periods. From an hourly perspective, it is envisaged the busiest period at any time throughout the life of the Proposal would require up to 50 truck movements (25 loads) per hour. It is recognised that the number of trucks would have generally lesser numbers departing throughout the latter stages of the day in line with industry practice, however, it is proposed that the maximum rate of trucks departing the Site would be kept at 25 per hour throughout any hour of the day, to account for large scale local deliveries or specific major construction projects.

Backfilling Operations

The Applicant proposes to import VENM/ENM to the Site for the use as backfill to create the final landform. All VENM/ENM would be imported in trucks travelling to the Quarry to collect sand product for delivery. Therefore, the backloading operations would not result in any additional truck movements for the Proposal.

5.1.6 Design and Operational Safeguards

The key design safeguards are those reflected in the proposed changes to the public road network outlined in Section 5.1.3.

The Applicant would implement a range of operational safeguards to ensure that other motorists travelling on the Hume Highway and surrounding roads would be minimally impacted upon by the Proposal especially in terms of road safety. The already high standard of Hume Highway as a safe road for use by heavy vehicles by virtue of its excellent engineering would assist with the implementation of these safeguards. The operational safeguards that would be implemented are as follows.

- The Applicant would prepare a detailed Traffic Management Plan, following the receipt of development consent, to safely manage the traffic impacts during all phases of the Proposal.
- The Applicant would require all drivers of heavy vehicles travelling to and from the Quarry to sign a Driver's Code of Conduct that clearly outlines the Applicant's expectations of each driver whilst travelling to and from the Quarry and whilst on site.

5.1.7 Assessment of Impacts

5.1.7.1 Site Establishment and Construction Stage

The traffic generation during the site establishment and construction stage would be relatively low and well within the capacity of the adjacent road network with the majority of the construction traffic expected to arrive and depart from / to the north along the Hume Highway. The construction access location at the highway has good sight distance in both directions of the Hume Highway for construction vehicles entering and exiting the Construction Access Road. The holding area between the northbound and southbound carriageways in Hume Highway can accommodate heavy vehicles, without impacting on the through lanes.

The construction of the new Quarry Interchange would result in minimal impact on motorists using the existing northbound off-ramp given the bulk of the construction activity is not within the road reserve for the Hume Highway. There may be short periods when the Applicant's Contractor would need to occupy parts of the existing road network to finalise construction and this would be negotiated and approved by the RMS through the Section 138 Permit required for the roadworks.

Overall, the impacts arising during the site establishment and construction stage would be acceptable given the long term improvements for all motorists.

5.1.7.2 Operational Stage

Hume Highway

Based on the traffic volumes estimated by TUP (2018) and assuming that 95% of all heavy vehicles despatched from the Site would travel to and from the north, along the Hume Highway (see Section 5.1.5.2), the Proposal would increase the daily volume of heavy vehicles using the northbound and southbound lanes of the Hume Highway by a maximum of 6% on any given day whilst the average increase would be 3.1%.

The maximum number of heavy vehicles travelling to and from the Site on any given day would represent 2.1% of the total weekday traffic travelling north and south on the Hume Highway, north of Sallys Corner Interchange. The increase represented by the average number of heavy vehicles due to the Proposal would be 1.1% of the total weekday traffic travelling north and south on the Hume Highway, north of Sallys Corner Interchange.

As each of the northbound and southbound carriageways of the Hume Highway have a theoretical design capacity of 3 600vph, increases in traffic volumes attributable to the Proposal would be relatively small and would result in a decrease in current or future safety levels on the Hume Highway.

Quarry Interchange: Southbound Off-ramp

Whilst heavy vehicles approaching the entry to the southbound off-ramp would reduce their speed from 110km/h to enter the southbound off-ramp from the southbound kerbside lane of the Hume Highway, this should not affect southbound vehicles using the southbound kerbside lane in the Hume Highway.

This is due to the separation distance between the entry to the southbound off-ramp and the end of the acceleration lane of southbound on-ramp from the Sallys Corner Interchange being 1.1km which means the travel time for a vehicle travelling at 110km/h is 36 seconds. Any southbound vehicles using the kerbside lane in the Hume Highway, including those who have joined the Hume Highway via the southbound on-ramp from the Sallys Corner Interchange will therefore be able to change lanes readily, given the low traffic volumes using the southbound median lane at this location.

The southbound truck layover stop in the Hume Highway does not have either a deceleration lane and or an acceleration lane for vehicles entering or exiting this facility. As trucks exiting the truck stop are currently required to pick a gap in traffic flow when re-joining the Hume Highway, the construction of the southbound off-ramp would not impact this truck layover as the present arrangements would remain in place.

Quarry Interchange: Overbridge

The overbridge would span the Hume Highway and provide a minimum clearance of 7.5m over the carriageways, therefore no impacts to Hume Highway traffic would occur as a consequence of the overbridge.

The installation of the overbridge would require the relocation of the electronic highway information sign and this would be subject to further negotiations with RMS to identify a suitable site.

Quarry Interchange: Northbound On-ramp

With respect to heavy vehicles entering the highway from the northbound on-ramp of the Quarry Interchange, drivers of vehicles travelling at higher speeds in the kerbside lane have adequate sight distance of vehicles using the 890m acceleration lane which would be sufficient to allow these drivers to adjust their speed, or, alternatively change lanes to the adjoining median lane.

The separation distance between the end of the northbound on-ramp of the Quarry Interchange and the entry to the northbound off-ramp at the Sallys Corner Interchange is approximately 560m. A speed of 100km/h or less would be the desirable speed for any northbound vehicles exiting the Hume Highway and entering the Sallys Corner Interchange and for vehicles travelling at 100km/h, the separation distance of 560m equates to 20 seconds of travel time. Furthermore, traffic volumes during a period of peak product despatch (between 4:00am and 9:00am) using the northbound off-ramp at the Sallys Corner Interchange are relatively low (22vph to 136vph).

The construction of the northbound on-ramp would require the relocation of the existing northbound truck layover stop in the Hume Highway and this would be subject to further negotiations with the RMS to identify a suitable site.

Penrose Forest Way / Kingsbury VC Rest Area Intersection

The construction of the southbound off-ramp of the Quarry Interchange would increase the length of the deceleration lane for vehicles exiting the Hume Highway and entering Penrose Forest Way and the Kingsbury VC Rest Area from the current 150m to 380m. As shown on **Table 5.3**, whilst traffic movements at this intersection are relatively low (<10vph, average), vehicles entering from the southbound lanes of the Hume Highway represent the largest proportion (53%) of all traffic movements.

The current arrangements for the entry of vehicles from the northbound lanes of the Hume Highway as well as the exit of vehicles from Penrose Forest Way into either the northbound or southbound lanes of the Hume Highway would remain unchanged.

Kingsbury VC Rest Area

The construction of the southbound off-ramp of the Quarry Interchange would require the relocation of the Kingsbury VC Rest Area, including the current range of amenities to a location adjacent to the present arrangements. The final location would be subject to further negotiations with the RMS and the FCNSW to identify a suitable site, however, it is anticipated that the rest area would remain within the boundaries of Lot 12 DP1199557.

Road Safety

The new southbound off-ramp entry to Penrose Forest Way would increase the deceleration distance for vehicles on the immediate approach to the Penrose Forest Way.

The proposed access to the Quarry Access Road via the new Quarry Interchange is considered an improvement for the landowners of Lot 12 DP241054 and Lots 3 and 4 DP253435 as they currently access their properties directly from the Hume Highway. Furthermore, whilst the landowners of Lots 1 and 2 DP253435 would still access their properties directly from the Hume Highway, exit from these properties via the northbound on-ramp would provide a safer point of entry to the Hume Highway than the current arrangements.

Drivers of vehicles using the on-ramps and acceleration lanes have good sight lines of other vehicles in the adjoining kerbside lane in the Hume Highway, which allows these drivers to select a suitable gap to merge with the through traffic.

Drivers of vehicles in the kerbside lanes of the Hume Highway have sufficient sight distance and travel times to enable safe lane changes when encountering Proposal related vehicles entering or exiting the Hume Highway. Furthermore, the median lanes of the Hume Highway have spare capacity which is unlikely to limit opportunities for lane changes should they be required.

5.1.7.3 Cumulative Impacts

When consideration is given to additional heavy vehicles traffic travelling to and from the operating Penrose Quarry and approved Green Valley Quarry located adjacent to the Hume Highway south of the Site, there could be up to an additional 50vph using the northbound lanes of the Hume Highway. Cumulatively, this respectively represents a 45% and 41% increase in the calculated average hourly heavy vehicle movements in each direction. However, when compared to average weekday heavy vehicle movements travelling north (2 881vpd) and south (2 912vpd) on the Hume Highway, the cumulative increase would be 12% for each direction of travel.

As the Hume Highway has a theoretical capacity in each direction of travel (i.e. each carriageway) of 86 400 equivalent passenger car units per day, the increases are relatively small and proportionally would decrease with the future traffic growth in the Hume Highway.

5.1.7.4 Conclusion

A range of design and operational safeguards are proposed by the Applicant to ensure that the existing high safety standards on the Hume Highway adjacent to the Site would be maintained. The new Quarry Interchange would improve safety for all motorists accessing the Site as well as those landowners entering and exiting Lot 12 DP241054 and Lots 1, 2, 3 and 4 DP253435.

The assessment has found that provided these safeguards are adopted then the road and traffic impacts relating to the Proposal would be acceptable.

5.2 GROUNDWATER

5.2.1 Introduction

The DGRs for the Proposal identified "*Soil and Water*" as a key issue for assessment within the EIS. With respect to groundwater, the DGRs require that the "*EIS include:*

- *a detailed assessment of potential impacts on the quality and quantity of existing groundwater resources, including the impacts on:*
  - *existing user entitlements, affected licensed water users and basic landholder rights;*
  - *groundwater-dependent and riparian ecology; and*
  - *regional water supply infrastructure.*
- *identification of any licensing requirements or other approvals under the Water Act 1912 and/or Water Management Act 2000;*
- *demonstration that water for the construction and operation of the development can be obtained from an appropriately authorised and reliable supply in accordance with the operating rules of any relevant Water Sharing Plan (WSP) or water source embargo; and*
- *a detailed description of the proposed water management system, water monitoring program and other measures to mitigate groundwater impacts.*

Additional matters for consideration in preparing the EIS were also provided in the correspondence attached to the DGRs from the former NSW Office of Water (NOW) now Department of Industry – Crown Lands and Water (CL&W)) and the Environment Protection Authority (EPA) which amongst several more general water impact and assessment related requests included a request for a predictive assessment of the impact of the Proposal on all groundwater sources that includes impacts on connectivity, yield of groundwater, water quality, groundwater dependent ecosystems and existing groundwater users. A consolidated list of the identified requirements relating to groundwater and where each is addressed is presented in **Appendix 2**.

The Applicant sought further advice from DPI-Water (now CL&W) regarding the groundwater assessment in April 2015. The response from DPI-Water (now CL&W) indicated that, as the proposed extraction depth would be below the regional groundwater table, the Proposal would be assessed under the *"Aquifer Interference Policy"* (2012) (AIP). The AIP details the way in which the CL&W assesses aquifer interference projects to determine their potential impacts on water resources. There are three key components of the AIP, namely:

1. all water taken must be properly accounted for;
2. the aquifer interference activity must address Minimal Impact Considerations for any potential impacts on the water table, water pressure levels and water quality; and
3. planning for measures in the event that the actual impacts are greater than predicted including a contingency for monitoring.

Based on the risk assessment undertaken for the Proposal (**Appendix 4**), the potential impacts relating to groundwater and their risk rankings (in parenthesis) after the adoption of pre-existing or standard mitigation measures are as follows.

- Reduction in the volume of water contained within the local aquifer / availability resulting in reduced yields of groundwater bores (low).
- Reduction in base flows / spring flows leading to:
  - reduced discharge to receiving systems (medium);
  - degradation of riparian or aquatic vegetation / ecosystems (low); or
  - reduced availability of water to downstream users (low).
- Reduced availability resulting in the degradation of groundwater dependent ecosystems (low).
- Reduced availability to local users as a result of contamination (low).
- Degradation of groundwater dependent ecosystems due to contamination of groundwater (low).
- Contamination of surface flows (from contaminated recharge) resulting in reduced availability of water to downstream users (low).
- Degradation of riparian or aquatic vegetation / ecosystems due to contamination of surface flows (from contaminated recharge) (low).

The groundwater impact assessment for the Proposal was undertaken by Larry Cook Consulting Pty Ltd. The assessment is presented as Part 2 of the *Specialist Consultants Studies Compendium* and is referred to hereafter as "Cook (2018)". The groundwater assessment included the development of a calibrated transient groundwater flow model prepared by Coffey Geotechnics Pty Ltd, referred throughout this subsection as Coffey (2016), to predict and assess the Proposal with regards to the minimal impact considerations of the AIP. In accordance with the AIP requirements for State Significant Developments, the modelling and the predictions arising from the modelling assessment were independently reviewed by Dr Frans Kalf (Kalf and Associates). This subsection provides a summary of Cook (2018) and Coffey (2016), concentrating on those matters raised in the DGRs, the AIP and related requirements provided by various government agencies.

5.2.2 Existing Hydrogeological Setting

5.2.2.1 Regional Setting

The Site is located on the southwestern edge of the Sydney Basin where the main stratigraphic units also form the major hydrogeological units, namely the Hawkesbury Sandstone (aquifer) which is underlain by the less permeable Berry Formation (aquitard).

The regional hydraulic gradient and direction of groundwater flow parallels the gentle 1.0˚ to 1.5˚ dip to the north-northwest of the Hawkesbury Sandstone sequence.

Groundwater studies and investigations by Larry Cook Consulting in the Hawkesbury Sandstone of the Southern Highlands including the Sutton Forest area and hydrogeological investigations in the broader Sydney basin (McKibben and Smith, 2000) indicate that aquifers hosted by the Hawkesbury Sandstone in the vicinity of the Site are found in two main occurrences.

- Sub-horizontal relatively porous and stacked layers (beds) of sheeted sandstone with increased primary permeability. These primary aquifers provide the main aquifer storage and are characterised by variable yields.
- Pervasive sub-vertical, semi-continuous to continuous, rock defects such as fractures and joints with secondary 'enhanced' permeabilities. These aquifers constitute a major component of the aquifers transmissivity but only a minor component of the aquifer's storage.

5.2.2.2 Local Setting

Water-bearing zones (aquifers) are commonly developed within the Hawkesbury Sandstone in the Southern Highlands at different elevations down to the base of the unit, which is the contact with the underlying Permian Illawarra Coal Measures or the Shoalhaven Group. Registered bores in the Sutton Forest area extract water from aquifers hosted by the Hawkesbury Sandstone. The aquifers are known throughout the sandstone sequence but are more productive in the upper and lower thirds (Lee and Cook, 2005).

The occurrence of 'shallow' groundwater in the form of springs, are commonly developed in the Southern Highlands area. Natural discharge of groundwater from the sandstone aquifer system within and surrounding the Site is mainly via springs and lateral flow to ephemeral watercourses and perennial watercourses such as Long Swamp Creek. The hydrogeological investigations conducted by Cook (2018) identified elevation-controlled springs that discharge into the Long Swamp Creek valley system west, and downstream of the Site. The apparent elevation control of these springs is believed to be associated with the base of the sheeted sandstone beds of the Hawkesbury Sandstone sequence. Spring discharge of local subsurface flow systems is closely related to recharge of precipitation and can show wide fluctuations in flow.

5.2.2.3 The Site

Groundwater occurrences within and immediately surrounding the Site is interpreted as being present as two distinct systems, namely;

- an upper (shallow), perched localised system controlled by the underlying geology (shale or basalt) responsible for elevated spring discharges. Interbeds (or lenses) of shale within the Hawkesbury Sandstone were recorded by Lee (2016) with perching of shallow groundwater likely to occur above this geological unit.
- a deeper, saturated system which was interpreted to be representative of the regional groundwater system that is responsible for base flows to Long Swamp Creek.

5.2.2.3.1 Groundwater Levels and Flow

The direction of groundwater flow on the local scale may be influenced by the gently south plunging anticlinal flexure interpreted beneath the Site by Graham Lee & Associates (Lee, 2016).

Baseline measurements of groundwater levels were collected by Cook between late 2012 and mid 2016 in the network of on-site monitoring bores (see **Figure 5.5**).

In summary, the hydrographs reveal minor fluctuating water levels in all monitoring bores. The water levels recorded in monitoring bores SFQ DDH3, SFQ OH1 and SFQ OH4 fluctuate within an approximate 1.0m range whilst monitoring Bore SFQ OH2 fluctuates over approximately 2.0m. There appears to be broad correlation between fluctuations in water level and rainfall. The water level in monitoring Bore SFQ DDH1 has remained relatively constant until about January 2014 after which a decline over approximately 2.0m was observed with the reason for the decline in the water level difficult to interpret. Ongoing recording of water level measurements and local rainfall observations would provide improved analysis of the association between rainfall and groundwater levels.

The measurements of water levels recorded in the seven monitoring sites are listed in Cook (2018) – Annexure 1. A composite set of hydrographs for the on-site monitoring bores hosting groundwater are provided in **Figure 5.6**.

5.2.2.4 Groundwater Quality

Baseline groundwater sampling and water quality analyses were carried out in three monitoring bores in July 2014 and in eight monitoring bores in March 2016. The objective of the groundwater sampling and water quality analysis was to establish a baseline set of water quality data for the local aquifer systems. The laboratory results are presented in full in Cook (2018). The following provides a general overview of the local groundwater quality.

- The pH levels recorded in two monitoring bores were slightly alkaline whereas the pH levels for the remaining six bores were moderately acidic.
- Measurements of electrical conductivity (EC) levels and laboratory calculation of Total Dissolved Solids (TDS) indicate that the groundwater has low salinity.
- Measurements of dissolved metals concentrations recorded concentrations below guidelines values stated in ANZECC (2000) with the exception of zinc.

5.2.2.5 Aquifer Characteristics

An attempt was made to carry out short-term pumping tests in those monitoring bores with the longest water columns in order to establish a set of representative aquifer parameters including hydraulic conductivity and transmissivity. However, none of these monitoring bores could sustain continuous periods of pumping (>1hr).

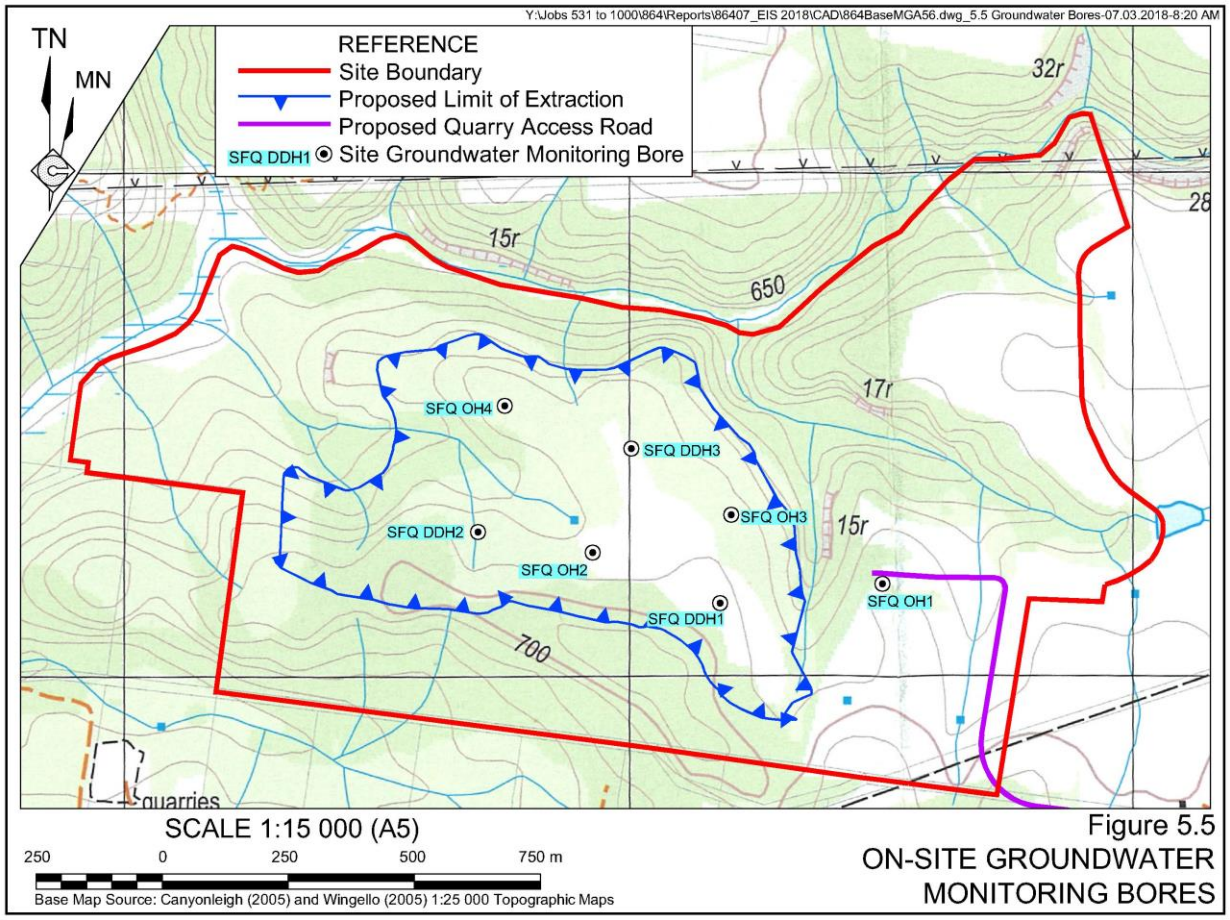
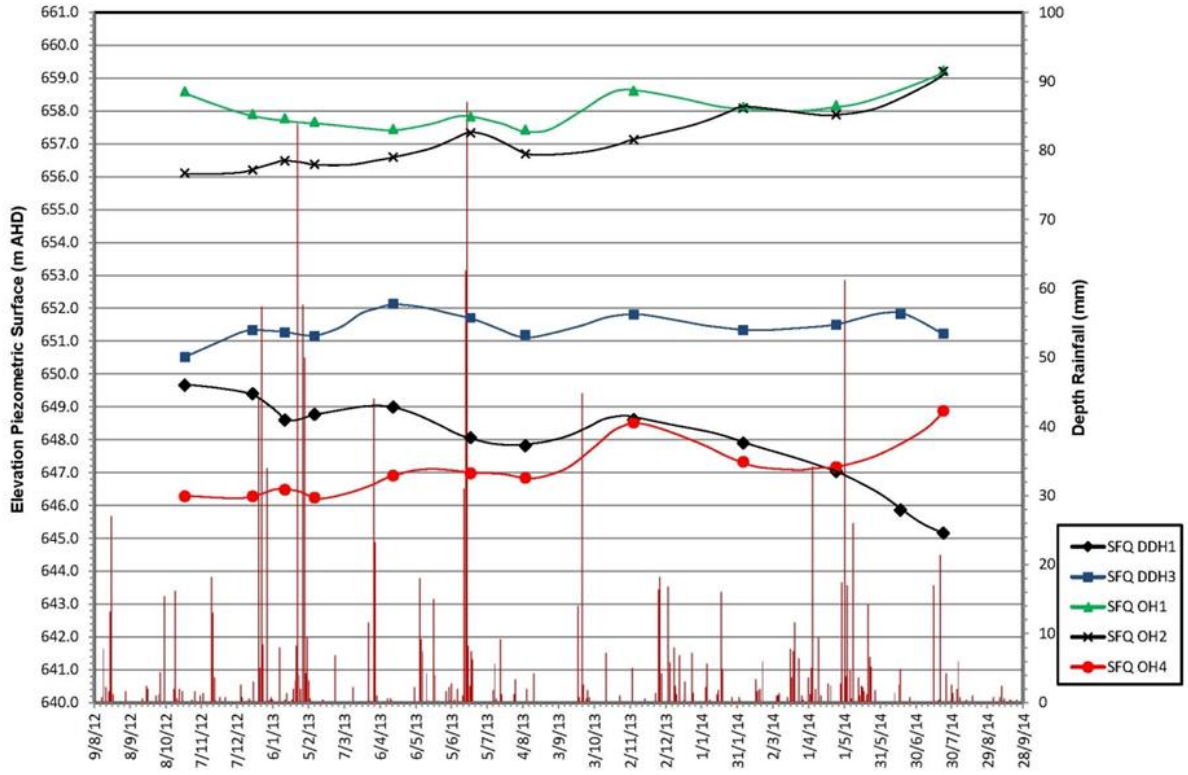


Figure 5.5
ON-SITE GROUNDWATER MONITORING BORES



Source: Cook (2018). Figure 15

Figure 5.6
GROUNDWATER LEVELS

Rising head 'slug' tests were then performed in selected monitoring bores with a sufficient water column to estimate the near-bore hydraulic conductivity. Pumping tests carried out in a local bore GW051450 situated outside of the Site in 2012. Laboratory permeability testing was carried out on three sections of sandstone drill core collected from drill holes SFQ DDH 1 and SFQ DDH 3. The results of the testing and estimates of aquifer characteristics are presented in **Table 5.4**.

Table 5.4
Summary of Hydraulic Conductivity Values Derived from Testing and Analysis

Location		SFQ DDH 1	SFQ OH 2	GW051450 (2006)	GW051450 (2012)	SFQ DDH 3 (26mbgs)	SFQ DDH 3 (35mbgs)
Test	**Method**	**Hydraulic Conductivity (k) (m/day)**					
Slug	Hvorslev	0.49	0.11	–	–	–	–
	Bouwer and Rice	0.33	0.08	–	–	–	–
	KGS	0.35	0.09	–	–	–	–
Pump		–	–	1.63	0.71	–	–
Laboratory permeability		0.04	–	–	–	0.87	0.07
Source: Cook (2018) – Modified after Tables 9, 10 and 16							

The results of the aquifer testing in Bore GW104765, located adjacent to the Site and hosted by the Hawkesbury Sandstone suggests that the near-bore global storativity values are approximately 1×10^{-2} which is consistent with the results of hydrogeological studies conducted in the Sydney metropolitan area and elsewhere by Tametta and Hewitt (2004). The results of these studies indicated a specific yield of between 0.010 and 0.015 that is reasonable for typical, undeformed Hawkesbury Sandstone. A storativity of 1×10^{-2} is adopted in this groundwater assessment.

5.2.2.6 Groundwater Inflows and Outflows

Cook (2018) records that aquifer recharge is primarily by way of excess precipitation (rainfall), particularly the water that infiltrates the vadose (unsaturated) zone and is not lost through evapotranspiration. A review of the Canyonleigh 1:25 000 topographic sheet and knowledge of the occurrence of Hawkesbury Sandstone in the region suggest that the recharge area for sandstone-hosted aquifers in the vicinity of the Site is approximately $22km^2$. However, it is noted that a reduced recharge proportion would apply to areas of Hawkesbury Sandstone presently overlain by Wianamatta Group sedimentary rocks. Based on the results of regional hydrogeological investigations, Coffey (2016) suggests a recharge proportion of 0.4% of rainfall for sandstone overlain by the Wianamatta Group shale. Calibrated recharge rates adopted by Coffey in the numerical groundwater model approximate 3.2% for areas with Hawkesbury Sandstone to 0.4% for areas covered by shale (Ashfield Shale).

Natural discharge of groundwater from the sandstone aquifer systems within and surrounding the Site is mainly via springs and lateral flow to ephemeral watercourses and perennial watercourses such as Long Swamp Creek.

A series of 'water features' which are essentially areas of shallow groundwater discharge have been identified in the region. These are in the main developed where there is a permeability contrast at the contact between more permeable sheeted sandstone overlying less permeable

massive sandstone or where sheeted sandstone overlies shale units. As a result, the water spreads laterally until it intersects the land surface where erosion has lowered the topography to the water's level (e.g., on the side of a gully, hill or valley).

Spring discharge of local subsurface flow systems is closely related to recharge of precipitation and can show wide fluctuations in flow.

Investigations conducted by Cook (2018) identified elevation-controlled springs that discharge into the Long Swamp Creek valley system west, and downstream of the Site. However, the occurrence of sheeted sandstone and steeply dissected valley topography along the Long Swamp Creek valley system bordering the Site to the north suggest that a multitude of elevation-controlled springs may exist but are difficult to locate due to debris covering the slopes and inaccessible country.

The apparent elevation control of these springs is believed to be associated with the base of the more permeable sheeted sandstone beds of the Hawkesbury Sandstone sequence and representative of the localised perched aquifer system.

5.2.2.7 Interaction with Surface Water

The results of the hydrogeological investigations (Cook, 2018) and surface water investigations (SEEC, 2018a) conducted for the Proposal suggests that watercourses within the local area are either ephemeral or perennial. The first order watercourses within and surrounding the Site are all ephemeral, that is, apart from periods following rainfall, they are relatively dry and only flow in response to rainfall runoff. Some watercourses experience flow during only part of the year when runoff triggers flow conditions that are sustained for a longer period due to either the perched or regional water table being sufficiently high to intersect the streambed thus providing the watercourse with base flow for a period of time. The larger watercourses such as Long Swamp Creek are generally permanent watercourses (perennial) as they receive year-round base flow from groundwater.

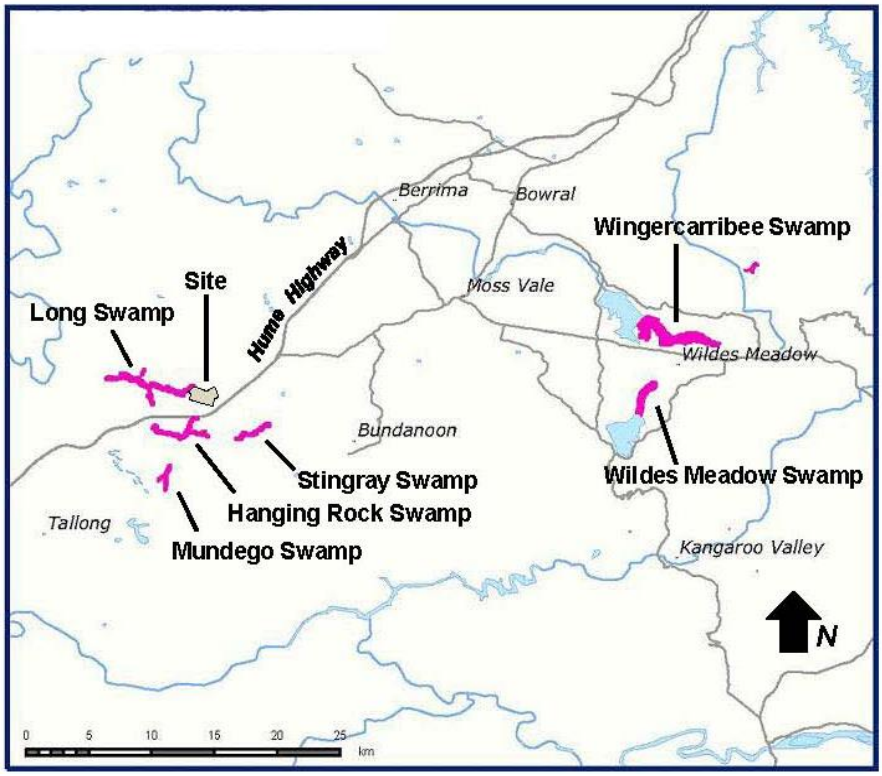
The ephemeral watercourses within and surrounding the Site are losing / disconnected watercourses where the flow decreases in a downstream direction due to infiltration through the channel bed which recharges surrounding sandstone hosted aquifers as the local water table is at a lower elevation than the surface of the watercourse. The higher order watercourses in the area such as Long Swamp Creek are considered to be gaining/connected watercourses where groundwater continually enters into the stream as the channel bed is at a lower elevation than the regional water table.

It should be noted that hydrologic conditions are dynamic and watercourses may temporarily change from being 'gaining' to 'losing' systems. Equally, watercourses can be 'gaining watercourses' along one segment of their length and 'losing' watercourses' along another part depending on their relationship to the water table at those points.

5.2.3 Groundwater Dependent Ecosystems

The hydrology and hydrodynamics of groundwater dependent ecosystems (GDEs) is complex. The New South Wales State *Groundwater Dependent Ecosystems Policy* (NSW Government 2002) identifies four types of GDEs in New South Wales which are supported by five broad

types of aquifers (groundwater systems). The dominant type of GDE identified within the southern highlands is Temperate Highland Peat Swamps Developed on Sandstone such as Long Swamp, in particular within natural depressions or along watercourses such as Long Swamp, Hanging Rock Swamp and Stingray Swamp. Other swamps in the southern highlands include Wingecarribee and Wildes Meadow Swamp. **Figure 5.7** displays the location of each of these swamps.



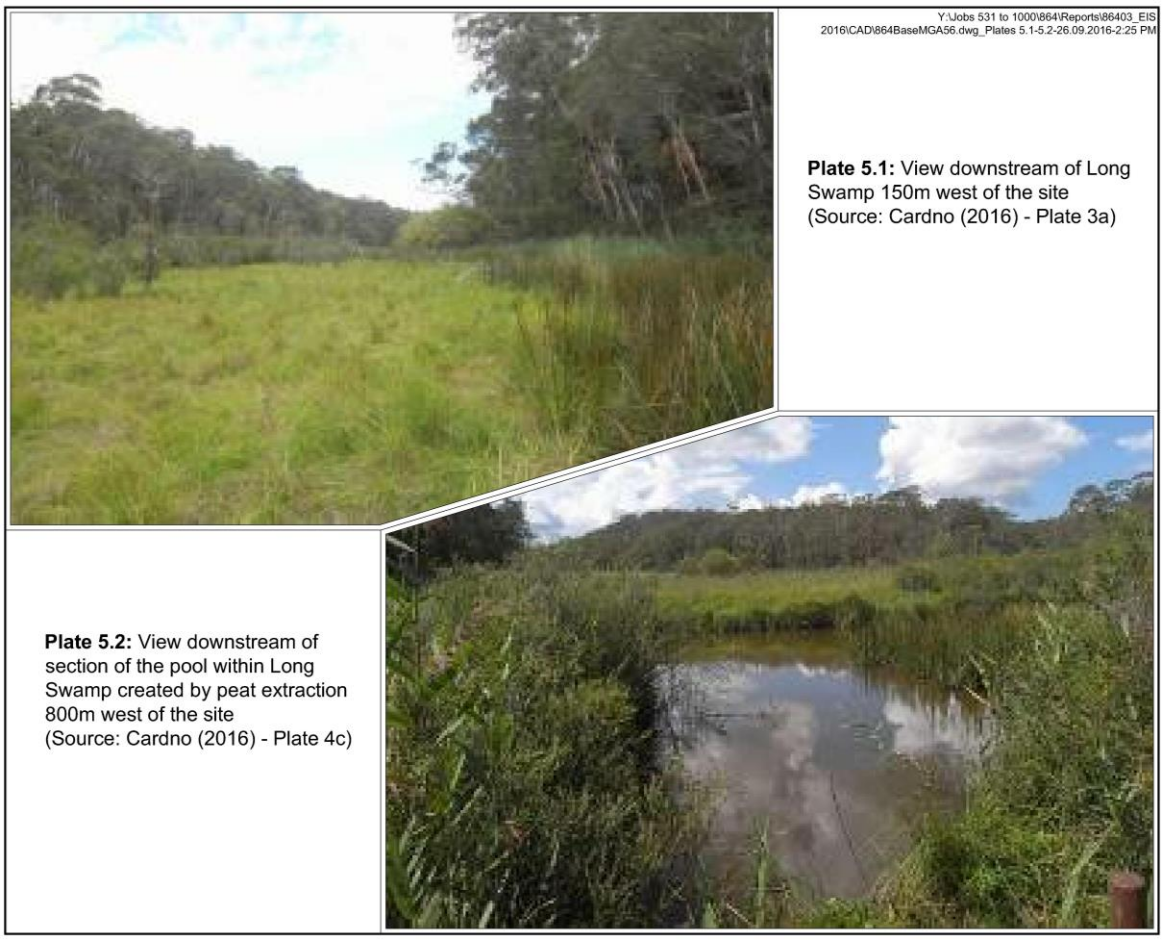
Source: OEH (2004)

Figure 5.7
INDICATIVE LOCATIONS OF TEMPERATE HIGHLAND PEAT SWAMPS

Three GDEs are present within 5km of the proposed extraction area, namely Long Swamp approximately 0.4km north and west of the extraction area, Hanging Rock Swamp approximately 2km to the south and Stingray Swamp located approximately 4.5km southeast of the Site in the eastern section of Penrose State Forest.

Long Swamp is located within the Long Swamp Creek system downstream of the Site and extending for approximately 5km along Long Swamp Creek (Cardno, 2018). A field investigation of the reach of Long Swamp Creek in the vicinity of the Site was conducted as part of the aquatic ecology assessment for the Proposal (Cardno, 2018). The investigation identified that Long Swamp is discontinuous in sections of Long Swamp Creek to the north of the Site and only becomes contiguous west of the Site.

The field investigation also identified evidence of modifications to the environment in the local area (and region) from in excess of 100 years of agricultural pursuits (clearing, soil improvements and cropping), grazing and sand and peat extraction. Extraction of peat in some Temperate Highland Peat Swamps such as Long Swamp Creek has caused localised changes in those areas through the creation of open water bodies. **Plates 5.1** and **5.2** display sections of Long Swamp west of the Site.



5.2.4 Current Groundwater Usage

A district search for data and information for registered groundwater bores held by CL&W (formerly the New South Wales Office of Water (NOW)) in their computerised database revealed the existence of 43 registered bores within a 24km^2 search area centred on the Site. The area was selected to cover areas of potential impacts from the proposed extraction operations on neighbouring water users. The locations of the registered bores including those within the Site are shown in **Figure 5.8**.

The majority of registered bores intersect aquifers at various elevations within the Hawkesbury Sandstone. The bores were drilled to depths of between 23m and 204m with five of these bores drilled to depths greater than 100m. The main use of the groundwater is stock and domestic under basic rights licences. Twelve of these registered bores are licensed under the Greater Metropolitan Region Groundwater Sources (Nepean Management Zone 1) Water Sharing Plan (WSP) for industrial and/or irrigation (such as those associated with Coca-Cola Amatil's bottling operations). Water allocations (entitlements) for the industrial and/or irrigation bores range from 19 to 120 share components (one share component representing a specified volumetric unit, in this assessment share components are referred to as 1ML). The majority of the groundwater extraction licences within the search area are for bulk mineral water and attached to properties adjacent to Hanging Rock Road. These properties are situated on the southern side of the Long Swamp Creek valley system area over 1km down hydraulic gradient from the proposed extraction area.

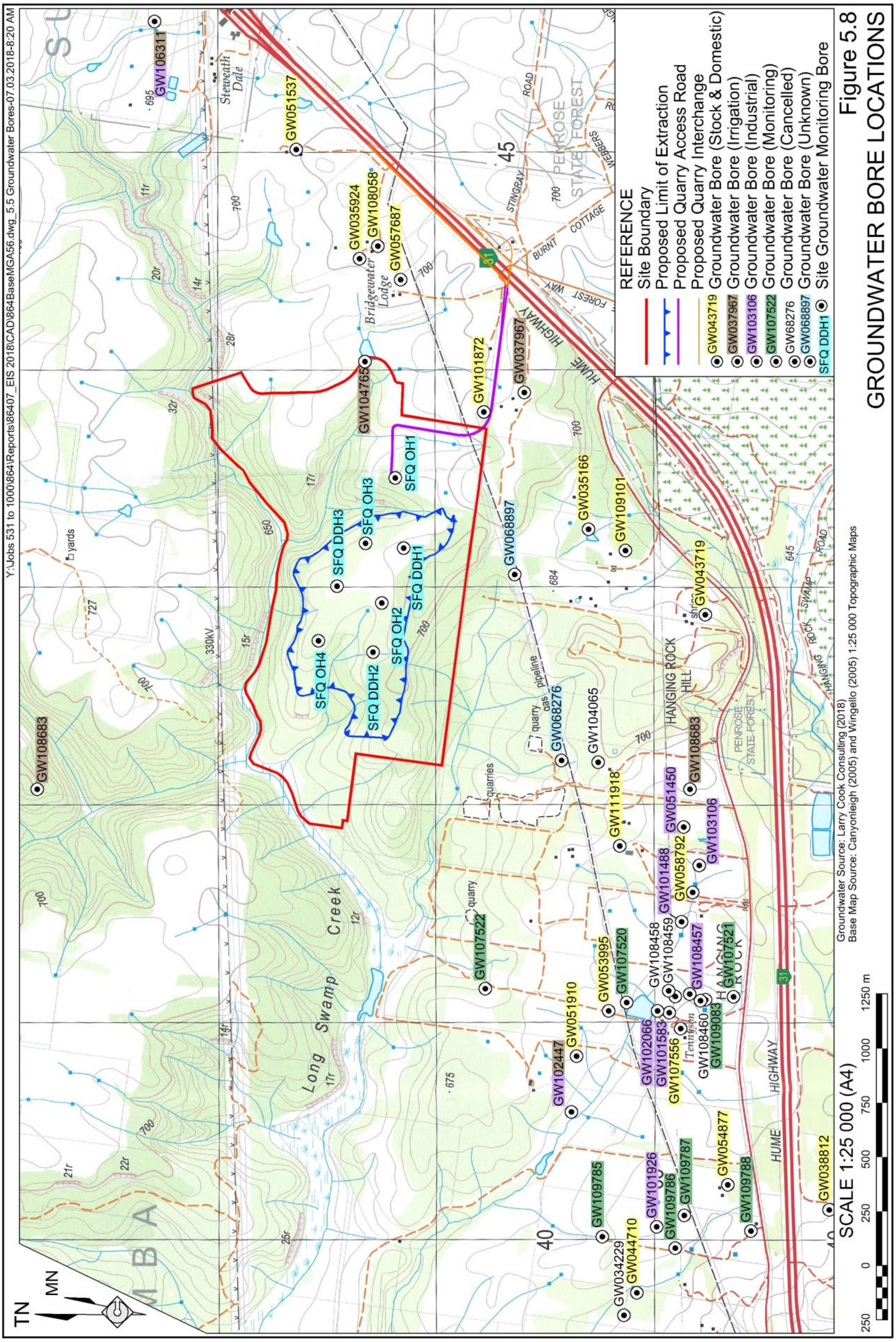


Figure 5.8
GROUNDWATER BORE LOCATIONS

Three high volume extraction licences are located up hydraulic gradient from the Site.

- GW104765, located on the Site with an annual allocation of 45ML.
- GW106311, located 2.3km northeast of the Site with an annual allocation of 30ML.
- GW037967, located 600m southeast of the Site with an annual allocation of 19ML.

It is noted that Cook (2018) conducted aquifer performance testing at bore GW104765 and estimated an aggregate long term safe yield of 2.1L/s for the bore which equates to annual groundwater production of approximately 67ML/yr, a level higher than the licenced allocation.

5.2.5 Potential Impacts

Potential impacts may include impacts to water supply bores, GDEs and culturally significant sites that are dependent on groundwater. The impact assessment criteria have been developed for a range of groundwater sources and whether they fall into a highly productive or less productive category as defined for each WSP area. Highly productive groundwater sources are those meeting the criteria of 1 500mg/L total dissolved solids (TDS) and a bore yield rate of greater than 5L/s. Thresholds for minimal impact considerations have been developed for the AIP and relate to impacts on groundwater table and pressure, and to groundwater and surface water quality.

Five potential impacts associated with the Proposal are listed below and discussed in the following sections.

- Local and regional groundwater system
- Local groundwater users
- Local creek flow
- Groundwater chemistry
- Groundwater dependent ecosystems (GDEs).

5.2.6 Groundwater Modelling Assessment

5.2.6.1 Introduction

The potential local and regional impacts of the Proposal on the groundwater environment, local groundwater users, local surface water systems and GDEs have been assessed with the aid of a calibrated transient groundwater flow model. Coffey (2016) developed a calibrated groundwater model to run predictive simulations covering 45 years of extraction followed by 20 years of recovery in order to assess the groundwater impacts.

The main aims of the modelling assessment were to develop a three-dimensional groundwater flow model to assess:

- the amount of groundwater drawdown at neighbouring groundwater bores and GDEs due to the extraction operations;

- groundwater inflow to the extraction area; and
- the post-extraction groundwater regime and long-term impacts.

This subsection reviews the design of the groundwater model and the predicted groundwater flow rates into and from the extraction area, potential changes to groundwater levels and long term groundwater occurrences.

5.2.6.2 Groundwater Model Design

The conceptual groundwater model is a simplified representation of the groundwater system, identifying the most important geological units and hydrogeological processes, while acknowledging that the actual system may be hydrogeologically and geologically more complex. The conceptual model forms the basis for the numerical groundwater flow model.

5.2.6.3 Model Domain and Boundary Conditions

A regional transient groundwater flow model was developed by Coffey (2016) to simulate extraction and any potential impacts on the local groundwater system as a consequence using the Modflow-Surfact modelling code. The active model area and boundary conditions are shown in **Figure 5.9** (referred to as the "numerical Model Boundary") and covers an area of approximately 32km^2 with approximate dimensions 9km east-west by 7km north-south. The physical model boundary follows natural features and is of sufficient coverage to significantly minimise the effect of drawdown on them attributable to sand extraction.

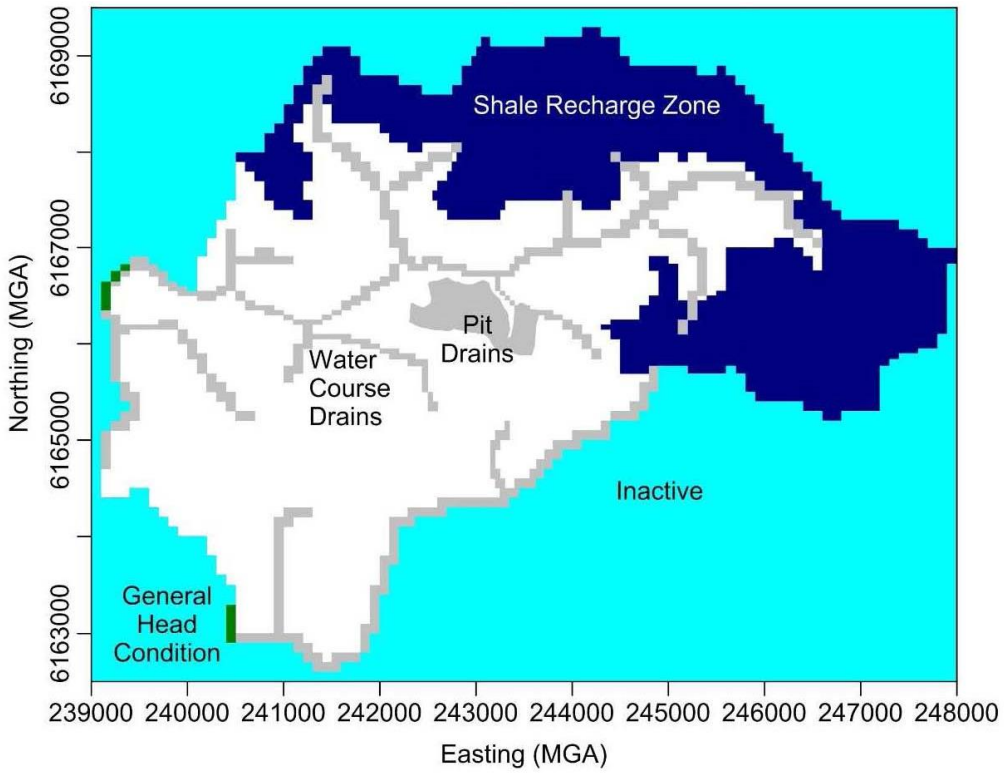


Figure 5.9
GROUNDWATER MODELLING ASSESSMENT
MODEL DOMAIN AND BOUNDARY CONDITIONS

Source: Coffey (2016) – Figure 5.4

5.2.6.4 Recharge

For the purposes of the groundwater modelling assessment, the dominant recharge process incorporated into the model is rainfall infiltration. A distinction is made between the recharge zones above areas of shale (and basalt) outcrop and outcrop of Hawkesbury Sandstone.

5.2.6.5 Discharge

Discharge of groundwater from the sandstone aquifer would occur via the following processes.

- Lateral flow (baseflow discharge) to ephemeral watercourses and any perennial watercourses such as Long Swamp Creek. Coffey (2016) assumed that, based on the available data, the lower lying watercourses (generally below 630m AHD) are perennial and watercourses at higher elevations are ephemeral.
- Evapotranspiration by vegetation with sufficient root depth and evapotranspiration in the unsaturated zone, in zones with shallow perched water tables, at escarpments, and in forested areas. Evapotranspiration was not explicitly simulated in the model but was accounted for in the recharge rate.
- Groundwater abstraction from surrounding pumping bores, including the bores on Lot 4, i.e. bores GW101872 and GW104765. The ten registered bores identified within a 2.5km radius of the proposed extraction area that have licensed water allocations were incorporated in the groundwater model using a long-term pumping rate commencing at 67% of the annual allocation.
- During extraction at elevations below the regional water table, discharge would also occur via groundwater inflow to the extraction area and consumption of groundwater from evaporation (from the exposed extraction faces).

5.2.6.6 Predictive Model Simulation Scenarios

Two predictive scenarios were simulated using the calibrated groundwater model.

- **Extraction inactive (base case)**. This scenario provides changes in the hydraulic head field with the absence of extraction operations and allows calculation of impacts due to extraction operations only.
- **Extraction active (developed case)**. This scenario provides drawdowns and inflows in the presence of extraction operations.

Private pumping was active in both scenarios at the same rates modelled for the calibrated base case.

5.2.7 Mitigation Measures

5.2.7.1 Introduction

The Applicant would adopt an integrated strategy to manage all water sources for the Proposal in recognition of the important and dynamic interrelationship between surface water and groundwater systems. Such a strategy would include a program that would monitor the groundwater and surface water systems.

5.2.7.2 Groundwater Supply

The Applicant holds an agreement for the supply of water from Bore GW104765 immediately adjacent to the Site. The current water allocation for the Site Bore (GW104765) is 45ML. This allocation is attached to Water Access Licence WAL25051 for the purpose of irrigation. Condition 3 of the licence restricts the pumping rate to less than 2.0L/s, a level that Cook (2018) has confirmed can be sustained. The results of the safe yield analysis undertaken by Cook (2018) indicated that bore GW104765 is capable of sustaining a pump rate of 2.1L/second which equates to annual groundwater production of approximately 67.2ML.

Subject to the receipt of development consent, the Applicant would apply to CL&W for a change of purpose for WAL25051 from 'irrigation' to 'industrial' under the *Water Management Act 2000*. However, an additional water supply would likely be required to satisfy the Site water demand during periods of low rainfall and to account for the average 51ML/year groundwater inflow into the extraction area. In order to meet the licensing requirements for the Proposal, the Applicant has acquired additional groundwater allocations within the area covered by the Greater Metropolitan Region Groundwater Sources (Nepean Management Zone 1) Water Sharing Plan.

The Applicant has also commenced discussions with Goulburn Mulwaree City Council regarding access to the water from the Wingecarribee to Goulburn water supply pipeline (see Section 4.7), i.e. as a contingency water supply, if required.

Subsequently the evaluation of groundwater and commercial supply arrangements in order to meet the water supply requirements of the Proposal is ongoing.

5.2.8 Assessment of Impacts

5.2.8.1 Predictive Model Simulation Scenario Results

The results of the predictive model simulations are as follows.

- Long Swamp Creek receives baseflow of 2.01ML/day in the base case model scenario.
- The developed case model scenario, with the high volume production bores active, once extraction occurs below 665m AHD (Stage 2), groundwater inflow the extraction area would average daily 0.14ML/day with the maximum inflow to the extraction area being 0.2ML/day in Stage 6.
- The modelled inflow from the regional groundwater system to the extraction area would be approximately 2332ML over the 45 years (average 51ML/year) of operation modelled for the developed case.
- Extraction operations would remove the local, perched system in the immediate vicinity and drain the surrounding system at an average rate of approximately 0.004ML/day in the developed case.

- In the developed case model scenario, groundwater inflow to the extraction area would cause a maximum reduction in baseflow to Long Swamp Creek system of 0.052ML/day. Coffey (2016) predicts that this maximum reduction in baseflow to the Long Swamp Creek system represents approximately 2.6% of the average annual baseflow in the base case scenario.
- The developed case model generates an asymmetrical cone of depression surrounding the Site from the inflow of groundwater into the progressively expanding extraction area which extends for a distance up to approximately 1km to the south and up to 750m to the east. The modelled contour of 0.2m drawdown of the regional water table (due to extraction operations) extends a maximum of about 1km from the extraction area at the end of Stage 5 (Year 28) and about 1.2km at the end of Stage 7 (end of extraction operations, Year 45).
- The developed case model predicted a maximum drawdown of the regional water table, at the end of extraction operations (Year 45) at each private bore of less than 0.5m, i.e. well below the 2m depth nominated as the maximum permissible under the Aquifer Interference Policy. This amount of drawdown for the four closest private bores, as a proportion of available drawdown is less than 1.5%.

The drawdown of the local groundwater system in Year 28, predicted by the developed case model of the Proposal is shown in **Figure 5.10**.

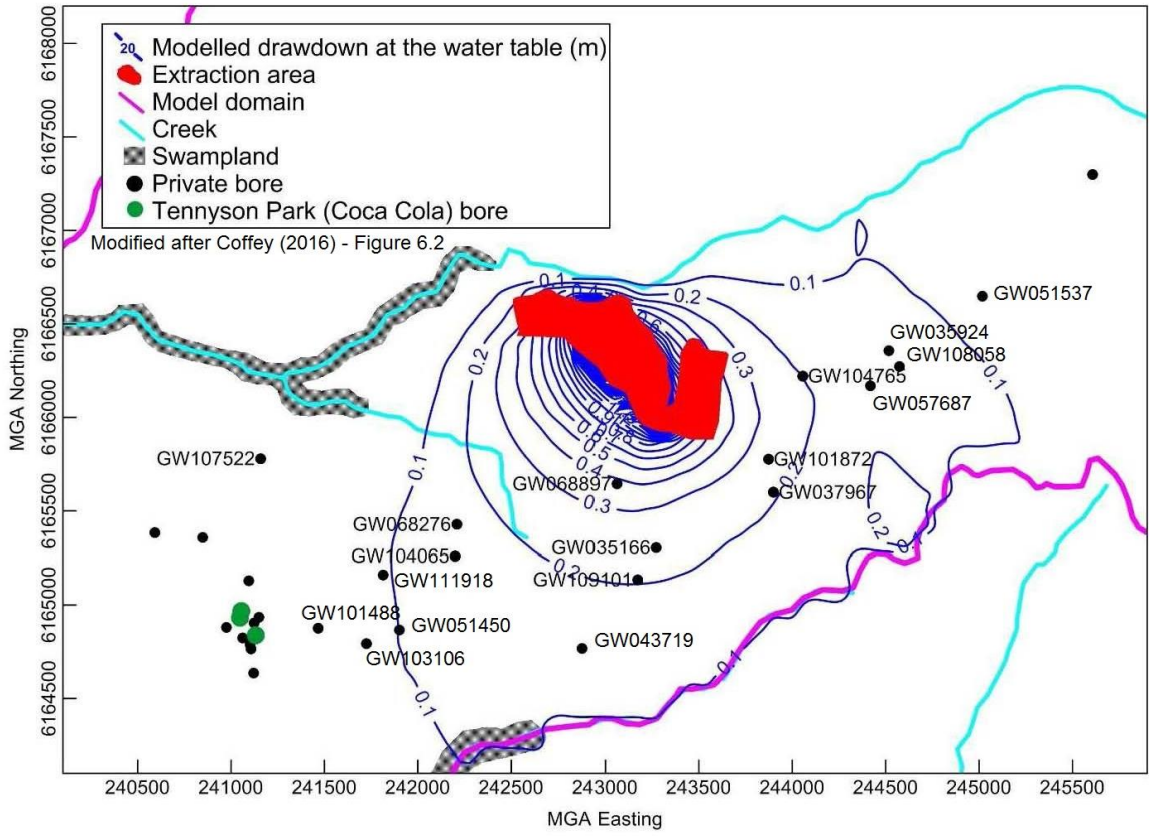


Figure 5.10
Source: Coffey (2016) – Figure 6.2 **PREDICTED GROUNDWATER DRAWDOWN – YEAR 28**

5.2.8.2 Predicted Post-Extraction Groundwater Regime

As a result of backfilling, the final landform topography beyond Year 45 would slope from south to north, in the direction of groundwater flow. Groundwater discharge from the backfill in the extraction area, calculated by Coffey (2016) as being 0.002ML/day, would likely be consumed by evapotranspiration before discharging to the surrounding watercourses.

The model predicts that periodically, in response to significant rainfall recharge events, the localised standing water level within the backfilled void would potentially intersect the ground surface elevation and this may lead to minor surface flow events.

5.2.8.3 Groundwater Dependent Ecosystems

The active extraction transient computer groundwater model scenario predicts a maximum baseflow reduction of 0.052ML/day in Long Swamp Creek and Long Swamp over the 45 years of extraction. This equates to a reduction for Long Swamp Creek and Long Swamp of 2.6% of the modelled baseflow. This reduction in baseflow is considered to be within the range of natural variation in flows for this type of GDE.

In addition, the active extraction groundwater modelling scenario also predicts maximum drawdown of the regional water table at the eastern end of Long Swamp of less than 0.1m at the end of Stage 5 – Year 28 and the same prediction at the end of Stage 7, i.e. in Year 45.

5.2.8.4 Groundwater Availability

Calculations of the make-up water required to satisfy the water demands of the sand processing operations and dust suppression for the Proposal indicate that approximately 33ML per annum may be required in 50% of years to supplement water supplied under harvestable rights. These requirements could be met using either the allocation attached to licensed bore GW104765 (45ML/year), subject to CL&W approval or via commercial water supply arrangements. The transient groundwater modelling assessment incorporated the utilisation of annual bore allocations which commenced at 67% of the annual allocation of the surrounding production bores, including bore GW104765 to predict impacts on the local water table associated with the extraction operation.

Safe yield analyses by Cook (2018) calculated using field data collected from aquifer performance testing at bore GW104765 indicate that the bore is capable of sustaining abstraction rates of 2.1L/second.

Based on the results of the groundwater modelling assessment and the safe yield analysis calculated using aquifer performance testing data from bore GW104765, the pumping of volumes greater than 67% of the current licence allocation for bore GW104765 would not result in additional impacts on the groundwater system.

5.2.8.5 Groundwater Quality

Any groundwater inflow into the extraction area is predicted to be low salinity, non-toxic and effectively diluted by rainwater. That is, the chemistry of any residual water retained in the final void would have similar characteristics to that of rainwater.

5.2.9 Monitoring

The Applicant proposes to implement a long-term program of regular water level measurements (automatic and manual readings) and water quality sampling. The key objective of the program would be to collect sufficient hydrogeological data to adequately identify the extent of impacts (if any) on the regional groundwater table and groundwater chemistry. It is recognised that some monitoring bores would be removed from the network as a consequence of extraction operations (see **Figure 5.8**) and that this would require the approved installation of additional monitoring bores outside (but adjacent to) the extraction area. The monitoring program would include the following.

- Collection and analysis of water level data in monitoring bores and the immediate surrounding production bores to assess the changes to water levels and compare as predicted by the transient computer groundwater model. This monitoring would also record the extent of pumping undertaken during the period prior to collection of monitoring data from production bores.
- Collection and analysis of groundwater quality data in the monitoring bore network would be carried out on a quarterly (3 monthly) basis for an initial period of 24 months to verify baseline groundwater quality and establish any natural variation.
- Collection and collation of rainfall data.

It is proposed that baseline water level data would also be used to inform management actions in the event that a departure from predicted groundwater levels occurs.

It is noted that measurements of water level are currently collected using automated water level sensors/data loggers and recorders (with telemetry) in six on-site monitoring bores with the data being downloaded on a weekly basis.

At this stage, with available monitoring data, it is considered premature to establish a set of absolute water levels, bore yield or water quality trigger values that if 'exceeded' may require further investigation. The results of the Coffey (2016) numerical groundwater modelling assessment indicate that no impacts on the regional water table would occur within the first three years of extraction. This timeframe would allow for collection and assessment of further water level and water quality monitoring data from the monitoring bore network and development of meaningful trigger levels. Numeric ranges, based on collected data would be established that take into account, natural variability and fluctuations in climate and rainfall, and possible artificial changes induced by pumping from the network of existing district and neighbouring bores.

The development of a set of trigger levels is considered an important component of on-going long-term assessment of any potential impacts from extraction operations on the regional groundwater systems and environment.

In the event that the established trigger water levels in monitoring bores are 'exceeded' and an impact is indicated, action would include an assessment of rainfall data and water level fluctuations in other monitoring bores to establish trends and ascertain whether there is a correlation or otherwise with activities associated with the Proposal.

The approach to the adoption of any additional mitigation measures would depend on the degree of fluctuations in water levels in the monitoring bores, and the assessment of the significance of any impacts. Additional mitigation measures may need to be developed depending on the nature and degree of any impacts that may be revealed at the end of the review stages.

5.2.10 Conclusions

The results of the transient computer groundwater modelling assessment indicate the following.

- The regional water table would not be intersected until extraction operations reach 665m AHD, i.e. within the third year of extraction within the processing and stockpiling area (Stage 0) and about Year 5 (Stage 2).
- The total groundwater inflow to the extraction area void over 45 years is estimated to be about 2332ML. This equates to approximately 0.14ML/day on average (51ML per year).
- The developed case groundwater model predicts a cone of depression surrounding the extraction area would extend a maximum of about 1km from the extraction area at the end of Stage 5 (Year 28) and about 1.2km at the end of Stage 7 (end of extraction operations, Year 45).
- The developed case groundwater model predicts the maximum drawdown of the regional water table at the end of extraction operations (Year 45) at each private bore would be less than 0.5m. This is within the limits set in the NSW Aquifer Interference Policy, i.e. <2m drawdown.
- The long-term average groundwater discharge from the backfill in the extraction area is calculated as 0.002ML/day.
- The developed case groundwater model predicts a maximum reduction of 0.052ML/day in baseflow to Long Swamp Creek over the 45 years of extraction which equates to of 2.6% of the calculated average annual baseflow. This baseflow reduction is considered to be a minimal impact and within the range of natural variation in flows for this type of GDE.
- The developed case groundwater model predicts the maximum drawdown of the water table at the eastern end of Long Swamp to be less than 0.1m at the end of Stage 5 - Year 28 and the same prediction at the end of Stage 7 – Year 45. This amount of drawdown is not considered significant and is within the range of natural variation.
- Supplementary water supply could be sourced from Bore GW104765 and would not result in any additional impacts on the groundwater system.
- A safe yield assessment of Bore GW104765, based on aquifer performance testing, suggests that the aquifer can sustain pumping at a rate of 2.1L/second which equates to a maximum yield of 67.2ML/year.

- Additional water allocations would be required to account for the average 51ML/year groundwater inflow into the extraction area predicted by the developed case groundwater model.
- Regular monitoring of water levels (and water quality) in the network of on-site monitoring bores and selected off-site private bores during the life of the Proposal would provide valuable real-time data to assess the amount and degree of any impacts and enable comparison against transient groundwater model predictions.

5.3 SURFACE WATER

5.3.1 Introduction

The DGRs for the Proposal identified "*Soil and Water*" as a key issue requiring that the "*EIS include:*

- *a detailed assessment of potential impacts on the quality and quantity of existing surface and groundwater resources, including the impacts on:*
  - *existing user entitlements, affected licensed water users and basic landholder rights;*
  - *groundwater-dependent and riparian ecology; and*
  - *regional water supply infrastructure.*
- *detailed site water balance, including a description of site water demands, water disposal methods (inclusive of volume and frequency of any water discharges), water supply infrastructure and water storage structures;*
- *identification of any licensing requirements or other approvals under the Water Act 1912 and/or Water Management Act 2000;*
- *demonstration that water for the construction and operation of the development can be obtained from an appropriately authorised and reliable supply in accordance with the operating rules of any relevant Water Sharing Plan (WSP) or water source embargo; and*
- *a detailed description of the proposed water management system, water monitoring program and other measures to mitigate surface and groundwater impacts.*

Additional matters for consideration in preparing the EIS were also provided in the correspondence attached to the DGRs from the former NSW Office of Water (NOW) now Department of Industry – Crown Lands and Water (CL&W)) and the Environment Protection Authority (EPA) which amongst several more general water impact and assessment related requests included a request for a predictive assessment of the impact of the Proposal on all groundwater sources that includes impacts on connectivity, yield of groundwater, water quality, groundwater dependent ecosystems and existing groundwater users. A consolidated list of the identified requirements relating to groundwater and where each is addressed is presented in **Appendix 2**.

Based on the risk assessment undertaken for the Proposal (**Appendix 4**), the potential impacts relating to surface water and their risk rankings (in parenthesis) after the adoption of pre-existing or standard mitigation measures are as follows.

- Reduced flows to Long Swamp Creek (medium).
- Reduced availability of water to downstream users (low).
- Reduced volume of water available to local flora and fauna resulting in:
  - stress and possible reduction in viability of native vegetation (low); or
  - degradation of riparian or aquatic vegetation / ecosystems (medium).

- Discharge of dirty or contaminated water resulting in:
  - temporary sedimentation or hydrocarbon pollution of downstream waters (medium);
  - ongoing sedimentation or major hydrocarbon pollution event impacting on aquatic ecosystem for medium to long term (medium);
  - reduced potential for future land uses (low);
  - health-related impacts (people) due to consumption of contaminated water (low);
  - pollution of local waterways resulting in detrimental effects to flora and fauna (medium); and
  - health-related impacts (stock) due to consumption of contaminated water (low).
- Soil erosion and loss of agriculturally productive capacity (medium).
- Erosion causing decreased availability of soil for rehabilitation (medium).

The surface water impact assessment for the Proposal was undertaken by Strategic Environmental and Engineering Consulting Pty Ltd (SEEC). The assessment is presented as Part 3 of the *Specialist Consultants Studies Compendium* and is referred to hereafter as "SEEC (2018a)". This subsection of the EIS provides a summary of the surface water impact assessment, concentrating on those matters raised in the DGRs and related requirements provided by various government agencies.

5.3.2 The Existing Environment

5.3.2.1 Surface Water Catchments

The Site is located within the wider Hawkesbury-Nepean Catchment. Runoff from the Site flows into Long Swamp Creek, a tributary of the Paddys River. Paddys River in turn flows into the Wollondilly River approximately 2km downstream from its intersection with Long Swamp Creek. The Wollondilly River flows into the Warragamba Dam, the key water supply dam for Sydney's drinking water.

Figure 5.11 displays the local drainage and surface water catchments surrounding the Site including Long Swamp, Long Swamp Creek, Stingray Swamp and Hanging Rock Swamp.

5.3.2.2 Site Rainfall

High-quality, extended-duration rainfall data was obtained from a number of nearby Bureau of Meteorology (BoM) Weather Stations to develop a composited daily rainfall dataset since 1945. The data which was used for surface water balance modelling is summarised in **Table 5.5**.

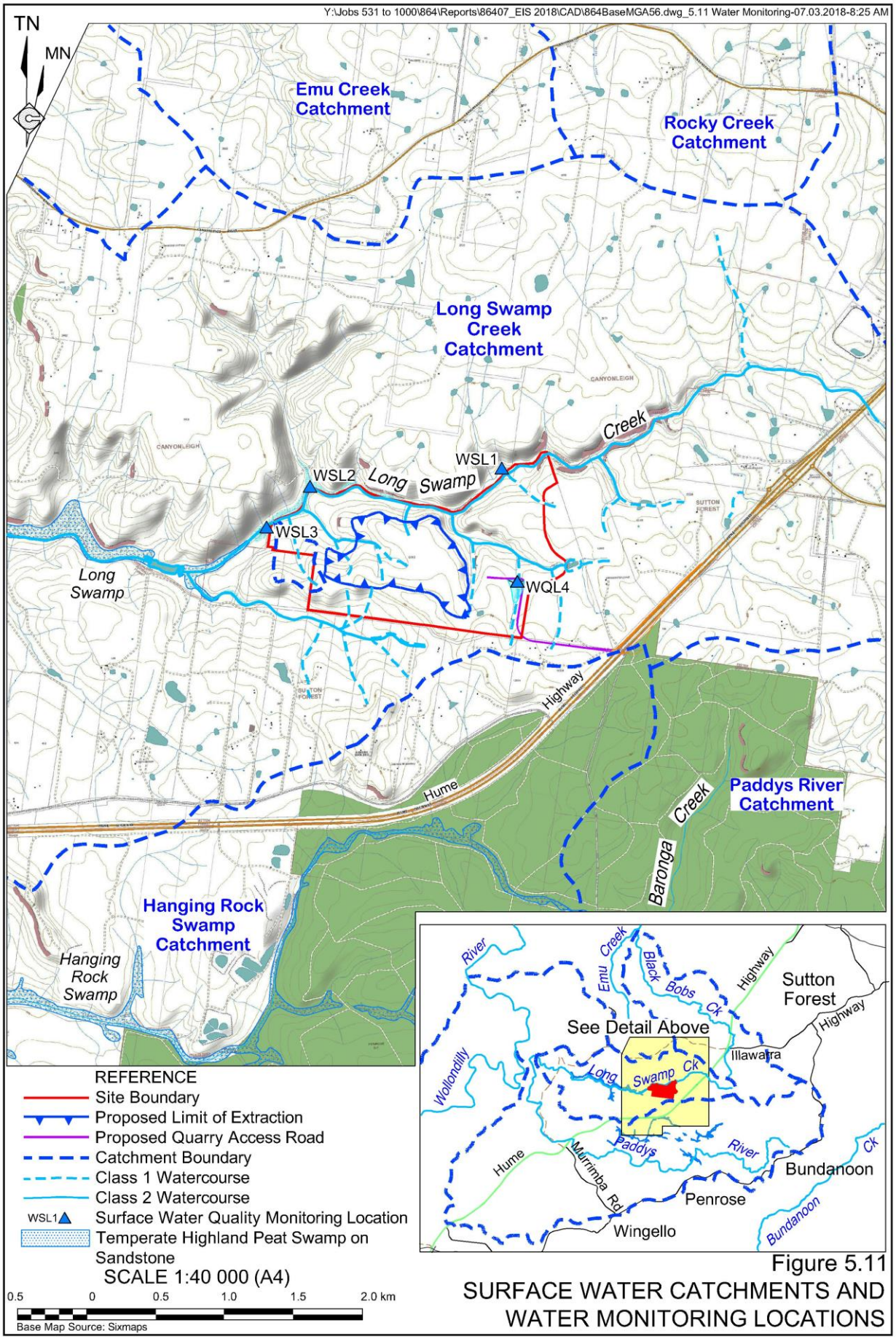


Figure 5.11
SURFACE WATER CATCHMENTS AND WATER MONITORING LOCATIONS

Table 5.5
Rainfall and Potential Evapotranspiration Statistics

	Statistics (mm)						
	Mean	**Median**	**Maximum**	**Minimum**	**10%ile**	**90%ile**	**Mean Annual**
Rainfall (daily steps)	2.47	0	170.8	0	0	6.8	902
Areal Potential Evapo-transpiration (PET) (mm/day)	3.19	2.76	5.23	1.26	1.28	5.11	1167
Source: SEEC (2018a) – Table 4							

5.3.2.3 Surface Water Runoff

The most accurate method of estimating the mean surface water volumetric runoff coefficient (C_v, the percentage of rainfall that flows off a natural site as surface flow) is to use calibrated data from nearby or similar catchments (Boughton, 2003). Unfortunately, there are no monitoring stations on the receiving waters and none within an appropriately close proximity. However, given the Site's topographic location, and the soil landscapes present, the estimated C_v in all areas of the Site is 0.08.

Therefore, for most of the existing Site, approximately 8% of incident rainfall would become surface runoff and it is assumed that the remainder would be lost to evapotranspiration or infiltrated to groundwater. Of these, the former is predicted to be the most significant due to the presence of the existing vegetation cover over the bulk of the Site.

The C_{10} runoff coefficient (10-year storm-flow runoff coefficient) for natural lands in this location is 0.6 (Institute of Engineers Australia, 2003).

The estimated mean annual flow in Long Swamp Creek at WQL3 (**Figure 5.11**) that is attributable to surface water runoff is approximately 2 050ML/year. This is calculated from an overall upstream catchment of 19km^2, a mean rainfall of 902mm/year and an overall C_v of 0.12. The actual flows in Long Swamp Creek at WQL3 would be higher due to groundwater inputs. Based upon the detailed groundwater modelling undertaken for the Proposal, Coffey (2016) estimates the groundwater inflows throughout the catchment would be approximately 733ML/year which equates to an overall annual flow budget of approximately 2 783ML/year for Long Swamp Creek at WQL3.

5.3.2.4 Site Drainage

The proposed extraction area lies immediately to the north of a prominent ridge which lies between two watercourses, namely Long Swamp Creek to the north of the Site and Watercourse D to the south of the Site which in turn drains into Long Swamp Creek to the west of the Site. A small section of the proposed Quarry Interchange would be situated in the catchment of Hanging Rock Swamp, however, no watercourses are mapped in the vicinity of the proposed Quarry Interchange.

The proposed extraction area lies within an elevated area (with respect to the surrounding watercourses) and as such contains mainly first order and two second order watercourses (see **Figure 5.11**). The proposed water storage dams are located on first order watercourses that flow into Watercourse A (see **Figure 2.1**) and then northwards to Long Swamp Creek. The proposed Quarry Access Road crosses one of these first order watercourses via the embankment of Water Storage Dam A.

All watercourses within the Site are identified as intermittent (i.e. not perennial) streams on the Canyonleigh 1:25 000 topographic map.

However, Long Swamp Creek has a significant catchment and it is also fed by groundwater base flow. Therefore, it is anticipated that Long Swamp Creek would flow for the majority of the year.

There are no existing dams in the extraction area, and only one small (approximately 1ML) dam within the boundary of the Quarry Operations Area. The dam's location, together with others on adjoining lands, are shown in **Figure 5.11**. The total estimated volume of existing dams within the Site boundary is, therefore, 1ML.

5.3.2.5 Water Quality

Three water quality testing locations were established on Long Swamp Creek during the compilation of the Surface Water Assessment. **Figure 5.11** identifies these locations.

Two rounds of water quality, i.e. sampling and testing were undertaken during the preparation of this Surface Water Assessment in August 2013 and March/April 2014. The results of the water quality testing are presented in **Table 5.6.** These results show that water quality in Long Swamp Creek is mostly consistent with the ANZECC (2000) guidelines. Waters are not saline and there are no exceedances of the ANZECC Toxicity Triggers. However, some variance from the Stress Indicators in ANZECC (2000) guidelines was identified as follows.

- pH values lower than 6.5 in March/April 2014.
- Dissolved Oxygen levels were significantly lower than 90% on both occasions.

Total Nitrogen concentrations were higher than 250µg/L on both occasions.

Table 5.6
Water Quality Test Results Including Stress Indicators

	Measured Values (August 2013)			Measured Values (March/April 2014)			
Pollutant/parameter	**WQL1**	**WQL2**	**WQL3**	**WQL1**	**WQL2**	**WQL3**	**Trigger Value***
pH	7.5	7.4	7.1	6.3	6.3	5.5	>6.5 and <8
Electrical Conductivity (µS/cm)	221	211	295	314	268	125	350
Total Phosphorous (µg/L)	0	0	10	0	0	20	20
Total Nitrogen (µg/L)	600	900	850	300	300	260	250
Dissolved Oxygen (%)	57	53	40	38	47	54	<90 or >110
Alkalinity ($CaCO_3$) (mg/L)	37	31	58	49	32	24	NA
Total Suspended Solids (mg/L)	0	0	0	7.5	0	0	Site-specific equivalent to <25NTU
* Trigger values from ANZECC (2000).							
Source: SEEC (2018a) – Table 2.							

Further water quality monitoring is proposed in the event the Proposal is approved (see Section 5.3.4.4).

5.3.3 Management and Mitigation Measures

5.3.3.1 Introduction

The design and operational safeguards that the Applicant proposes to adopt to manage surface water on site would be incorporated within a surface water management strategy incorporated within an overall Water Management Plan for the Site. The strategy would be based on capturing, treating and reusing process waters and address the following objectives.

i) Achieve a neutral effect on water quality compared to the existing (i.e. pre-Quarry) conditions in the receiving waters.

ii) Provide as much water as is feasibly possible for processing and dust suppression operations without altering the surface water or groundwater flows.

iii) Minimise changes to the amount of groundwater recharge from the Site.

iv) Maintain the terrestrial and aquatic conditions in downstream waters.

The focus in the surface water management strategy would be upon achieving an appropriate water balance and constructing and maintaining an appropriate range of structures to control/manage surface water flows on site. Both of these are discussed in the following sub-sections.

5.3.3.2 Water Balance

In order to be able to meet the anticipated annual 85ML operational water demand for the Proposal (see Section 2.7.1), the Applicant would source water from both surface runoff and groundwater. A water balance for the proposal has been undertaken to ensure water demands would be met and to illustrate the distribution of water around the Site. **Figure 5.12** displays the water balance for the Proposal based upon mean annual rainfall and maximum sales of 860 000tpa. Two main water supply sources considered in the water balance are as follows.

i) Surface water runoff to be captured in two Water Storage Dams (Water Storage Dam A and B) from the 12ha processing and stockpiling area under Harvestable Rights. Water Storage Dam A would also receive runoff from upstream catchments.

ii) Groundwater supply from an existing licensed bore (GW104765) located on the Site.

Surface water runoff from the processing and stockpiling area would be captured and diverted into the Water Storage Dams A and B for storage as it could potentially contain significant quantities of sediment and, as a result, it would be directed through appropriate sediment controls (e.g. sediment basins) prior to flowing into either water storage dam.

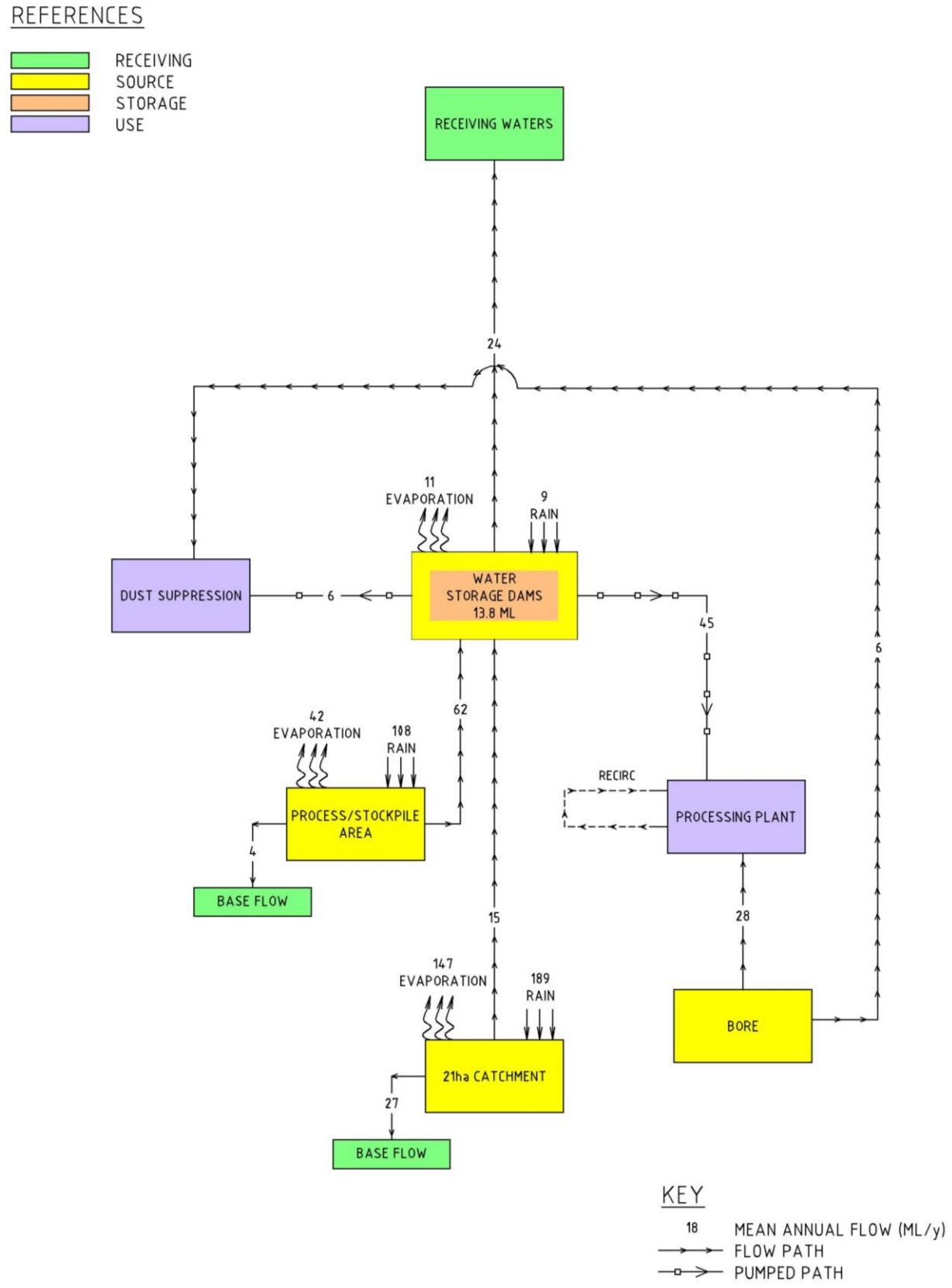


Figure 5.12 Water Balance Summary Full Production

Source: SEEC (2018a) – Figure 16

5.3.3.3 Water Management

The following water management structures would be constructed, as required, and maintained throughout the operational life of the Proposal (see **Figure 5.13**).

- The surface water runoff from within the processing and stockpiling area would drain to small sediment basins (<100m^3) and thence to the Water Storage Dams, both of which would be built as part of initial site establishment and construction. The sediment basins would be intentionally small to collect coarse sediment for frequent removal (and processing).
- A diversion drain would be constructed along the southern boundary of the extraction area to direct upslope runoff away from the Fines Storage Area 2 and the Temporary Topsoil and Mulch stockpile towards Water Storage Dam A.
- Runoff from Fines Storage Area 2 and the Temporary Topsoil and Mulch Stockpile Area would report to Sediment Basin A which would be designed for the 5-day, 95th percentile rainfall depth and so would have a conceptual volume of approximately 6ML. The basin would be constructed before land clearing commences within the Fines Storage Area 2 and Temporary Topsoil and Mulch Stockpile Area.
- Clean water diversion drains would be constructed upslope of Sediment Basin A to limit its required capacity.
- Fines Storage Area 1 would require the construction of two sediment basins (Sediment Basin B and Sediment Basin C) designed for the 5-day 95th percentile rainfall depth and so would have a conceptual volume of 1.65ML. The basins would be constructed before land clearing commences. Trapped sediment would be periodically removed and processed.
- All extraction benches would be orientated and sloped such that all runoff would be contained on the active benches within the extraction stage and directed to the pre-determined drop-down areas on the floor of the extraction stage.
- All runoff from roofs within the processing area would be collected for use in domestic supply (drinking, toilets, showers, etc.).
- Ablution facilities with a design wastewater load of 1 500L/day would be constructed.
- A series of Type C sediment basins designed to treat the 2-year ARI storm flow would be installed. These basins would temporarily detain sediment-laden runoff and allow for natural settlement or filtration of sediment.
- Any changes in runoff volumes as a result of construction of the southern and eastern barriers would be short-term because the barriers would be quickly re-vegetated. As a result, long-term surface water runoff volumes from the lands to be used for the southern and eastern barriers would not change significantly.

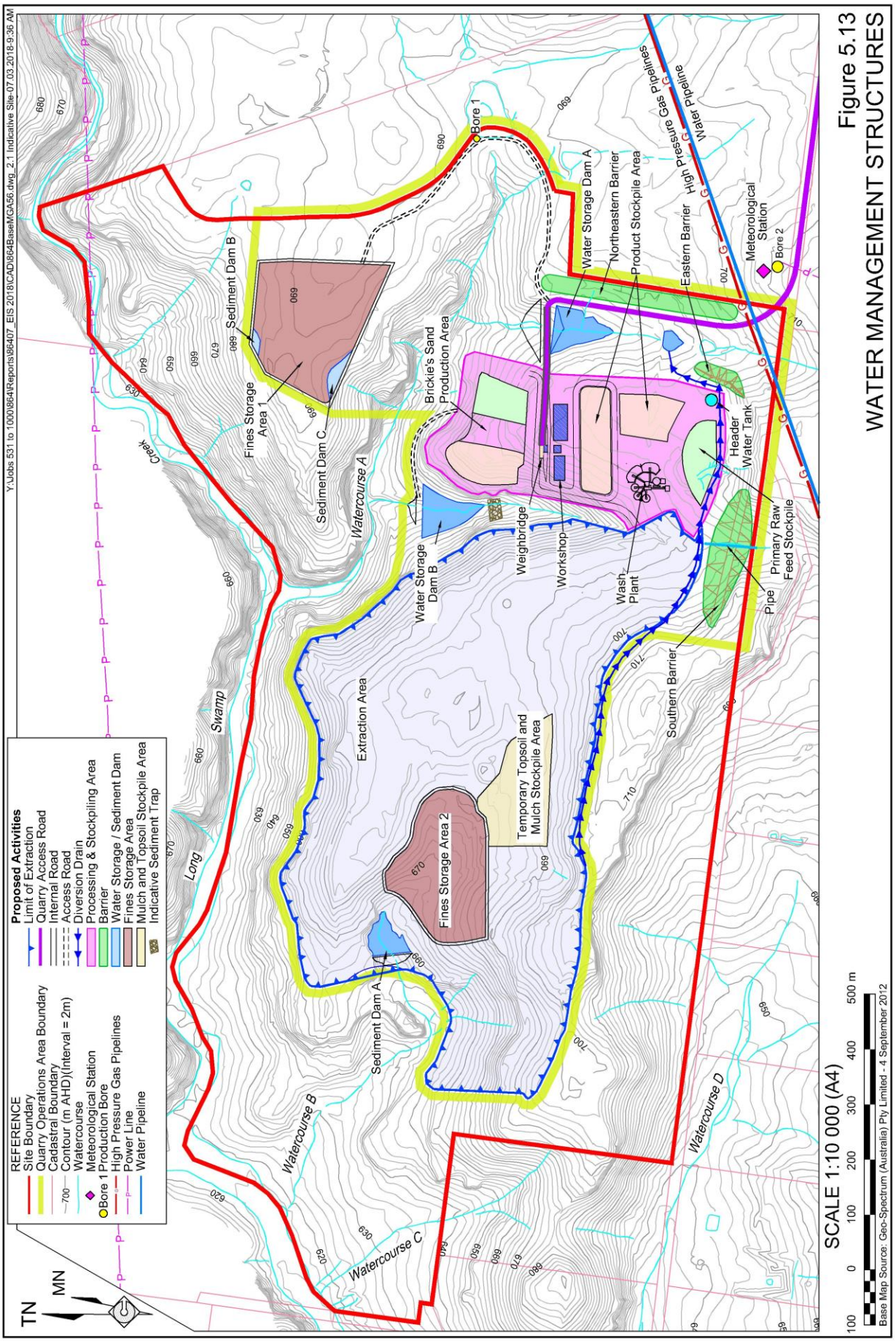


Figure 5.13
WATER MANAGEMENT STRUCTURES
Y:\Jobs 531 to 1000\864\Reports\86407_EIS 2018\CAD\864BaseMGA56.dwg_2.1 Indicative Site-07.03.2018-9:36 AM
REFERENCE
Site Boundary
Quarry Operations Area Boundary
Cadastral Boundary
Contour (m AHD)(Interval = 2m)
Watercourse
Meteorological Station
Bore 1 Production Bore
High Pressure Gas Pipelines
Power Line
Water Pipeline
Proposed Activities
Limit of Extraction
Quarry Access Road
Internal Road
Access Road
Diversion Drain
Processing & Stockpiling Area
Barrier
Water Storage / Sediment Dam
Fines Storage Area
Mulch and Topsoil Stockpile Area
Indicative Sediment Trap
TN
MN
SCALE 1:10 000 (A4)
100 0 100 200 300 400 500 m
Base Map Source: Geo-Spectrum (Australia) Pty Limited - 4 September 2012
Sediment Dam B
Fines Storage Area 1
Sediment Dam C
Watercourse A
Brickie's Sand Production Area
Water Storage Dam A
Northeastern Barrier
Product Stockpile Area
Eastern Barrier
High Pressure Gas Pipelines
Water Pipeline
Meteorological Station
Bore 1
Bore 2
Header Water Tank
Weighbridge
Workshop
Wash Plant
Pipe
Primary Raw Feed Stockpile
Water Storage Dam B
Extraction Area
Temporary Topsoil and Mulch Stockpile Area
Fines Storage Area 2
Southern Barrier
Sediment Dam A
Watercourse B
Watercourse C
Watercourse D
Creek
Swamp
Long

5.3.4 Assessment of Impacts

5.3.4.1 Introduction

The Proposal could potentially impact surface water flow rates, surface water flow volumes and surface water quality directly and indirectly leaving the Site. At present, the Site consists of mostly vegetated, highly permeable catchments, which generate low levels of runoff as a consequence of high levels of infiltration into the soils and groundwater. This cycle is a factor in maintaining the hydrologic regime of nearby hanging swamps and measures would be required to:

- minimise changes in the absolute amount of water that leaves the Site, either via surface and/or subsurface flows;
- minimise changes in the pattern of flow leaving the Site, either via surface or subsurface pathways; and
- minimise changes in the quality of water leaving the Site. This is most prevalent for surface water flows because subsurface waters are generally subjected to natural treatment and polishing by their movement through the regolith layers.

SEEC (2018a) undertook a comprehensive assessment of the affected catchments, runoff, water quality and review of the Proposal's harvestable rights to quantify the potential impacts outlined above. Each of these assessments are reviewed in the following subsections.

5.3.4.2 Surface Water Volumes

The Extraction Area

The proposed extraction area covers approximately 47ha, all of which drains to Long Swamp Creek. The proposed extraction area is presently well vegetated and the soils are Hydrological Group B with an estimated volumetric coefficient of runoff (C_v) of 0.08. This equates to an existing mean annual surface flow volume of approximately 34ML/year from this area which represents approximately 1.7% of the estimated mean annual flow in Long Swamp Creek attributable to surface runoff.

Clearing and compaction of the land surface for internal roads and operational areas would progressively occur over the Quarry Operations Area. As a result, the estimated volumetric coefficient of runoff (C_v) could progressively rise to 0.57 in high rainfall events (Landcom, 2004).

Runoff from the extraction area during Stage 1 of the extraction process would continue as it is presently with appropriate sediment controls (e.g. sediment basins/sumps) used to manage potentially sediment-laden runoff from the extraction area prior to it draining into Long Swamp Creek.

The Processing and Stockpiling Area

The processing and stockpiling area would occupy approximately 12ha, much of it (approximately 75%) as compacted hardstand. Raw feed (of friable sandstone) would be recovered from within the footprint of the processing and stockpiling area during the first

3 years of the Quarry's operation (Extraction Stage 0). Surface flow would progressively increase in this area compared to the existing conditions as a result of clearing and compaction. Surface water runoff from the processing and stockpiling area could potentially contain significant quantities of sediment.

The Barriers

Areas to be used for the barriers lie to the south and east of the processing and stockpiling area. During construction of the barriers, there would be an increase in surface runoff compared to the existing conditions.

The Quarry Access Road

The Quarry Access Road would be approximately 1.4km in length, with a 7.5m wide sealed pavement, two 0.75m wide compacted unsealed shoulders and adjacent table drains all contained within a road corridor approximately 10m wide. The design of the Quarry Access Road requires construction largely at ground level with minimal fill.

An assessment of the proposed road design suggests it would be approximately 45% effectively impervious. This would result in an increase in runoff when compared to the existing conditions.

The Fines Storage Areas

There would be two Fines Storage Areas.

- Fines Storage Area 1 would be located north of the processing and stockpiling area and occupy up to 4ha.
- Fines Storage Area 2 would be located on land that would ultimately become Stages 6 and 7 of the extraction area and occupy approximately 3.5ha.

All existing vegetation would be removed from the fines storage areas prior to their use and, as such, the runoff coefficient (Cv) would rise from about 0.08 to up to 0.70 in high rainfall events (Landcom, 2004).

Temporary Topsoil and Mulch Stockpile Area

A stockpile area would be located immediately east of Fines Storage Area 2, i.e. on land that would ultimately become Stages 6 and 7 of the Extraction Area. It would occupy up to 2.4ha. All existing vegetation would be removed from the stockpile area and, as such, the runoff coefficient (Cv) could rise from about 0.08 to about 0.57 in high rainfall events (Landcom, 2004).

Harvestable Right Dams

As noted above, the water storage dams would also have pervious (clean water) catchments totalling approximately 21ha.Water Balance modelling shows there would be a net decrease in mean annual surface flow to receiving waters from this overall catchment of about 6ML/year or 0.016ML/day as a result of the Proposal.

5.3.4.3 Surface Water Quality

No chemical processes are required for processing and producing the sand products as part of the Proposal. As such, potential impacts to downstream water quality may occur due to Site disturbance and activities from the following sources:

- sediments, soils or fines from disturbance area
- hydrocarbons (e.g. fuels)
- domestic wastewater.

5.3.5 Monitoring

5.3.5.1 Site Establishment and Construction Stage

During the site establishment and construction stage, all sediment basins and the water storage dams would be considered site discharge points. Controlled discharges (i.e. stormwater managed up to the design rainfall events) from these structures would be required to meet the water quality standards in **Table 5.7**. Uncontrolled discharges (i.e. stormwater released during rainfall events that exceed the design capacity of the sediment retention structures) would occur periodically and, during such events, the concentration of suspended solids detailed in **Table 5.7** may be exceeded.

Table 5.7
Water Quality Targets for Sediment Basins and Water Storage Dams (Conditional Discharges)

Pollutant/parameter	Target Value
pH	6.5-8.5
Total Suspended Solids	<50mg/L
Electrical Conductivity (EC)	<350µS/cm
Oil and Grease	None Visible

5.3.5.2 Operational Stages

During the operational stages of the Proposal, Sediment Basins A, B and C and the two water storage dams would be considered site discharge points. Controlled discharges (i.e. stormwater managed up to the design rainfall events) from these structures would be permissible but would need to meet the water quality targets in **Table 5.7**. These water quality targets, and their associated design rainfall events, would be prescribed in the Site's Environment Protection Licence (EPL).

Uncontrolled discharges (i.e. stormwater released during rainfall events that exceed the design capacity of the sediment retention structures) would occur periodically and, during such events, the concentration of suspended solids detailed in **Table 5.7** may be exceeded.

The sediment basins installed adjacent to the Quarry Access Road during the construction phase would be converted into water quality basins and would not be considered site discharge points.

Therefore, regular monitoring and water quality testing would not be required. All areas disturbed during construction of the Quarry Access Road would be effectively stabilised either as sealed pavement or as vegetated or rock-lined batters, vegetated table drains (swales) or verges.

Water quality monitoring in Long Swamp Creek would be undertaken monthly (and any substantial rainfall events). During the first two years of on-site activities to assemble sufficient data to more accurately define the baseline (existing) water quality (for use in reviewing the water quality targets provided in **Table 5.7**).

A regime of monitoring is proposed beyond this two year period to accurately establish the impacts the Proposal is having on downstream surface water quality. Details of this monitoring program would be included in the Water Management Plan which would be submitted to DPE for approval prior to the commencement of activities within the Site.

5.3.5.3 Water Usage

Records would be kept on site of rainfall, site water use, water recirculation dam levels and any pumping volumes around the Site.

5.3.5.4 Infrastructure

The Applicant's monitoring and maintenance regime would also include the following.

- Inspecting the condition of all water management structures fortnightly or following any substantial rainfall event (>25mm/day) for any signs of damage, failure or erosion.
- Conducting monthly inspections on all pumps to ensure they are working properly.
- Identifying any areas across the entire Site where eroded sediment could leave the site untreated as part of a fortnightly inspection regime.
- Records of inspections and maintenance would be kept in the site office, and appropriate action taken to quickly address any water management problems.

5.3.6 Conclusion

Surface water impacts would be managed through the adoption of the requirements of relevant best-practice guidelines and mitigation measures to minimise the risk that surface runoff from the Site might cause unacceptable pollution of Long Swamp Creek and/or its tributaries. Implementation of recommended plans for water quality monitoring, plus associated response plans, would ensure the effectiveness of these measures.

5.4 NOISE AND VIBRATION

5.4.1 Introduction

The DGRs for the Proposal identified "*Noise*" as a key issue requiring that the "*EIS include a quantitative assessment of the potential:*

- *construction, operational and transport noise impacts;*
- *reasonable and feasible mitigation measures, including evidence that there are no such measures available other than those proposed; and*
- *monitoring and management measures, in particular real-time, attended noise monitoring."*

Additional matters for consideration in preparing the EIS were also provided in the correspondence attached to the DGRs from the EPA which related to both noise and vibration impacts and requested that: "*the Proponent must carry out a detailed Noise Impact Assessment and Modelling that addresses:*

- *off-site road noise impacts focusing on current versus proposed hours of operation – consistent with the NSW Road Noise Policy (DECCW, 2011);*
- *construction noise impacts – consistent with the NSW Interim Construction Noise Guideline (DECC, 2009);*
- *operational noise impacts – consistent with the NSW Industrial Noise Policy (EPA, 2000) and the Assessing Vibration: a technical guidelines (DEC, 2006a); and*
- *mitigation and management strategies."*

However, in correspondence dated 22 January 2018, DPE requested that the Noise Impact Assessment be prepared in accordance with the NSW *Noise Policy for Industry* (NPI) (EPA, 2017).

Additional matters relating to noise for consideration in preparing the EIS were also provided in the correspondence attached to the DGRs from Wingecarribee Shire Council and the DRE (now DRG). The additional matters identified by these two agencies were generally consistent with the DGRs. A consolidated list of the identified requirements relating to noise and vibration and where each is addressed is presented in **Appendix 2**.

Based on the risk assessment undertaken for the Proposal (**Appendix 4**), the potential impacts relating to noise and vibration and their risk rankings (in parenthesis) after the adoption of pre-existing or standard mitigation measures are as follows.

- Noise from fixed and mobile plant and equipment on site, unladen trucks on site and laden trucks transporting quarry products off site resulting in:
  - local annoyance and/or distractions (medium);
  - adverse effects on physical and mental health (medium);
  - community and regulatory scrutiny (medium);

  - loss, relocation or reduction in native fauna species (medium); and/or
  - reduced agricultural productivity (low).
- Vibration from blasting activities resulting in:
  - reduced local amenity (low);
  - structural damage to buildings or structures (low); and/or
  - community and regulatory scrutiny (low);

The noise and vibration assessment of the Proposal was undertaken by Spectrum Acoustics Pty Ltd. The full assessment is presented in Part 4 of the *Specialist Consultant Studies Compendium* and is referenced throughout this section as Spectrum (2018), with a summary of the assessment presented in the following subsections.

5.4.2 Study Area

Figure 5.14 shows the noise monitoring locations and residences considered in this assessment.

It is noted that the assessed residences other than the Grotto of the Shrine of Our Lady of Mercy – "Penrose Park" have been grouped based generally upon their respective proximity to the Hume Highway, i.e. main source of noise near the Site. Background noise at these residences is assumed to be consistent with the closest monitored location as follows.

- Location N1 - Pauline Fathers (Grotto).
- Location N2 - Pauline Fathers (residential area) and R16, R18, R19, R20, R21, R22, R23, R24, R25 and R26.
- Location N3 - R1 and R15.
- Location N4 - R2, R3, R8, R11, R12 and R13.
- Location N5 - R4 and R5.
- Not monitored (default noise levels assumed) - R27, R28A, 28B, R30, R31, R33 and R35.

5.4.3 The Existing Environment

5.4.3.1 Introduction

The existing meteorological and acoustic environment surrounding the Site has been reviewed in order to determine the atmospheric conditions under which noise modelling is required, as well as to establish noise criteria at representative receivers surrounding the Site. The following subsections provide a summary of the existing noise sources, meteorological conditions and background noise levels against which noise criteria are set.

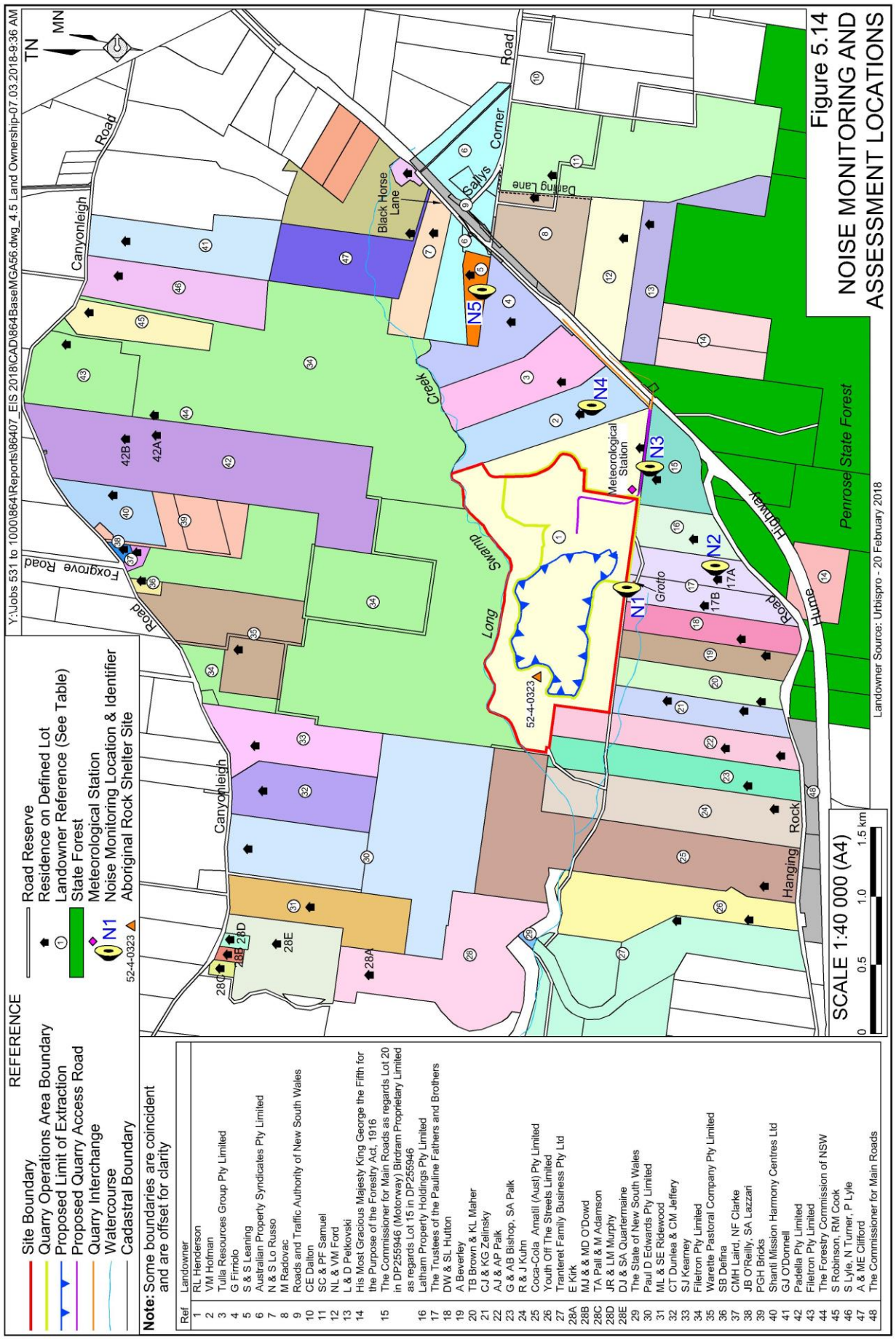


Figure 5.14
NOISE MONITORING AND ASSESSMENT LOCATIONS
REFERENCE
Site Boundary
Quarry Operations Area Boundary
Proposed Limit of Extraction
Proposed Quarry Access Road
Quarry Interchange
Watercourse
Cadastral Boundary
Road Reserve
Residence on Defined Lot
Landowner Reference (See Table)
State Forest
Meteorological Station
Noise Monitoring Location & Identifier
Aboriginal Rock Shelter Site
N1
52-4-0323
Note: Some boundaries are coincident and are offset for clarity
Ref Landowner
1 RL Henderson
2 VM Hofman
3 Tulla Resources Group Pty Limited
4 G Firriolo
5 S & S Leaning
6 Australian Property Syndicates Pty Limited
7 N & S Lo Russo
8 M Radovac
9 Roads and Traffic Authority of New South Wales
10 CE Dalton
11 SC & PF Samuel
12 NL & VM Ford
13 L & D Petkovski
14 His Most Gracious Majesty King George the Fifth for the Purpose of the Forestry Act, 1916
15 The Commissioner for Main Roads as regards Lot 20 in DP255946 (Motorway) Birdram Proprietary Limited as regards Lot 15 in DP255946
16 Latham Property Holdings Pty Limited
17 The Trustees of the Pauline Fathers and Brothers
18 DW & SL Hutton
19 A Beverley
20 TB Brown & KL Maher
21 CJ & KG Zelinsky
22 AJ & AP Palk
23 G & AB Bishop, SA Palk
24 R & J Kuhn
25 Coca-Cola Amatil (Aust) Pty Limited
26 Youth Off The Streets Limited
27 Tranteret Family Business Pty Ltd
28A E Kirk
28B MJ & MD O'Dowd
28C TA Pall & M Adamson
28D JR & LM Murphy
28E DJ & SA Quartermaine
29 The State of New South Wales
30 Paul D Edwards Pty Limited
31 ML & SE Ridewood
32 CT Dunlea & CM Jeffery
33 SJ Kearney
34 Filetron Pty Limited
35 Waretite Pastoral Company Pty Limited
36 SB Defina
37 CMH Laird, NF Clarke
38 JB O'Reilly, SA Lazzari
39 PGH Bricks
40 Shanti Mission Harmony Centres Ltd
41 GJ O'Donnell
42 Padella Pty Limited
43 Filetron Pty Limited
44 The Forestry Commission of NSW
45 S Robinson, RM Cook
46 S Lyle, N Turner, P Lyle
47 A & ME Clifford
48 The Commissioner for Main Roads
SCALE 1:40 000 (A4)
0 0.5 1.0 1.5 km
Landowner Source: Urbispro - 20 February 2018
Y:\Jobs 531 to 10001864\Reports\86407_EIS 2018\CAD\864BaseMGA56.dwg_4.5 Land Ownership-07.03.2018-9:36 AM
TN MN
Canyonleigh Road
Foxgrove Road
Black Horse Lane
Sallys Corner Road
Darling Lane
Long Swamp Creek
Meteorological Station
N1 N2 N3 N4 N5
Grotto
17A 17B
Hilltop Road
Penrose State Forest
Hanging Rock
Canyonleigh
42A 42B
28A 28B 28C 28D 28E

5.4.3.2 Meteorology

The atmospheric conditions most relevant to noise assessments are temperature inversions and gentle winds (indicative of possible wind shear) and relative humidity. The NPI requires that inversions be considered in a noise impact assessment if Pasquil stability classes F and G occur more often than 30% of night times during winter. These stability classes correspond to very stable atmospheric conditions with wind speeds generally less than 2m/s. Analysis of site meteorological data conducted by Pacific Environment Pty Ltd for the Proposal has established that stable atmospheric conditions are a feature of the Site, therefore the NPI default 4^0C/100m inversion strength has been adopted for noise modelling.

In order to assess regional wind patterns, data were analysed from the Site automatic weather station. An analysis of wind speed vector components showed that while strong winds are a feature of the area, westerly and south-easterly winds at average speeds up to 2.7m/s from the southeast and up to 2.1m/s from the west occurred for more than 30% of the time during some seasons and therefore adverse wind conditions require assessment. **Figure 4.4** displays annual and seasonal wind roses.

It is noted that extremes of relative humidity are rarely experienced in the Southern Highlands. Therefore, a constant value of 70% has been adopted for all noise modelling.

5.4.3.3 Background Noise Levels

The principal source of noise that contributes to background noise levels in the vicinity of the Site is traffic on the Hume Highway. Other sources include agricultural equipment (occasional) and ambient noises such as domestic animals, birds and wind in trees.

Background noise levels were recorded by Spectrum Acoustics during unattended noise monitoring at the five representative locations displayed on **Figure 5.14** between 24 September 2013 and 3 October 2013. There is no reason to believe that the acoustic environment has changed since the background monitoring was undertaken. If anything, traffic noise on the Hume Highway would have increased, indicating that the measured noise levels are conservative for the assessment. Spectrum Acoustics identified which residences would have comparable noise levels to the five selected monitoring locations. **Table 5.8** sets out the background L_{A90} and L_{Aeq} noise levels recorded during the daytime, evening and night-time periods for the five locations and records the nearby residences that are considered to correspond to these locations as they would have comparable background noise levels.

Table 5.8
Unattended Background Noise Monitoring Results

Location*	Residences with Comparable Noise Level	Day		Evening		Night	
		L_{A90}	L_{Aeq}	L_{A90}	L_{Aeq}	L_{A90}	L_{Aeq}
N1	R17 - Grotto	39	69	41	49	36	47
N2	17A & 17B All Residential areas on site R16, R18, R19, R20, R21, R22, R23, R24, R25, R26	36	58	38	50	32	45
N3	R1, R15	38	52	43	49	36	45
N4	R2, R3, R8, R11, R12 and R13	38	53	39	47	34	45
N5	R4, R5	47	58	48	58	41	57
Day = 7:00am-6:00pm / Evening = 6:00pm-10:00pm / Night = 10:00pm-7:00am. * See **Figure 5.8**.							
Source: Spectrum (2018) – Modified after Table 5							

It is noted that the background noise level at locations N2, N3 and N4 are all comparable given their similar distances from the Hume Highway. The L_{A90} level at location N5 reflects its closer proximity to the Hume Highway and the western service centre adjacent to the Sallys Corner Interchange. Location N1 is the Grotto at the Shrine of Our Lady of Mercy – "Penrose Park" and was selected in light of the religious significance of this location and to ensure that assessment of noise levels at this location was included in the assessment.

5.4.4 Criteria for Assessment

5.4.4.1 Introduction

For the purposes of defining noise criteria relevant to the assessment of the on-site operations of the Proposal, the following times are relevant to the daytime, evening, night-time periods.

- Daytime – 7:00am to 6:00pm;
- Evening – 6:00pm to 10:00pm;
- Night – 10:00pm to 7:00am (8:00am on Sundays); and
- Morning shoulder – 5:00am to 7:00am.

For the purposes of considering road traffic noise, two periods are considered.

- Daytime – 7:00am to 10:00pm (15 hours).
- Night-time – 10:00pm to 7:00am (9 hours).

5.4.4.2 Construction Stage

The various noise sources that would be present during the site establishment and construction stage would be confined largely to the processing and stockpiling area. Given Operational Noise Scenario 1 addresses noise levels from more noise sources than during the construction stage, it is considered appropriate to rely upon the operational noise criteria for the assessment of construction noise.

5.4.4.3 Operational Noise Assessment Criteria

The NPI provides a framework and process for deriving operational noise criteria for assessment of potential noise impacts associated with development and setting operational noise limits in environment protection licences under the POEO Act. The Proposal is a scheduled activity under Schedule 1 of this Act. For the purposes of assessing noise, operational activities are assumed to include all extraction and processing operations plus the movement of heavy vehicles along the Quarry Access Road. Criteria for the assessment of road noise on the Hume Highway resulting from heavy vehicle movements for the Proposal are considered in Section 5.4.4.3. The NPI specifies two noise criteria, namely:

- an intrusiveness noise level which requires that the equivalent continuous noise level ($L_{Aeq,15min}$) from a specific industrial source at a privately-owned residence should not exceed the background noise level by more than 5 decibels; and

- an amenity noise level which aims to maintain noise amenity throughout a community over the whole daytime, evening or night-time periods and considers cumulative noise from all industrial sources.

Project Noise Trigger Levels (PNTLs) for the assessment of the Proposal are derived from the lower of the intrusiveness noise level and the amenity noise level and the worst case or most conservative operational time period based on recorded background levels.

Intrusiveness Criteria

The intrusiveness noise level limits Equivalent Continuous Noise Levels ($L_{Aeq\ 15min}$) from an industrial source to a value of 'background plus 5dB'. That is, the Rating Background Level (RBL) for the time period, plus 5dB(A). The RBL (L_{A90}) is defined as the overall single figure background level representing each assessment period.

Amenity Criteria

The amenity noise level aims to protect against excessive noise levels where an area is becoming increasingly developed. Amenity noise levels are dependent upon the nature of the receiver area and the existing level of industrial noise. There is very little existing industrial noise in the surrounding area and the residential area that is potentially affected by noise emissions from the Proposal is best described acoustically as an area dominated by environmental and road traffic noise.

The amenity criteria specified in the NPI also provides recommended maximum noise levels for different land uses. For places of worship (such as the Grotto and international chapels at the Shrine of Our Lady of Mercy – "Penrose Park"), an $L_{Aeq15min}$ of 40dB(A) is provided as an acceptable noise level, although it should be noted that this is based on these activities occurring within a building.

Project Noise Trigger Levels

Based upon the above, the PNTL is the intrusiveness criteria of "background + 5dB" for residences corresponding to monitoring locations N2, N3 and N4. The amenity criteria is the PNTL for residences corresponding to monitoring locations N5, as the high traffic noise amenity noise level (based on Section 2.4.1 of the NPI) is the more conservative criteria and has therefore been applied for assessment for residences corresponding to this location. The amenity criteria for places of worship is the assessment criteria used for N1, noting that each of the shrines are effectively outdoor making this a conservative assessment criteria for these locations.

For each location, the most conservative time period was the night-time period and therefore this period is applied for assessment, i.e. if predicted noise levels satisfy the night-time criteria, they would also satisfy the higher daytime and evening criteria.

Table 5.9 lists the proposed worst-case Project Noise Trigger Levels relevant to the noise assessment of the Proposal based upon the rating background levels for the five representative noise monitoring locations displayed in **Figure 5.14**.

Table 5.9
Proposal Noise Assessment Criteria

Location	RBL L_{A90}			Project Noise Trigger Levels $L_{Aeq(15minute)}$		
	Day	Evening	Night	Day	Evening	Night
N1 "Penrose Park" - Worship areas	N/A			40 (when in use)		
N2 (R17A and 17B) "Penrose Park" - Residential areas Representative of R16, R18, R19, R20 R21, R22, R23, R24, R25, R26	36	36	32	41	41	37
N3 (R15)	38	38	36	43	43	41[#]
N4 (R2) Representative of R8, R11, R12 and R13	38	38	34	43	43	39
N5 (R4) Representative of R5	47	47	41	52	52	42*
R27, R28A, R28B, R30, R31, R33, R35	35	30	30	40	35	35

[#] Intrusiveness noise level applies due to absence of other industrial sources at R15. Cumulative noise at R22-R26 is discussed further in Section 6.6.

* High traffic noise amenity level is adopted at this location, in accordance with Section 2.4.1 of the NPI, as this is lower than the intrusiveness criterion.

Source: Spectrum (2018) – Table 7

Residences 1 and 3 are considered project-related residences as these properties have entered into commercial agreements with the Applicant regarding the operation of the Quarry.

Maximum Noise Level Assessment

The potential for sleep disturbance is assessed by considering maximum noise level events resulting from the Proposal. Sleep disturbance is most relevant to night-time noise emissions and is considered to be both awakenings and disturbance to sleep stages.

Section 2.4.1 of the NPI specifies that where the night-time noise levels at a residential location exceed:

- $L_{Aeq,15min}$ 40 dB(A) or the prevailing RBL plus 5 dB, whichever is the greater, and/or
- L_{AFmax} 52 dB(A) or the prevailing RBL plus 15 dB, whichever is the greater,

a detailed maximum noise level event assessment should be undertaken.

Other factors that may be important in assessing the extent of impacts on sleep include:

- how often high noise events would occur;
- the distribution of likely events across the night-time period and the existing ambient maximum events in the absence of the subject development;
- whether there are times of day when there is a clear change in the noise environment (such as during early-morning shoulder periods); and

- current scientific literature available at the time of the assessment regarding the impact of maximum noise level events at night.

The NPI requires that maximum noise level event assessments should be based on the L_{AFmax} descriptor on an event basis under 'fast' time response.

The assessment criteria that would be used to trigger a detailed maximum noise level assessment for the Proposal are presented in **Table 5.10**.

Table 5.10
Sleep Disturbance Criteria

Location	Criterion, $L_{A1(1minute)}$
N1 "Penrose Park", worship areas (outdoor shrines)	52
N2 (R17A and 17B) "Penrose Park", residential areas	52
R1, R15, R16, R18, R19, R20, R21, R22, R23, R24, R25, R26	52
R2, R3, R8, R11, R12, R13.	52
R4, R5	56
R27, R28, R30, R31, R33, R35	52

5.4.4.4 Voluntary Land Acquisition and Mitigation Rights

The *Voluntary Land Acquisition and Mitigation Policy* (NSW Government, 2014) applies to all State Significant extractive industry developments and sets out the rights of a landowner with respect to requests for voluntary mitigation and land acquisition as a result of excessive noise and air quality (particulate matter) impacts. A recent update to the policy was available for public exhibition and comment until 16 February 2018. Although no changes were proposed regarding noise criteria for this assessment, the revised policy has been considered for this assessment. The policy is applied through conditions of the development consent whereby the impact assessment has determined that it is not possible to comply with the impact assessment criteria after the implementation of all reasonable and feasible avoidance and/or mitigation measures. The assessment criteria for voluntary mitigation or land acquisition are the same as the assessment criteria presented in **Table 5.9**.

It should be noted that this policy also applies to vacant land, which is considered as being impacted should the predicted noise levels exceed the impact assessment criteria over an area greater than 25% of the land holding, irrespective of a residence being situated on that property.

5.4.4.5 Road Traffic Noise Assessment Criteria

The Proposal requires assessment under the provisions of the NSW *Road Noise Policy* (RNP) (DECCW, 2011) as vehicles used for product transportation would access public roads. The noise associated with traffic activities within the Site (and specifically, the Quarry Access Road) are considered within the assessment of operational noise. The Proposal has therefore been considered against the criteria established in the RNP.

Table 5.11 provides the road traffic noise criteria, described in the RNP that has been adopted for the assessment of road traffic noise for the Proposal.

Table 5.11
Road Traffic Noise Criteria

Situation	Recommended Criteria (dB(A))	
	Day 7:00am to 10:00pm	**Night 10:00pm to 7:00am**
Existing residences affected by additional traffic on existing freeway/arterial/sub-arterial roads generated by land use developments.	$L_{Aeq\ (15\text{-}hour)}$ 60	$L_{Aeq\ (9\text{-}hour)}$ 55
Source: Spectrum (2018) – Table 9		

Section 3.4 of the RNP discusses the assessment of reasonable and feasible traffic noise mitigation measures and notes that *"an increase of up to 2dB represents a minor impact that is considered barely perceptible to the average person"*.

5.4.4.6 Blasting Criteria

Human Comfort

The EPA has adopted recommended airblast and ground vibration levels published 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 – September 1990.* These recommended levels are based on prevention of human discomfort and have been adopted as the assessment criteria for the blasting assessment for residences.

- The maximum airblast overpressure level should not exceed 115dB linear peak on more than 5% of the total number of blasts over 12 months. The maximum level should not exceed 120dB linear peak at any time.
- The maximum ground vibration velocity should be less than 5mm/s peak vector sum (PVS) for more than 5% of the total number of blasts over 12 months. The maximum level should not exceed 10mm/s at any time.
- Blasting should generally only be permitted during the hours of 9:00am to 5:00pm Monday to Saturday and should not take place on Sundays and Public Holidays.
- Blasting should generally take place no more than once per day, unless a misfire occurs.

Building Damage Criteria

Building damage assessment criteria are nominated in the Australian Standard AS 2187.2-1993 "Explosives – Storage, Transport and Use. Part 2: Use of Explosives". These criteria are summarised in **Table 5.12**.

The human discomfort (ANZECC) criteria are more stringent than the building damage criteria and have been applied for the Spectrum (2018) assessment.

Table 5.12
Building Damage Vibration Criteria

Building Type	Vibration Level (mm/s)	Airblast Level (dB re 20 µPa)
Sensitive (and Heritage)	5	133
Residential	10	133
Commercial/Industrial	25	133
Source: Spectrum (2018) – Table 10		

Non-residential Receivers

There are three potentially vibration-sensitive locations near the proposed extraction area, these being the Grotto near the northern boundary of the Shrine of Our Lady of Mercy – "Penrose Park" (R17), high pressure gas and water pipelines to the south of the Site and a rock shelter identified as AHIMS Site 54-4-0323 by Landskape (2018). These locations are displayed on **Figure 5.14**.

A ground vibration criterion of 50mm/s to 80mm/s for sensitive heritage rock structures has previously been applied by the EPA to coal mining projects in NSW. The more conservative criteria of 50mm/s has been applied for assessment at the rock shelter.

The building damage criteria in **Table 5.12** are the limits for minor cosmetic damage such as paint cracking at cornice junctions. For the purpose of assessment, the commercial/industrial cosmetic building damage vibration criterion of 25mm/s (see **Table 5.12**) and the human comfort blast over pressure criterion of 115dB would be applied for assessment at the Grotto.

Underground gas and water pipelines located to the south of the Site are located approximately 250m from the proposed extraction area. Spectrum (2018) adopted a conservative vibration assessment criteria at this location of 20mm/s based on the consultant's previous experience and noting at previously accepted assessment criteria have ranged from 20mm/s to 100mm/s.

5.4.5 Design and Operational Safeguards

5.4.5.1 Introduction

The principal mechanism for management of noise and blasting at the Site would be the preparation and implementation of a Construction Noise Management Plan and an Operational Noise and Vibration Management Plan. The former plan would focus on the site-specific safeguards and mitigation measures to be adopted for each construction activity. The latter plan would incorporate the following components and be prepared in consultation with DPE.

- Blast notification protocols for those residences within 2km of the extraction area.
- A noise monitoring program (see Section 5.4.8).
- Blast monitoring protocols.
- Protocols for incident identification and notification.
- Protocols for management of noise complaints.

In addition, noise and blast-related sensitivities and expectations would be incorporated in site-specific inductions for all site personnel and contractors.

5.4.5.2 Noise

The Proposal has been designed with the key objective to minimise the noise generated by sand extraction/processing activities and the transportation of sand products from the Site. The design features and operational noise controls of the Proposal to meet this objective are as follows.

Design Features

The location and design of the extraction area itself, i.e. being sufficiently distant from surrounding residences and shielded to the south by natural topography (and the southern barrier), would contribute to reduced noise levels. The progressive development of benches downwards within the extraction area would assist to further reduce noise from extraction activities, particularly to the south.

The location of the wash plant has been selected to reduce the distance that trucks need to travel to the raw feed stockpile area but provides for mitigation of noise from this equipment as it is located closer to the southern barrier and natural topography that mitigates noise from this location. The central pad for the processing and stockpiling area would be excavated into the landscape, i.e. by up to 12m below the surrounding natural ground levels, thereby providing a further level of noise attenuation.

Amenity barriers would be constructed (as described in Section 2.4.8 and displayed on **Figure 2.1**) to the south of the Quarry Operations Area to mitigate potential noise impacts at the Shrine of Our Lady of Mercy – "Penrose Park" and on the eastern boundary of the processing and stockpiling area to mitigate potential noise impacts at Residence 2.

An amenity barrier, referred to as the northeastern barrier, would be constructed on the eastern side of the north-south section of the Quarry Access Road (see **Figure 5.15**). The barrier would be up to 10m in height above the road level and would comprise an earthen base and a panel/fence on top of the base. Native vegetation would be established on the earthen section of the barrier. The southern end of the barrier would blend into the topography as the road turns in an easterly direction.

Roadside noise barriers would be erected adjacent to the east-west section of the Quarry Access Road to limit noise at privately-owned residences and on vacant land, specifically at Residence 2 and Residence 15. **Figure 5.15** displays the proposed locations of the roadside barriers. In order to account for the standard height of the exhaust on heavy vehicles of 3.5m, the roadside noise barriers would be constructed to a maximum effective height of 3.8m, have an approximate mass of 15kg/m^2, make contact with the ground and have no significant cracks or gaps. The sealing of the road itself would minimise truck body noise, especially for empty trucks travelling along the Quarry Access Road.

Operational Safeguards

- All hours of operation presented in **Table 2.5** would be adhered to.
- All equipment on site would be regularly serviced to ensure that noise impacts from equipment are not exacerbated.
- The internal unsealed road network would be graded, as required, to limit body noise from empty trucks.

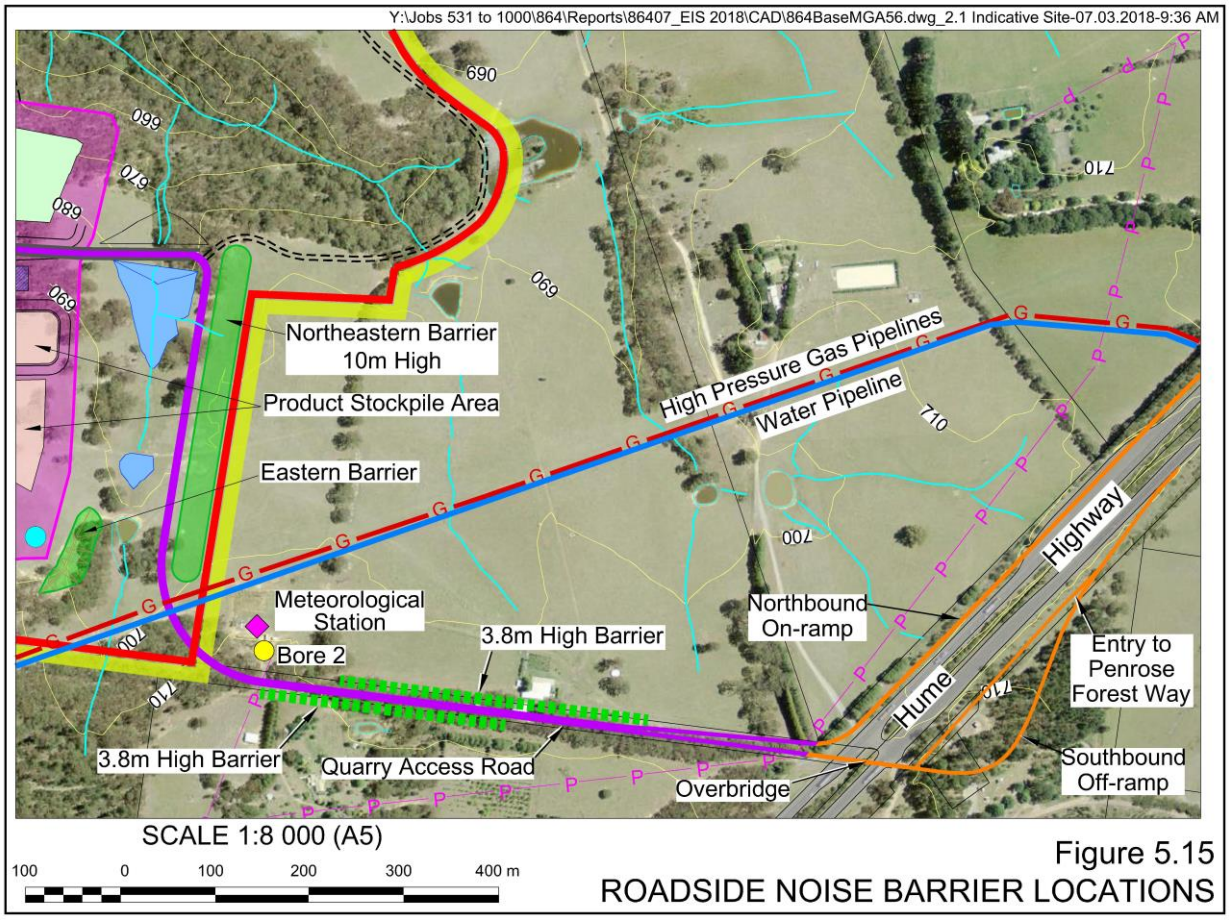


Figure 5.15
ROADSIDE NOISE BARRIER LOCATIONS

- The Quarry Access Road and Quarry Interchange would be fully sealed to limit noise.
- Noisy mobile plant operating simultaneously close together would be avoided, wherever possible.
- The Quarry Access Road would be constructed with emphasis placed upon maximising cut and minimising fill to achieve the lowest profile and elevation.
- Truck speeds on the Quarry Access Road would be limited to 70km/hr and truck speeds on internal roads limited to 40km/hr.
- Maintenance work on all plant and equipment would be carried out away from noise sensitive areas and confined to standard daytime operational hours when practicable. Any inaudible maintenance would be undertaken beyond the daytime hours.

Noise Reduction Program

In consideration of the concerns of the Pauline Fathers regarding the potential for intrusive noise impacts at the Grotto and international chapels within the Shrine of Our Lady of Mercy – "Penrose Park", the Applicant proposes to undertake a comprehensive noise reduction program within three months of commissioning the processing plant to further reduce noise levels

experienced at the Grotto and outdoor shrines[2]. The program would involve detailed measurements of noise sources to identify the location of key noise sources and potential for further noise mitigation. For example, the program may consider the noise sources of the wash plant at different heights (that is, at the hopper, the crushing system, cyclones and conveyors) and make recommendations for further mitigation such as partial enclosure or strategic location of additional bunding or stockpiles to mitigate potential noise impacts.

The scope of the noise reduction program which would be undertaken by a suitably experienced acoustic consultant would be agreed with DPE and the EPA prior to commissioning the assessment. The final report would be provided to DPE and made publicly available on the Company website. Where the consultant makes recommendations that are additional to measures implemented at the Quarry, the Noise and Vibration Management Plan would be updated to incorporate the additional measures. The Noise and Vibration Management Plan would be provided to DPE for approval and would be subject to ongoing demonstration of compliance through compliance noise monitoring, the Annual Review and independent environmental auditing.

5.4.5.3 Blasting

The Applicant would control the adverse effects of blasting within the extraction area principally through the design of each blast. The approach to the design of each blast and the design variables would be reviewed by the blast contractor following each blast with a focus upon minimising both airblast overpressure and ground vibration, within practical and operational constraints.

The Applicant would ensure that the initial blasts are conservatively designed such that the levels of both airblast overpressure and ground vibration from proposed blasting activities are well within recommended criteria at all potentially-affected privately-owned residences and the Grotto and international chapels within the Shrine of Our Lady of Mercy – "Penrose Park" receivers. The outcome of this monitoring would then be used in the development and subsequent refinement of a specific site law for blasting within the extraction area.

The Applicant would adopt the following measures to complement the blast design-related safeguards for blasting.

- Blasting would be limited to the period between 9:00am to 5:00pm Monday to Saturday and would not occur on Sundays or public holidays.
- The Applicant would maintain communication with the Pauline Fathers to ensure that all planned blasts within the Site are discussed prior to final planning for each blast.
- A notification protocol for blasting impacts would be prepared for all residents within 2km of the extraction area. Residents would be consulted to establish their preferred method for notification (i.e. letterbox drop, SMS, email or phone call).
- No blasting would occur within 500m of the Grotto within the Shrine of Our Lady of Mercy – "Penrose Park".

[2] The program would focus upon reducing noise levels below the compliance level noted in the EPL for the Quarry.

- Blasting would take place no more than once per day as specified in the ANZECC guidelines.
- Blast design and impacts would be monitored during each blast to ensure that overpressure or ground vibration levels are consistent with predicted impacts.

There would be no need for any specific management or mitigation measures to protect the gas and water pipelines located to the south of the extraction area. No other public infrastructure is located within the vicinity that requires protection.

5.4.6 Assessment Methodology

5.4.6.1 Operational Noise

The assessment of operational noise was conducted using Renzo Tonin & Associates Environmental Noise Model (ENM) v3.06. All major noise producing items were modelled at their known (for stationary sources such as the processing plant) or most exposed (for mobile sources such as the bulldozer) positions and noise contours and/or point to point calculations were generated for the surrounding area. The noise model developed by Spectrum Acoustics covers the area around the Site. Any residences not covered by the model are more distant than the intervening residences. Therefore, compliance is assumed at the more distant locations when compliance is predicted at the residences/location(s) closer to the activity(ies) being assessed.

The sound power levels of the equipment used in the modelling of each scenario are listed in **Table 5.13**.

Table 5.13
Noise Source Sound Power Levels

Equipment	Number			Use/Activity	Lw, dB(A)	
	500 ktp	820 ktp	1Mtpa		Leq	Lmax
Bulldozer (Komatsu 475 or similar)	1-2	2-4	3-4	Friable sandstone extraction (ripping/ pushing), site works (e.g. tree clearing)	113	121
Excavator 45t (PC 450 or similar)	1-2	2-3	3-4	Friable sandstone extraction and haul truck loading	108	112
Haul truck 50t (Hitachi B50D or similar)	1-2	1-2	2-3	Raw material haulage to processing area	108	113
Front-end loader (WA 500 or similar)	2-3	3-5	4-5	Haul truck and product truck loading	106	109
Hydraulic Drill Rig (Atlas Copco ROC Series)	1	1	1	Drilling blast holes (typically for 3 - 4 days every one to two months)	110	112
Grader (Cat 140 M or similar)	1	1	1	Haul road construction. Hired for occasional use	98	102
Water Truck (Minimum 12 000L)	1	1	1	Dust suppression activities	108	113
Powerscreen Chieftain or similar	1	1-2	1-2	Brickie's sand production	112	114
Front-end loader (Volvo L120 or similar)	1	1-2	1-2	Loading of brickie's sand plant	106	109
B-double truck				Product transport	104	109
* Notes: All equipment would be periodically replaced/refurbished with better equipment of a similar capacity and noise rating. Leq value for B-doubles is calculated for 12.5 movements per 15 minutes.						
Source: Spectrum (2018) – Table 11						

Noise models were generated for three representative operational scenarios. These scenarios are considered to be the worst cases in terms of noise generation and potential impacts. Details of each scenario are provided in Section 4 of Spectrum (2018). The predicted noise levels have been assessed under the worst case conditions of a temperature inversion and a winds from the west and southeast.

Scenario 1 – Extraction Stage 0

Sand extraction and processing activities being undertaken within the processing and stockpiling area with sand products despatched at a rate of 430 000tpa, i.e. with up to 26 truck movements per hour along the Quarry Access Road.

Scenario 2 – Extraction Stage 2

Sand extraction within Stage 2 of the extraction area with sand products despatched at a rate of 700 000tpa, i.e. with up to 50 truck movements per hour along the Quarry Access Road. This scenario includes one brickie's sand screening plant in the northern part of the processing and stockpiling area.

Scenario 3 – Extraction Stage 4

Sand extraction within Stage 4 of the extraction area with sand products despatched at the maximum rate of 860 000tpa, i.e. with up to 50 truck movements per hour along the Quarry Access Road. This scenario incorporates two mobile brickie's sand screening plants located in the extraction area and in the northern part of the processing and stockpiling area, respectively.

All product vehicle movements whilst on the Site are considered as site noise and assessed against the operational noise criteria.

A potential for sleep disturbance would occur during operations from 10:00pm to 7:00am due to short-term high impact noises from the wash plant, front-end loader and haul trucks travelling on the Quarry Access Road. Sound power levels of modelled L_{Amax} noise sources (as an estimation of $L_{A1(1min)}$ levels) are listed in **Table 5.13**. Maximum noise levels were modelled using the ENM program under neutral conditions.

5.4.6.2 Road Traffic Noise

As noted previously, product vehicle movements within the Site and on the Quarry Access Road are considered as site noise and assessed against the operational noise criteria.

The assessment of road traffic noise considers off-site vehicle movements along the Hume Highway which would generally be of a discreet, rather than constant nature. There are many methods available for calculating the noise impact arising from intermittent signals of various shapes. The methodology employed in this assessment was sourced from the US Environmental Protection Agency document No. 550/9-74-004 *"Information on Levels of Noise Requisite to Protect Public Health and Welfare with an Adequate Margin of Safety, March 1974"* and incorporates an equation for determining the maximum vehicle noise based on triangular or trapezoidal noise signals. Section 4.4 of Spectrum (2018) provides more information regarding the methodology used for assessment of off-site road traffic.

The main parameters considered in the traffic noise assessment are:

Lb	=	background noise level, dB(A);
L_{max}	=	maximum vehicle noise at residence, dB(A);
T	=	assessment period (minutes);
D	=	duration of noise of each vehicle (min)and
n	=	number of vehicles during assessment period.

For the purposes of the road traffic noise assessment, it has been assumed the closest residence to the Hume Highway at which quarry-related truck noise is assessed, is the residence at "Black Horse Farm" at a distance of 30m from the Highway.

5.4.6.3 Blasting

In order to predict air blast overpressure and ground vibration levels, a series of standard equations were applied for the proposed blast design described in Section 2.5.3.3. The use of these equations is discussed in detail in Section 4.5 of Spectrum (2018). Locations for assessment included three residences, the Grotto at the Shrine of Our Lady of Mercy – "Penrose Park" and the rock shelter identified in Section 5.7.6 as being of significant Aboriginal cultural heritage value. The residences assessed were selected to be representative of potential impacts. Residence 33 is located to the north of the Site, Residence 2 is located to the east of the Site and Residence 17B is the residential area within the Shrine of Our Lady of Mercy – "Penrose Park". Together, these locations give a representative view of potential impacts due to blasting activities. Due to the nature of the assessment, if the Proposal is predicted to be compliant at these locations, compliance is assumed at residences located further from the site than the selected residences.

5.4.6.4 Road Traffic Vibration

Spectrum (2018) considered ground vibration levels from heavy vehicles travelling on the Quarry Access Road past Residence 15 based upon a study by Watts and Stait (2008).

5.4.7 Assessment of Impacts

5.4.7.1 Construction Noise

As outlined in Section 5.4.4.2, the activities undertaken during the site establishment and construction stage would be confined to the processing and stockpiling area and would involve fewer noise sources than in Operational Noise Scenario 1. Therefore, reliance has been placed upon the assessment for Scenario 1 (see Section 5.4.7.2) to assess impacts for the site establishment and construction stage.

5.4.7.2 Operational Noise

Predicted Noise Levels

Predicted noise levels for the three modelled scenarios are summarised in **Tables 5.14** to **5.16**. Criteria are taken as the lowest of the criteria for all proposed Site activities for day, evening and night.

Contour plots of the noise levels for each operational scenario under westerly winds and temperature inversions are displayed in Spectrum (2018).

Table 5.14
Scenario 1 – Predicted Noise Levels, dB(A),$L_{eq(15min)}$

Receiver*	Noise trigger levels			Meteorological condition			
	Day	Evening	Night	Neutral	Inversion	SE Wind	W Wind
R2	43	43	39	34	37	34	37
R4	52	52	42	28	35	26	33
R5	52	52	42	24	32	22	29
R8	43	43	39	22	30	20	28
R11	43	43	39	21	29	<20	28
R12	43	43	39	24	31	21	30
R13	43	43	39	24	30	20	30
R15	43	43	41	38	40	37	39
R16	41	41	37	24	31	22	24
R17 (Grotto)	40	40	40	32	35	33	33
R17A	41	41	37	24	26	23	23
R17B	41	41	37	25	28	25	23
R18	41	41	37	21	26	22	21
R19	41	41	37	20	25	20	20
R20	41	41	37	<20	20	<20	<20
R21	41	41	37	22	26	23	20
R22	41	41	37	<20	21	<20	<20
R23	41	41	37	<20	<20	<20	<20
R24	41	41	37	<20	<20	<20	<20
R25	41	41	37	<20	<20	<20	<20
R26	41	41	37	<20	<20	<20	<20
R27	40	35	35	<20	20	<20	<20
R28A	40	35	35	<20	26	26	<20
R28B	40	35	35	<20	26	26	<20
R28C	40	35	35	<20	26	26	<20
R30	40	35	35	22	27	27	21
R31	40	35	35	22	28	29	20
R33	40	35	35	21	31	30	21
R35	40	35	35	21	30	30	21
* See **Figure 5.14**							
Source: Spectrum (2018) – Table 14							

Table 5.15
Scenario 2 – Predicted noise levels, dB(A),$L_{eq(15min)}$

Receiver*	Noise trigger levels			Meteorological condition			
	Day	Evening	Night	Neutral	Inversion	SE Wind	W Wind
R2	43	43	39	36	38	35	39
R4	52	52	42	30	35	29	35
R5	52	52	42	25	31	24	30
R8	43	43	39	22	30	21	30
R11	43	43	39	21	29	20	29
R12	43	43	39	25	30	23	30
R13	43	43	39	25	30	23	30
R15	43	43	41	40	38	39	40
R16	41	41	37	25	26	25	25
R17 (Grotto)	40	40	40	30	32	32	30
R17A	41	41	37	24	26	24	24
R17B	41	41	37	25	27	25	25
R18	41	41	37	22	26	23	21
R19	41	41	37	20	25	21	20
R20	41	41	37	<20	20	<20	<20
R21	41	41	37	22	21	25	21
R22	41	41	37	<20	20	20	<20
R23	41	41	37	<20	<20	<20	<20
R24	41	41	37	<20	<20	<20	<20
R25	41	41	37	<20	<20	<20	<20
R26	41	41	37	<20	<20	<20	<20
R27	40	35	35	<20	20	20	<20
R28A	40	35	35	<20	25	26	<20
R28B	40	35	35	20	26	28	<20
R28C	40	35	35	20	26	28	<20
R30	40	35	35	23	29	30	22
R31	40	35	35	22	29	30	21
R33	40	35	35	24	31	33	23
R35	40	35	35	25	30	31	24

* See **Figure 5.14**

Source: Spectrum (2018) – Table 15

Table 5.16
Scenario 3 – Predicted noise levels, dB(A),$L_{eq(15min)}$

Receiver*	Noise trigger levels			Meteorological condition			
	Day	Evening	Night	Neutral	Inversion	SE Wind	W Wind
R2	43	43	39	35	39	34	39
R4	52	52	42	30	36	26	36
R5	52	52	42	25	31	23	34
R8	43	43	39	22	29	20	31
R11	43	43	39	21	28	<20	30
R12	43	43	39	24	30	20	32
R13	43	43	39	24	30	20	31
R15	43	43	41	40	38	39	40
R16	41	41	37	25	26	23	25
R17 (Grotto)	40	40	40	29	34	32	33
R17A	41	41	37	24	26	23	24
R17B	41	41	37	25	27	25	25
R18	41	41	37	22	26	24	21
R19	41	41	37	20	25	21	20
R20	41	41	37	<20	20	<20	<20
R21	41	41	37	22	21	26	21
R22	41	41	37	<20	20	20	<20
R23	41	41	37	<20	<20	<20	<20
R24	41	41	37	<20	<20	<20	<20
R25	41	41	37	<20	<20	<20	<20
R26	41	41	37	<20	<20	<20	<20
R27	40	35	35	<20	20	21	<20
R28A	40	35	35	<20	25	29	<20
R28B	40	35	35	20	26	28	<20
R28C	40	35	35	20	26	28	<20
R30	40	35	35	23	28	30	21
R31	40	35	35	22	29	31	20
R33	40	35	35	23	31	32	21
R35	40	35	35	22	30	31	21
* See **Figure 5.14**							
Source: Spectrum (2018) – Table 16							

In light of the predicted noise levels listed in **Tables 5.14** to **5.16**, Spectrum (2018) has confirmed the effectiveness of the proposed mitigation measures as there would be no exceedances of any of the noise criteria at any of the surrounding residences or the Grotto within the Shrine of Our Lady of Mercy – "Penrose Park". It is noted that whilst no exceedances are predicted, it is likely, from time to time, that noise would be audible at the surrounding residences and the Grotto[3], however, the noise level would be such that it would not be intrusive.

[3] Circumstances when noise from the Quarry operations are audible would typically be when the prevailing background noise level is lower than the rating background level which may, for example, be related to when wind is not enhancing noise from the Hume Highway.

The noise contours in Spectrum (2018) confirm that the area of coverage of noise levels above the relevant criteria would not exceed more than 25% of properties surrounding the Site. Therefore, the provisions of the *Voluntary Land Acquisition and Mitigation Policy* (VLAMP) are not applicable.

5.4.7.3 Maximum Noise Level Assessment

Predicted maximum noise levels (that is, L_{max}) were modelled using the ENM software and are displayed in **Table 5.17** for all assessed residences. The values shown represent the worst case over all modelled scenarios when night-time activities would occur.

Table 5.17
Predicted Sleep Disturbance Levels, dB(A),L_{max}

Receiver*	Meteorological condition				Criteria
	Neutral	Inversion	SE Wind	W Wind	
R2	39	42	38	43	52
R4	34	<40	<40	<40	56
R5	<30	<40	<40	<40	56
R8	<30	<35	<30	<35	52
R11	<30	<35	<30	<35	52
R12	<30	<35	<30	<35	52
R13	<30	<35	<30	<35	52
R15	47	46	45	46	52
R16	30	33	32	<30	52
R17A	<30	<35	<35	<30	52
R17B	<30	<35	<35	<30	52
R19	<30	<30	<30	<30	52
R22	<30	<30	<30	<30	52
R23	<30	<30	<30	<30	52
R24	<30	<30	<30	<30	52
R25	<30	<30	<30	<30	52
R26	<30	<30	<30	<30	52
R27	<30	<30	<30	<30	52
R28A	<30	<35	<35	<30	52
R28B	<30	<35	<35	<30	52
R28C	<30	<35	<35	<30	52
R30	<30	<35	<35	<30	52
R31	<30	<35	<35	<30	52
R33	<30	<35	<35	<30	52
R35	<30	<35	<35	<30	52
* See **Figure 5.14**					
Source: Spectrum (2018) – Table 18					

Predicted maximum noise levels in **Table 5.17** are well below the maximum noise level assessment trigger levels at all receivers. Therefore, a detailed maximum noise level assessment is not required.

5.4.7.4 Off-site Road Traffic Noise

Based on the maximum annual product despatch rate of 860 000t, the Proposal would generate up to 50 movements per hour. Product despatch is proposed to occur on a 24 hour basis and the most stringent traffic noise criterion is 55dB(A),$L_{eq(9hour)}$. Based on a speed of 110km/h and in the absence of noise barriers, it has been calculated that the criterion would be achieved at distances greater than 30m from the road. All residences within the noise study area are at distances greater than 250m from the Hume Highway and compliance with the RNP traffic noise criterion would be achieved. Outside the noise study area, there is a property called "Black Horse Farm" with a residence approximately 30m from the Hume Highway. The predicted traffic noise level attributable to trucks travelling from the Site would not exceed the traffic noise criterion at this receiver. Roads and Maritime Services (RMS) traffic count stations at nearby locations on the Hume Highway indicate approximately 240 heavy vehicles per hour pass the Site, compared to a maximum of 50 heavy vehicles per hour from the Proposal. The calculated increase in traffic noise level from the Proposal is less than 1dB which is less than the allowable 2dB increase under the NSW RNP for which mitigation is not required.

5.4.7.5 Blasting Assessment

The predicted air blast overpressure and ground vibration levels at the locations described in Section 5.4.2 are provided in **Table 5.18**. These results indicate that while blasts are likely to be heard within several kilometres of the blast location, the blast overpressure and ground vibration levels would be below the human comfort criteria at each of the assessed locations. The Proposal would easily satisfy criteria for ground vibration levels at the Grotto, rock shelter and gas and water pipelines assessed for realistic charge weights.

Table 5.18
Predicted Blast Overpressure and Ground Vibration Levels

Receiver	Distance (m)[a]	Criterion		MIC = 50 kg		MIC = 200 kg	
		PPV[b]	OP[c]	PPV	OP	PPV	OP
R33	2000	5	115	0.1	96	0.2	99
R17B	720	5	115	0.3	107	1.0	110
R2	585	5	115	0.4	109	1.2	111
R17 (Grotto) nearest point	500	25	115	0.6	110	1.4	112
R17 (Grotto) furthest point	800	25	115	0.2	106	0.9	109
Rock shelter	100	50	--	7.2	--	21.9	--
Gas/water pipelines	250	20	--	1.7	--	5.0	--

[a] Distance from receiver to closest point of extraction area.
[b] Peak vertical ground vibration, mm/s.
[c] Blast overpressure, dB

Source: Spectrum (2018) – Table 19

The majority of extraction activities would occur through ripping of friable sandstone, while blasting would be an intermittent activity at the Site. Spectrum (2018) established that the vibration impacts from ripping activities would be significantly lower than impacts relating to blasting and therefore would satisfy all relevant vibration criteria, including at the Grotto and outdoor shrines, rock shelter and for the gas and water pipelines.

5.4.7.6 Road Traffic Vibration Assessment

Noise and vibration measurements of a large number of passing vehicles were conducted in 2008 by G R Watts and R E Stait (TRL Limited, UK) with results are documented in a report titled "Characteristics of vehicles producing excessive noise and ground-borne vibration – Phase 1".

Watts and Stait (2008) found that there was little variation in vibration levels with vehicle speed and that the 95th percentile (2 standard deviations) level was approximately 0.23 mm/s. The recorded levels were approximately one tenth of the minimum human comfort criterion for intermittent events during night time.

When compared to the traffic volume and context of the Proposal, Spectrum (2018) concluded that vibration attributable to heavy vehicle movements would be at a level considered below "barely noticeable" perception levels, implying negligible potential vibration impacts at Residence 15.

5.4.7.7 Cumulative Impacts

The Proposal may result in cumulative noise impacts at residences to the southwest of the Site should operations for the Penrose Quarry and Green Valley Sand Quarry, both of which are south of the Hume Highway, reach maximum capacity at the same time. Residence 26 and Residence 24 have the greatest potential to be cumulatively impacted with respect to noise emission from the three quarries.

Spectrum (2018) assessed potential cumulative noise impacts at Residence 24 and Residence 26 and concluded that cumulative noise levels would be 35dB(A) and would remain within the default assessment criteria for these locations. The higher noise levels at these locations would likely result from activities within the Penrose Quarry. It should be noted that the amenity criteria of 40dB(A), used at these locations for the assessment of the Proposal alone, would also be satisfied.

5.4.8 Monitoring

In addition to the monitoring program discussed in Section 5.4.5.2 as part of the noise reduction program, the Applicant would commission a further noise monitoring program through an independent acoustic consultant to record representative noise levels throughout the site establishment and construction stage and on a quarterly basis for at least the first two years of operations. Monitoring locations would include agreed locations within the Shrine of Our Lady of Mercy – "Penrose Park" and at Residences R2 and R15. Details of the proposed monitoring program would be included in the Noise and Vibration Management Plan for the Quarry.

Each blast event would be monitored for ground vibration and airblast overpressure at the Grotto and other agreed locations with monitoring protocols established in an approved Noise and Vibration Management Plan.

5.4.9 Conclusion

An assessment of the Project-related operational noise, maximum noise impacts, airblast overpressure and ground vibration as well as heavy vehicle vibration has concluded that the Proposal would satisfy all relevant assessment criteria at all privately-owned residences and the Grotto and international chapels within the Shrine of Our Lady of Mercy – "Penrose Park".

5.5 TERRESTRIAL ECOLOGY

5.5.1 Introduction

The DGRs for the Proposal identified "*Biodiversity*" as a key issue requiring that the "*EIS include:*

- *accurate estimates of proposed vegetation clearing and impacts on regionally significant remnant vegetation, or vegetation corridors;*
- *a detailed assessment of potential impacts of the development on any terrestrial or aquatic threatened species or populations and their habitats, endangered ecological communities and groundwater dependent ecosystems; and*
- *a detailed description of the measures taken to avoid, reduce or mitigate impacts on biodiversity including an appropriate biodiversity offset strategy.*"

Additional matters for consideration in preparing the EIS were also provided in the correspondence attached to the DGRs from OEH which related to Biodiversity and included the following requirements.

- Include an assessment of biodiversity impacts using the *Biobanking Assessment Methodology* or a detailed biodiversity assessment, paying particular attention to indirect impacts on Long Swamp and the threatened entities associated with this formation.
- A field survey of the Site should be conducted and documented in accordance with relevant guidelines.
- An assessment of the significance of direct and indirect impacts of the proposal must be undertaken for threatened biodiversity known or considered likely to occur in the study area based on the presence of suitable habitat including indirect impacts on the threatened ecological communities and threatened flora associated with Long Swamp.
- Identify any relevant Matters of National Environmental Significance and whether the proposal has been referred to the Commonwealth or already determined to be a controlled action.

Also appended to the DGRs is correspondence from DRE requesting an assessment of the ecological sustainability of the Proposal.

It is noted that the commencement of the *Biodiversity Conservation Act 2016* (BC Act) on 25 August 2017, triggered the repeal of the *Threatened Species Conservation Act 1995* (TSC Act). All threatened species listings for NSW are now listed in the schedules of the BC Act. However, as the TSC Act is specifically referenced in the Director-General's Requirements for the Proposal, reference to the TSC Act is retained throughout this document.

Based on the risk assessment undertaken for the Proposal (**Appendix 4**), the potential impacts relating to flora and fauna and their risk rankings (in parenthesis) after the adoption of pre-existing or standard mitigation measures are as follows.

- Removal of flora and fauna species identified within the Site through clearing activities resulting in:
  - loss of biodiversity and alteration to existing habitat (medium);
  - local or regional reduction in distribution of threatened species, populations and endangered ecological communities (medium); and/or
- Detrimental effects of indirect Proposal impacts, e.g. noise, dust, lighting resulting in:
  - reduced biodiversity value of the Site (medium); and/or
  - reduced local distribution of threatened species, populations and endangered ecological communities (medium).

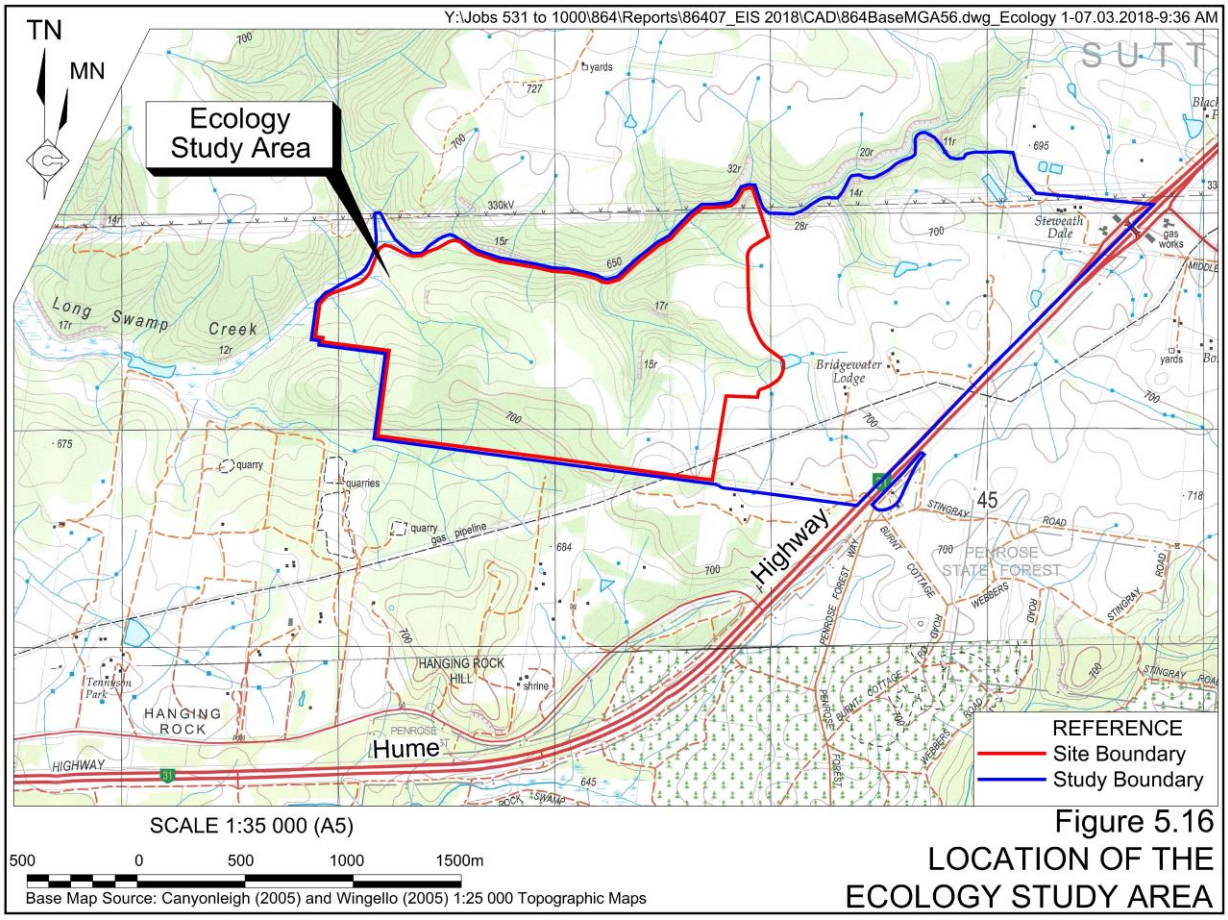
A Flora and Fauna Assessment of the majority of the Site and land to the east of the Site was undertaken by Dr Kevin Mills of Kevin Mills & Associates Pty Limited (KMA), with supplementary assessment of the Quarry Access Road corridor undertaken by Ms Kayla Asplet of Biosis Pty Ltd.

The resulting reports are presented as Part 5A and Part 5B, respectively, of the *Specialist Consultants Studies Compendium* and are referred to hereafter as "KMA (2018)" and "Biosis (2018)". This subsection of the EIS provides a summary of the flora and fauna impact assessments, concentrating on those matters raised in the DGRs and related requirements provided by various government agencies. A consolidated list of the identified requirements relating to flora and fauna and where each is addressed is presented in **Appendix 2**. Flora and fauna presence was assessed within a "study area" displayed relative to the Site in **Figure 5.16**.

This section makes reference to the Biodiversity Offsets Assessment prepared by Niche Environment and Heritage Pty Ltd (Niche, 2018). The assessment of residual impacts upon the terrestrial ecology includes reference to offsetting requirements and the preliminary Biodiversity Offset Strategy which are described further in Section 2.14 and Niche (2018) which is included as Part 11 of the *Specialist Consultant Studies Compendium*.

5.5.2 Assessment of the Site

The assessment of the Site and rural land to the east of the Site was undertaken by KMA (2018). The following subsections review the assessment of native flora and fauna identified within the KMA (2018) study area. More detailed information is presented in KMA (2018) included as Part 5A of the *Specialist Consultant Studies Compendium*.



5.5.2.1 Flora

The purpose of the KMA (2018) flora surveys was to:

- classify and describe the vegetation;
- map the distribution of the plant communities;
- record as many as possible of the plant species present;
- search for threatened plant species; and
- collect information for the Biodiversity Offset Assessment (Section 2.14 and Niche, 2018).

Study Methodology

The KMA (2018) flora survey involved several key components, aimed at describing and mapping the plant communities and preparing a comprehensive plant species list for the whole of the KMA (2018) study area. Particular attention was given to the identification, location and assessment of threatened and rare plants and communities.

The KMA (2018) flora survey targeted all vascular plant species, including indigenous (native) and exotic (introduced or weed) species of plant. The flora survey methods employed and the effort expended are summarised in Section 3 of KMA (2018).

The flora surveys were undertaken in the KMA (2018) study area on the following dates: 3, 4, 11, 18 and 26 September 2012, 17 October 2012, 10 September 2013, 10 September 2016 and 3 May 2016. Maps used in the study included the 1:25 000 Wingello topographic map produced by the Central Mapping Authority of New South Wales, a colour aerial photograph of the KMA (2018) study area and surrounding area and site plans. These resources allowed detailed targeted surveys to be undertaken to cover all variations in geology, topography and aspect across the KMA (2018) study area. Additional surveys in 2013 and 2016 support initial field survey results and indicate that the habitat and vegetation communities within the Site have remained unchanged since the 2012 surveys. This confirms that the results presented in this assessment remain reliable.

Additional surveys were conducted by Niche Environment and Heritage in February 2014 to validate the vegetation mapping prepared by KMA (2018) and to collect supplementary site attribute data relating to the biodiversity offsets assessment. The results of this assessment are presented in Section 2.14 and the complete assessment is provided as Part 11 of the *Specialist Consultants Studies Compendium* and referred to as Niche (2018).

Reliance has been placed upon the Applicant's commitment to provide a biodiversity offset to account for the clearing of remnant native vegetation throughout the life of the Quarry.

Survey Techniques

The KMA (2018) vegetation survey combined multiple traverses of the study area with disciplined vegetation sampling on specific sites (plots). The traverses, which were undertaken on foot, were targeted to cover the full topographic variation of the Site, the full range of plant communities and potential habitat for threatened plant species. The traverses were also random because of their exploratory purpose. Floristic surveys on 20m by 20m plots were employed to gather floristic information at selected sites, sampling the range of vegetation types present in the KMA (2018) study area.

Identification and description of the plant communities in the study area were prepared based on the field investigations undertaken across the whole of the KMA (2018) study area and the detailed plot surveys. Copies of the completed plot survey sheets are provided in Appendix 1 of KMA (2018). The proposed extraction area was targeted more than outlying parts of the KMA (2018) study area.

Vegetation Communities and Flora Species

A vegetation map for the KMA (2018) study area was prepared by marking the boundaries of the various communities directly onto a copy of the aerial photograph during the field study and then transferring this information to a topographic map to produce the final plant community map. KMA (2018) records that the boundaries on the vegetation map are reasonably accurate, however, there is usually an ecotone or transition zone between plant communities, where the vegetation changes gradually from one community to another and species are well mixed over the ecotone, which in some cases may be quite wide.

Based on the structural classification system of Walker and Hopkins (1990), the plant communities occurring in the study area were classified on the basis of their structure and the name(s) of the dominant species in the tallest stratum.

Minor updates to the vegetation mapping were made as a result of the additional surveys undertaken by Niche. The final map of vegetation communities used for the offset assessment and assessment of impacts to flora and fauna is displayed on **Figure 5.17**.

Seven plant communities were identified in the KMA (2018) study area. A complete description of each is provided in KMA (2018), however, a brief summary of the communities that occur within the KMA (2018) study area and proposed areas to be cleared within each community is summarised in **Table 5.19**.

Table 5.19
Vegetation Communities in the Study Area

Community/Name	Key Species	Distribution in the Study Area	Area to be Disturbed (ha)
1. Peppermint Tall Forest	*Eucalyptus elata* *Eucalyptus fastigata* *Eucalyptus elata*	In sheltered locations in valleys mainly along Long Swamp Creek and its tributaries.	0.0
2. Sydney Peppermint Forest	*Eucalyptus piperita* *Eucalyptus sieberi* *Eucalyptus agglomerata*	Extensive on gentle topography across the property, mainly growing on deep sand.	7.6
3. Stringybark Forest	*Eucalyptus sieberi* *Eucalyptus agglomerata* *Eucalyptus punctata*	On the rocky ridge in the south of the area.	2.7
4. Scribbly Gum Woodland	*Eucalyptus sclerophylla* *Eucalyptus sieberi* *Eucalyptus mannifera* *Eucalyptus dives*	On dry slopes and ridges, extending into some valleys where Berry Siltstone occurs.	23.1
5. Regrowth Peppermint Forest	*Eucalyptus piperita* *Eucalyptus sieberi* *Eucalyptus sclerophylla* *Pinus radiata**	Previously cleared and left to regenerate.	28.5
6. Freshwater Wetland (Swamp)	*Leptospermum* spp. *Carex appressa* *Eucalyptus aquatica* *Phragmites australis*	Alluvium along Long Swamp Creek.	0.0
7. Cleared Land	Variable - grassland dominated by exotic herbaceous species, particularly pasture grasses.	Across the eastern part of the property.	12.3
* Exotic Species			
Source: KMA (2018) – Table 9 and Table 12			

The native flora species recorded throughout the study area have been listed in Appendix 3 of KMA (2018). The area is floristically diverse, with 196 indigenous species being recorded. The relatively high floristic diversity exhibited across the study area is attributed to its location effectively on the overlap of the Sydney Basin and Southern Tablelands.

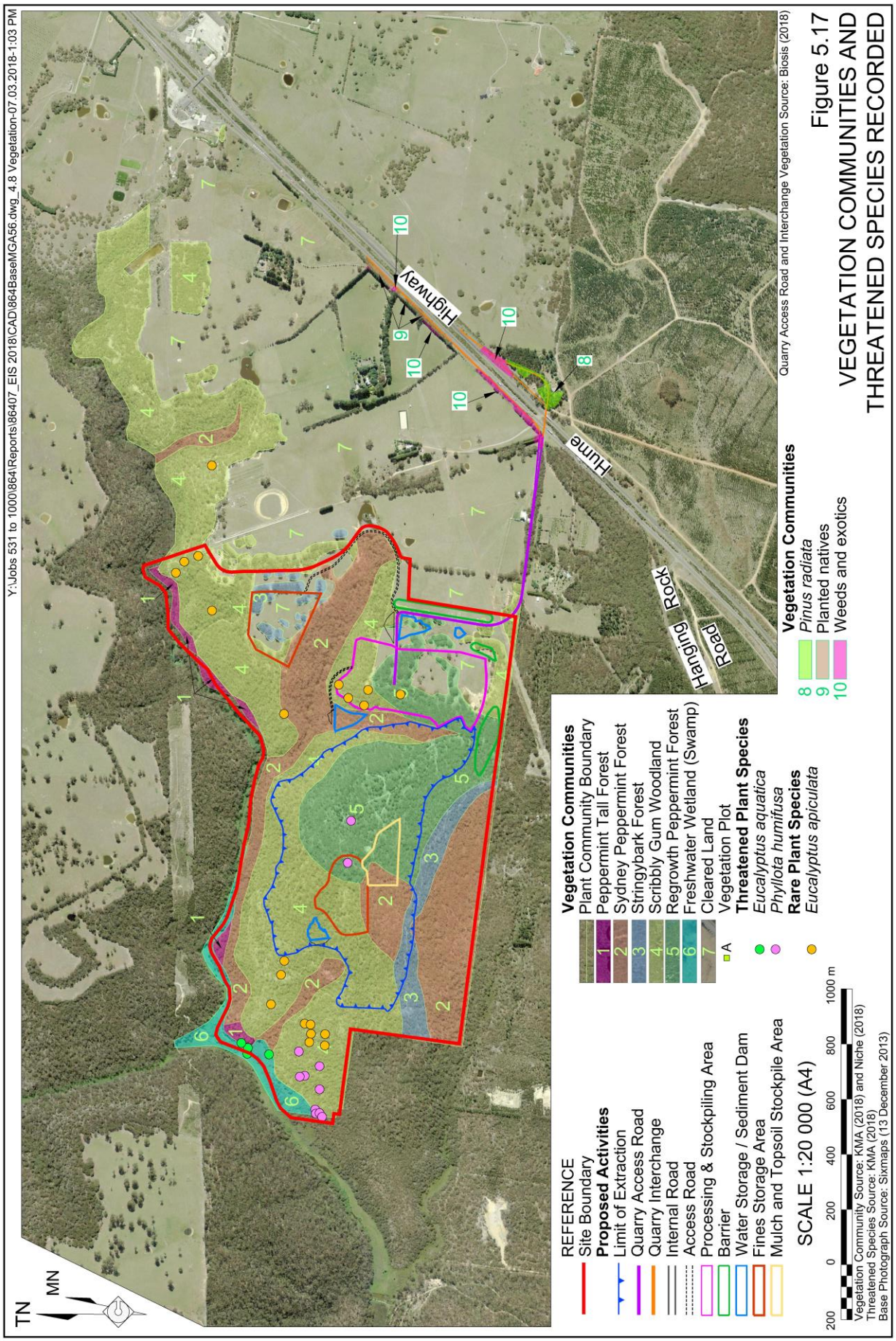


Figure 5.17
VEGETATION COMMUNITIES AND THREATENED SPECIES RECORDED

Exotic Species

A total of 26 exotic species were recorded within the KMA (2018) study area. Some of these species are listed as priority weeds for the Wingecarribee Local Government Area (under the *Biosecurity Act 2015*) or are regarded as environmental weeds. It is noted that environmental weeds have no legislative standing, whereas declared priority weeds must be controlled according to the relevant biosecurity duty. Both the priority and environmental weeds are listed in **Table 5.20**.

Table 5.20
Priority and Environmental Weeds within the Study Area

Category/Species	Common name	Habit
Priority Weeds		
Nassella trichotoma	Serrated Tussock	Grass
Rubus fruticosu sp. agg.	Blackberry	Shrub
Salix babylonica	Weeping Willow	Tree
Senecio madagascariensis	Fireweed	Herb
Environmental Weeds		
Lonicera japonica	Japanese Honeysuckle	Creeper
Pinus radiata	Radiata Pine	Tree
Salix babylonica	Weeping Willow	Tree
Source: KMA (2018) – Table 10		

Threatened Flora Species

Two threatened plants listed as vulnerable in the TSC Act (now BC Act) were recorded in the KMA (2018) study area, namely Paddys River Swamp Gum (*Eucalyptus aquatica),* and Dwarf Phyllota (*Phyllota humifusa).* Both species are also listed as vulnerable in the EPBC Act. The general locations of these species are shown on **Figure 5.17**. A list of GPS locations for each species within the study area is provided in Appendix 8 of KMA (2016).

Three individual plants of *Phyllota humifusa* were identified within the proposed extraction area, while the *Eucalyptus aquatica* would not be disturbed by the Proposal. More than 100 individual plants of *Phyllota humifusa* and more than 250 individual plants of *Eucalyptus aquatica* were identified within the proposed on-site biodiversity offset area.

Narrow-leaved Mallee Ash (*Eucalyptus apiculata*) was identified within the proposed areas of disturbance for the Site. This plant is not listed in the TSC Act or the EPBC Act but is listed in the Rare or Threatened Australian Plants (RoTAP) database.

Endangered Ecological Communities

Endangered ecological communities in New South Wales are listed under the TSC Act (now BC Act). Nationally threatened ecological communities are listed under the EPBC Act.

No endangered ecological communities occur in the area that would be disturbed for the Proposal. The swamp vegetation in the Long Swamp Creek catchment, outside the Site boundary has been identified as 'Montane Peatlands and Swamps' which is listed under the TSC Act (now BC Act). The vegetation community is also listed under the EPBC Act as 'Temperate Highland Peat Swamps on Sandstone'. This is discussed in detail in Section 5.2.3.

A copy of the NSW Scientific Committee's Final Determination for this community and information on the Commonwealth listing are respectively provided in Appendix 6 and 7 of KMA (2018).

5.5.2.2 Fauna

The KMA (2018) terrestrial fauna survey aimed to describe and map threatened fauna and their habitat in the study area and compile a comprehensive animal species list. Particular attention was given to the identification, location and assessment of threatened or rare animal species and their habitat.

Tables 4 in KMA (2018) describes in detail the survey methods used to identify fauna species on the study area, particularly threatened species nominated by the OEH.

Intensive fauna surveys were undertaken between 2 and 6 September 2012 inclusive with the consultants returning to collect and examine the hairtube traps, infrared cameras and echolocation devices on 12 October 2012 and 14 October 2012 that had been collecting data over the intervening period. The surveys targeted all vertebrate animal species, including indigenous (native) and exotic (introduced) species of fauna. KMA (2018) describes in detail the various survey methods adopted for the various fauna groups and the locations of survey efforts. KMA (2018) again visited the Site in May 2016 and found that there had been no change in the habitats present, the area of tree vegetation, or any other feature that may result in a change in the fauna inhabiting and visiting the Site. In brief, mammals were identified by sight, as well as by interpreting distinctive calls and other signs of their recent occurrence within the study area, e.g. scats, diggings, burrows, hair etc. Small mammals were surveyed using live trapping techniques such as Size A and B Elliott traps, wire cage traps and hairtube traps. Microchiropteran (insectivorous bats) were surveyed using ANABAT detection equipment and harp trapping. Arboreal mammals (possums and gliders) were searched for by spotlighting transects.

The bird fauna of the study area was investigated through timed 30 minute searches in all habitats throughout the study area. Nocturnal birds were sought through spotlighting and listening for calls during all nocturnal survey work. Call play-back was used for determining the presence of the Powerful Owl, Barking Owl, Sooty Owl and Masked Owl as well the Squirrel Glider, Yellow-bellied Glider and Koala.

Reptiles and frogs were surveyed by targeted searches in various locations across the study area. These were 20 minute hand searches, and involved lifting and looking underneath rocks, logs, ground debris, under exfoliated bark and, where present, in crevices/caves/overhangs.

Fauna Habitat

The fauna habitat within the study area consists primarily of forest and tall forest, with areas of woodland and cleared and modified land. The forests that have regrown from earlier clearing are largely composed of small trees that grow quite densely compared to the original forest.

Hollow-bearing trees were surveyed and the results are presented in Appendix 5 of KMA (2018). In all, 102 hollow-bearing trees were recorded in and immediately adjacent to the Site.

Sandstone outcrops and cliffs with overhangs are common around the edges of the ridges.

Swamp associated with Long Swamp Creek is located approximately 100m downstream of the Site. There are a few ephemeral watercourses in small gullies within the Site.

Species Recorded

The fauna species recorded within the study area are listed in full in Appendix 4 of KMA (2016). In addition to identified species, those previously recorded in the vicinity of the study area are also listed for consideration in the assessment. The latter information has come from studies undertaken nearby and from the NSW Wildlife Atlas (OEH, 2016).

Threatened Species Recorded

The following five threatened bird species and four threatened bat species listed in the TSC Act were recorded in the KMA (2018) study area and locations of identified species or where survey techniques were applied are displayed in **Figure 5.18**.

- Glossy black cockatoo (*Calyptorhynchus lathami*)
- Scarlet robin (*Petroica boodang*)
- Varied sittella (*Daphoenositta chrysoptera*)
- Gang-gang cockatoo (*Callocephalon fimbriatum*)
- Powerful owl (*Ninox strenua*)
- Eastern Falsistrelle / Eastern False Pipistrelle (*Falsistrellus tasmaniensis*)
- Eastern bentwing bat (*Miniopterus schreibersii*)
- Large-eared pied bat (*Chalinolobus dwyeri*)
- Greater broad-nosed bat (*Scoteanax rueppellii*)

A list of locations for each species within the study area is provided in Appendix 8 of KMA (2018) together with a GPS location for each observation.

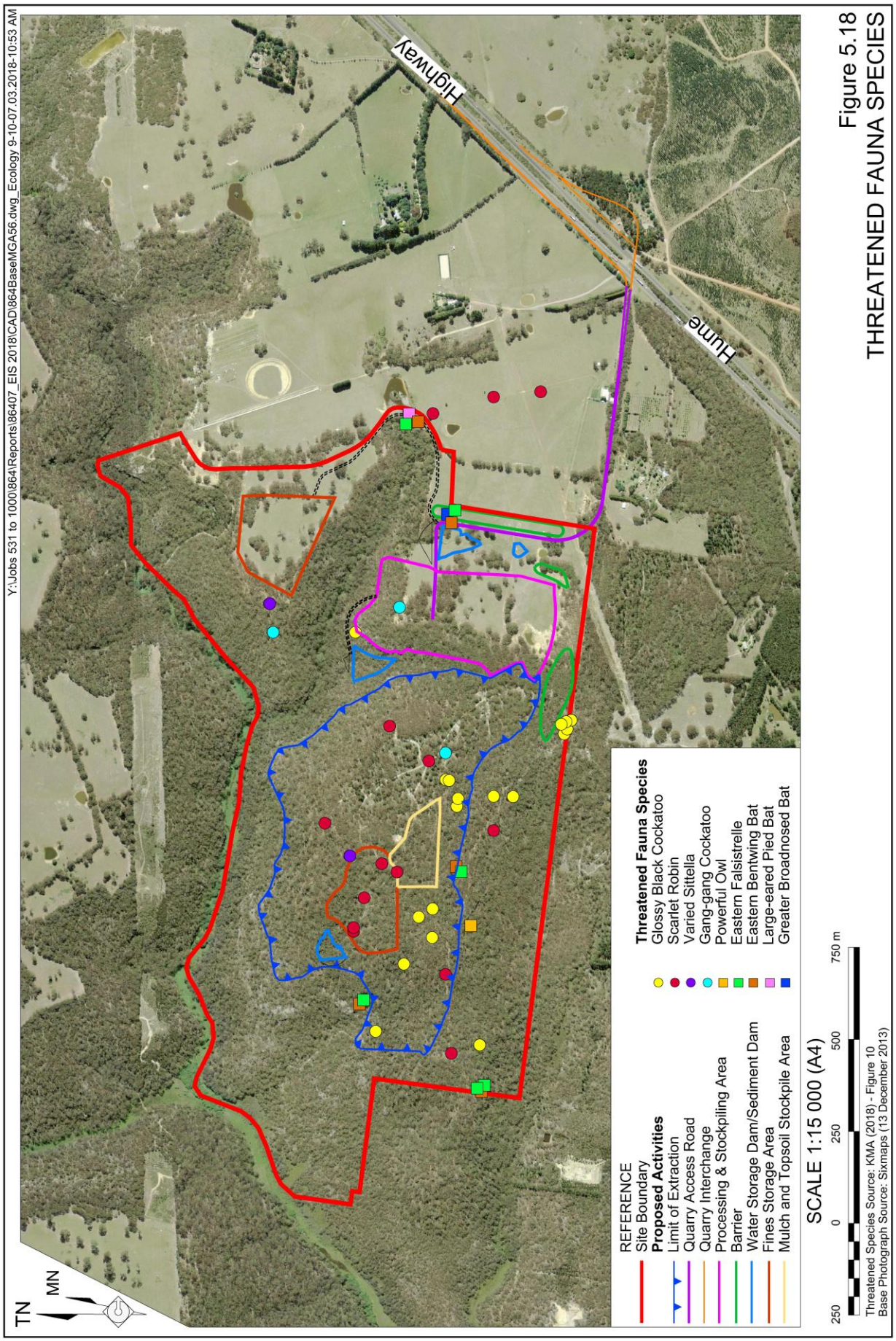
5.5.3 Assessment of the Quarry Access Road Corridor

At the time of the KMA (2018) surveys, the Applicant proposed to access the Site via the existing Sallys Corner Interchange and traverse the intervening four properties (Lots 1, 2, 3 and 4 DP253435). The proposed access arrangements via a new Quarry Interchange were finalised in late 2017 and Biosis Pty Ltd was commissioned to undertake an ecological assessment of the corridor of land that would be disturbed for construction and use of the Quarry Access Road and Quarry Interchange. The following subsections describe the methods and results of the Biosis (2018) assessment.

5.5.3.1 Survey Methodology

Ecological surveys of the Quarry Access Road and Quarry Interchange corridor included the following.

- Vegetation mapping and condition assessment and a threatened flora habitat assessment was undertaken by Mr Mathew Misdale on 9 January 2018. The survey included two plot/transects completed in accordance with BioBanking Assessment Methodology (OEH, 2014a). Targeted survey was also undertaken for potentially occurring threatened flora using a straight line transect with a 10m spacing, and detailed survey of high potential habitat areas.


Y:\Jobs 531 to 1000\864\Reports\86407_EIS 2018\CAD\864BaseMGA56.dwg_Ecology 9-10-07.03.2018-10:53 AM
Highway
Hume
TN
MN
REFERENCE
Site Boundary
Proposed Activities
Limit of Extraction
Quarry Access Road
Quarry Interchange
Processing & Stockpiling Area
Barrier
Water Storage Dam/Sediment Dam
Fines Storage Area
Mulch and Topsoil Stockpile Area
Threatened Fauna Species
Glossy Black Cockatoo
Scarlet Robin
Varied Sittella
Gang-gang Cockatoo
Powerful Owl
Eastern Falsistrelle
Eastern Bentwing Bat
Large-eared Pied Bat
Greater Broadnosed Bat
SCALE 1:15 000 (A4)
250 0 250 500 750 m
Threatened Species Source: KMA (2018) - Figure 10
Base Photograph Source: Sixmaps (13 December 2013)
Figure 5.18
THREATENED FAUNA SPECIES

- A habitat-based fauna assessment was undertaken on 27 February 2018 by Ms Kayla Asplet and Mr Sam McCann (Zoologist) and took into account the species predicted to occur by the BioBanking calculator (a total of 21 species), as well as recording the presence of suitable habitat for threatened species.

5.5.3.2 Flora

The vegetation communities recorded within the Quarry Access Road and Quarry Interchange corridor are described in detail in Biosis (2018) and included the following.

- Scribbly Gum Woodland (HN565 - Red Bloodwood - Hard-leaved Scribbly Gum - Silvertop Ash heathy open forest on sandstone plateaux of the lower Shoalhaven Valley, Sydney Basin) - moderate/good condition.
- Scribbly Gum Woodland (HN565 - Red Bloodwood - Hard-leaved Scribbly Gum - Silvertop Ash heathy open forest on sandstone plateaux of the lower Shoalhaven Valley, Sydney Basin) – low condition.
- Roadside Vegetation – including Radiata Pine with slashed groundcover with areas dominated by exotic vegetation, planted native trees and shrubs and occasional remnant River Peppermint (*Eucalyptus elata*)

These vegetation communities are displayed in **Figure 5.17**. No threatened flora was identified in targeted searches.

5.5.3.3 Fauna

Fauna species identified by Biosis (2018) are described in detail in Appendix 3 of Biosis (2018). In summary, no threatened fauna were identified by Biosis (2018) except for the Rufous Fantail (*Rhipidura rufifrons*) a migratory species listed under the EPBC Act. However, Biosis (2018) identified the following habitat features that may support threatened fauna.

- Feed trees including Eucalypts were identified that may provide nectar for a range of arboreal and flying fauna.
- Feed trees that may support Koala were identified.
- Hollow-bearing trees bearing small to medium sized hollows, that may support roosting microbats or birds.
- Ephemeral habitat was identified including abandoned nesting sites and loosened bark.

5.5.4 Conservation Significance

Threatened Species

Nine threatened fauna species and two threatened flora species listed in the TSC Act (now BC Act) were recorded in the study area. Detailed profiles of each species are presented in Section 6 of KMA (2018). Although the listing of *Eucalyptus apiculata* on the RoTAP database does not provide statutory protection, the Applicant has included this plant in its considerations for the design and planning of the Proposal.

Migratory Species

In addition to threatened species, the EPBC Act allows for the listing of internationally protected migratory species, i.e. species listed under the Japan – Australia Migratory Bird Agreement (JAMBA), the China – Australia Migratory Bird Agreement (CAMBA) and the Convention on the Conservation of Migratory Species of Wild Animals (Bonn Convention).

Various internationally protected migratory species occur in every part of Australia, at least from time to time, as many of the listed species are common and widespread Australian species. These include all species of native duck and diurnal birds of prey. Although Biosis (2018) identified the Rufous Fantail (*Rhipidura rufifrons*) in the Quarry Access Road and Quarry Interchange, the remainder of the Site contains no important habitat for migratory species and KMA (2018) concluded that the habitat within the Site is not likely to support an ecologically important proportion of a population of such species. Migratory species are therefore not further considered in this assessment.

5.5.5 Design and Operational Safeguards

The principal ecological safeguard for the Proposal has been the design of the area of disturbance. The Applicant has focussed the placement of the boundary of the extraction area such that the majority of the vegetation to be cleared would be regrowth forests. This in turn would limit the area used for foraging by native threatened species. The topsoil and mulch storage area and the second fines storage area have been located within the section of the proposed extraction area that would not be required until Stage 6, thereby limiting the area of remnant vegetation or agricultural land that would need to be used.

The proposed revegetation of the final extraction area with native vegetation would assist to re-create habitat for fauna species travelling either northwards or southwards through the Site (see Section 2.13 and **Figure 2.16**).

Management and preservation of biodiversity values within the Site would be guided by a Landscape and Rehabilitation Management Plan that would be provided to DPE for approval 3 months prior to the commencement of the site establishment and construction stage and would include protocols for the following activities.

- Soil stripping and stockpiling.
- Vegetation clearing protocols.
- Clearing, handling and placement of hollow-bearing trees.
- Weed management.
- Bush fire management.
- Threatened species management.
- Management of the biodiversity offset area(s), once secured.
- Progressive and final rehabilitation of the Site

The Applicant acknowledges that the removal of approximately 63.2ha of native vegetation would be a residual impact of the Proposal. As a result, a preliminary Biodiversity Offset Strategy has been prepared that includes securing an approximately 102ha on-site biodiversity offset area and an approximately 200ha property on which an off-site biodiversity offset would be developed. The preliminary Biodiversity Offset Strategy is presented in Section 2.14.

During consultation with the local community, it was identified that a population of Koala has been identified in the vicinity of the Site by local community members, who recalled seeing individuals and hearing the males in springtime. No Koala were identified within the Site by KMA (2018) or Biosis (2018), although the presence of feed trees has been noted. It should also be noted that KMA (2018) undertook targeted surveys for the species during Spring and therefore surveys for this species have been comprehensive.

As noted in Section 2.14, surveys of the on-site offset area and off-site offset area would be required to finalise the Biodiversity Offset Strategy in accordance with the Biodiversity Assessment Methodology under the Biodiversity Offset Scheme. In acknowledgement of the community concerns regarding the Koala, targeted surveys of this species would be included in these surveys. In addition, measures for identification and management of Koala identified prior to vegetation clearing would be included in the Landscape and Rehabilitation Management Plan for the Proposal.

5.5.6 Assessment of Impacts

5.5.6.1 Assessment of Significance

It is noted that as a State Significant Development, the Proposal is required to be considered under the Biodiversity Offset Scheme of the BC Act. As a result, an assessment of significance of the Proposal under Section 7.3 of the BC Act is not required. However, in order to demonstrate to the local community and the relevant government agencies the level of impact of the Proposal on the terrestrial flora and fauna within the study area, a five-part test has been conducted by KMA (2018). In summary, KMA (2018) concluded the following.

1. Although the Proposal would remove at least some habitat of the threatened plant *Phyllota humifusa* as well as habitat for five threatened birds and four threatened bat species, a viable local population of these species would not be significantly impacted because of the removal of the relatively small area when considered in relation to the larger areas of remnant native vegetation that are available nearby, particularly within the proposed biodiversity offset area.
2. There are no endangered ecological communities or critically endangered ecological community within the Site that would be significantly impacted. The groundwater impact assessment (see Section 5.2) has concluded that base flow impacts to Long Swamp Creek and therefore to the potentially groundwater dependent vegetation community listed in the BC Act as ‘Montane Peatlands and Swamps’, and under the EPBC Act as ‘Temperate Highland Peat Swamps on Sandstone’ would be within the range of natural base flow fluctuations.
3. While impacts to individual species would not be significant, the removal of a large area of potential habitat is considered by KMA (2018) to be significant for which a biodiversity offset area would be appropriate. The Proposal would not isolate or fragment any existing habitat.

4. There would be no impacts to areas of outstanding biodiversity value as none has been declared within the Site.
5. Three 'key threatening processes' would result from the Proposal. These include the following.
   - Clearing of native vegetation.
   - Loss of hollow-bearing trees.
   - Removal of dead wood and dead trees.

KMA (2018) concluded that the Proposal would not result in a significant impact to any individual threatened species such that a viable local population of the species would be at risk of extinction. However, the removal of 63.2ha of native vegetation, that includes known and potential habitat for threatened species as well as hollow-bearing trees and dead wood or dead trees, would exacerbate existing key threatening processes. This has the potential to adversely impact the threatened fauna species recorded within the Site and therefore represents a significant impact. The removal of this vegetation would be addressed through an offsetting mechanism such as the proposed preliminary *Biodiversity Offset Strategy* described in Section 2.14.

5.5.6.2 Environment Protection and Biodiversity Conservation Act 1999 Considerations

KMA (2018) concluded that, the development of the Proposal is not likely to have a significant impact on matters of national environmental significance listed under the *Environment Protection and Biodiversity Conservation Act 1995*. Therefore, a referral to the Commonwealth Minister for the Environment for assessment and approval is not necessary.

SEPP No. 44 – Koala Habitat Protection

Wingecarribee Local Government Area (LGA) is one of the LGAs for which *State Environmental Planning Policy No.44 - Koala Habitat Protection* (SEPP 44) applies. As already outlined in Section 3.2.3.2, Koalas are not likely to occur on the Site. Two Schedule 2 Koala food trees occur in the area, namely Ribbon Gum *Eucalyptus viminalis* and Grey Gum *Eucalyptus punctata*. However, less than 15% of the trees present were of these species. The area is therefore not "potential Koala habitat" and no further provisions of the Policy apply.

It is acknowledged that a community of Koala in the area is known to local community members. As no Koala were identified within the Site by KMA (2018) or Biosis (2018), offsetting for the Koala is not required. It should be noted that the preliminary Biodiversity Offset Strategy includes the options to establish an on-site and off-site offset area that is likely to include similar Koala feed trees. These areas (displayed in **Figure 2.19**) may be secured for biodiversity conservation in perpetuity and provide long-term habitat for any Koalas that may be in the area. Any process to offset ecosystem credits as a result of the Proposal would, in effect, preserve similar Koala habitat in this manner. In addition, specific management measures directed at identifying and relocating Koala during vegetation clearing have been described in Section 5.5.5.

5.5.6.3 Wildlife Corridors

The study area is located within a wildlife corridor identified in the *Illawarra Regional Environmental Plan No. 1* (Department of Planning, 1986), the *Wingecarribee Local Environmental Plan 2010* and the Southern Highlands Biolink, a regional corridor initiative described in the Great Eastern Ranges Initiative. The purpose of the designated wildlife corridor is to facilitate the interaction of fauna species through the upper Wollondilly River catchment to the north, including the extensive natural areas in the Warragamba Water Catchment Area, and Morton National Park to the south of Bundanoon and Wingello. The Site occurs on the eastern side of the delineated wildlife corridor. The Proposal extends across approximately 1km (13%) of the corridor width at that point. The development of the Proposal would not interrupt connectivity along the riparian vegetation of Long Swamp Creek and the establishment of the on-site biodiversity offset area and off-site biodiversity offset area would preserve this important corridor in perpetuity. A connectivity assessment is provided in Section 3.1.2 of the Niche (2018) (Part 11 of Volume 2 of the *Specialist Consultant Studies Compendium*) and concludes that the connectivity width would remain greater than 500m before and after the development.

5.5.6.4 Groundwater Dependent Ecosystems

The dominant type of Groundwater Dependent Ecosystem (GDE) identified near the Site is Temperate Highland Peat Swamps Developed on Sandstone such as Long Swamp. In particular, this GDE occurs within natural depressions or along watercourses such as Long Swamp Creek, Hanging Rock Swamp and Stingray Swamp. The vegetation has been described by KMA (2018) as Freshwater Wetland (Swamp). This vegetation community would not be directly impacted by the Proposal as it lies outside the proposed disturbance area (see **Figure 5.17**). A groundwater impact assessment prepared by Larry Cook Consulting Pty Ltd (Cook, 2018) reviewed potential impacts as a result of predicted groundwater drawdown and any changes to base flow at Long Swamp Creek, with particular reference to Long Swamp located 200m to the west of the Site.

The groundwater assessment predicts a maximum reduction of 0.052ML/day in base flow to Long Swamp Creek over the proposed 45 years of extraction. This equates to a reduction for Long Swamp Creek and Long Swamp of 2.6% of the modelled base flow. This reduction in base flow is considered to be within the range of natural variation in flows for this type of GDE. Therefore, the predicted change in base flow attributable to groundwater would be within the range of naturally expected fluctuation in base flow to Long Swamp Creek and these GDEs would not be significantly impacted.

5.5.7 Conclusion

The flora and fauna assessment has identified a single threatened flora species listed in the TSC Act (now BC Act) and EPBC Act, one flora species of conservation concern and nine threatened fauna species within areas proposed to be disturbed under the Proposal.

An assessment in accordance with Section 7.3 of the BC Act has concluded that while impacts to individual species would not be significant, the removal of 63.2ha of native vegetation would present a significant impact that requires residual impacts to be offset.

An assessment of potential impacts to groundwater dependent ecosystems has concluded that vegetation within Long Swamp Creek and the nearby Long Swamp would not be significantly impacted by the Proposal. In addition, the Proposal would not impact potential Koala populations or significantly alter established wildlife corridors in the Wingecarribee local government area and greater Illawarra region.

The Proposal would not significantly impact matters on national environmental significance to the extent that a referral to DoEE would be necessary.

Given that the preliminary Biodiversity Offset Strategy would offset residual impacts to native vegetation and the habitat therein, the Proposal would appropriately satisfy requirements to consider and assess potential impacts to threatened species or populations and their habitats, endangered ecological communities and groundwater dependent ecosystems.

5.6 AQUATIC ECOLOGY

5.6.1 Introduction

The DGRs for the Proposal identified "*Biodiversity*" as a key issue incorporating some elements of aquatic ecology that will be assessed in the following subsections. The DGRs require that the "*EIS include a quantitative assessment of the potential:*

- *impacts of the development on any terrestrial or aquatic threatened species or populations and their habitats, endangered ecological communities and groundwater dependent ecosystems paying particular attention to the indirect impacts on the threatened ecological communities and threatened flora associated with Long Swamp; and*
- *regionally significant remnant vegetation, or vegetation corridors, with particular consideration to the Illawarra Regional Environmental Plan No 1.*"

Additional relevant matters for consideration in preparing the EIS were also provided in the correspondence attached to the DGRs from DTIRIS which related to aquatic habitat protection requirements and can be briefly summarised as including:

- a series of general requirements for assessing the impact to the aquatic environment including identifying existing and likely populations, aquatic habitat descriptions and existing aquatic environment uses;
- considerations for assessing:
  - activities that may block fish passage;
  - threatened aquatic species; and
  - impacts to fishing and aquaculture; and
- ensuring appropriate management of riparian buffer zones.

Based on the risk assessment undertaken for the Proposal (**Appendix 4**), the potential impacts relating to aquatic ecology and their risk rankings (in parenthesis) after the adoption of pre-existing or standard mitigation measures are as follows.

- Pollution of local waterways resulting in detrimental effects to flora and fauna (medium).
- Reduced local distribution of threatened species, populations and endangered ecological communities (medium).
- Degradation of riparian or aquatic vegetation / ecosystems (low).
- Sedimentation or hydrocarbon pollution event impacting on aquatic ecosystem (temporary to long term impact (medium).
- Degradation of groundwater dependent ecosystems (low).

The Applicant notes that no instream works are proposed nor are there any commercial fisheries or aquaculture enterprises in the vicinity of the Site. Therefore, no further consideration is given to these two additional matters.

The aquatic ecology assessment for the Proposal was prepared by Cardno Ecology Lab ("Cardno"). The assessment is presented as Part 6 of the *Specialist Consultants Studies Compendium* and is referred to hereafter as "Cardno (2018)". This subsection of the EIS provides a summary of the aquatic ecology assessment, concentrating on those matters raised in the DGRs and related requirements provided by various government agencies. A consolidated list of the identified requirements relating to aquatic ecology and where each is addressed is presented in **Appendix 2**.

5.6.2 The Existing Environment

5.6.2.1 Background Research

Physical Setting

The Site is located near Sutton Forest in the NSW Southern Highlands and forms part of the Wollondilly River sub-catchment of the Hawkesbury - Nepean River catchment. The Site contains a network of first and second order ephemeral watercourses that would likely flow only following rain events due to the small upslope catchment.

The watercourses within the Site drain to the north and west into Long Swamp Creek. Long Swamp Creek is fed by groundwater baseflow, which generally maintains year-round flows. The groundwater inputs and rainfall runoff from the catchment have facilitated the formation of a peat swamp (Long Swamp) in the valley flats downstream of the Site, where the topography has resulted in slower drainage. Long Swamp extends approximately 5km along the length of Long Swamp Creek which drains a catchment of 30 km^2 (DEWHA 2008) (see **Figure 5.11**).

The Wollondilly River enters Lake Burragorang (Warragamba Dam) more than 100km downstream of its confluence with Paddys River. The Warragamba Dam wall represents a significant barrier to aquatic ecological processes and longitudinal connectivity with the Hawkesbury-Nepean river system and estuarine/marine habitat further downstream. NSW Department of Industry – Crown Lands and Water (CL&W) (formerly known as DPI – Water), have also identified several road crossings on Paddys River and Wollondilly River downstream of the Site that may create barriers to aquatic ecological processes (DPI NSW, 2006a).

Aquatic Plants

Previous aquatic surveys of the lower Wollondilly River and Paddys River recorded 17 aquatic plant species, all of which are common in the Hawkesbury-Nepean catchment (The Ecology Lab, 2006 and Cardno Ecology Lab 2010). These included the predominantly submerged macrophytes: pondweeds (*Potamogeton* spp.), watermilfoils (*Myriophyllum* spp.), water ribbons (*Triglochin microtuberosum*), ribbon weed (*Vallisneria gigantea*), emergent macrophytes: cumbungi (*Typha orientalis*), tall spike rush (*Eleocharis sphacelata*), river clubrush (*Schoenoplectus validas*) and aquatic plants more commonly found on the margins of water bodies, such as: knotweeds (*Persicaria* spp.), umbrella sedge (*Cyperus erograstus*) and rushes (*Juncus* spp.).

Long Swamp forms part of two Endangered Ecological Communities (EECs): Temperate Highland Peat Swamps on Sandstone, listed under the Commonwealth *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act) (Section 2.6.1.2) and Montane Peatlands and Swamps of the South Eastern Highlands listed under the NSW *Biodiversity Conservation Act 2016* (BC Act) which replaced the NSW *Threatened Species Conservation Act 1995* (TSC Act). Long Swamp is discussed further in Section 5.2.3.

Aquatic Macroinvertebrates

Fifty aquatic macroinvertebrate taxa were identified from samples collected in pool edge habitat from a reach of Paddys River immediately to the south of the Hume Highway in 2008 (Cardno Ecology Lab, 2010). The health of the macroinvertebrate assemblages was assessed using the AusRivAS protocol (Turak *et al*. 2004) and the majority were equivalent to reference condition indicating that this reach of Paddys River was in relatively good condition.

Brainwood *et al.* (2008) recorded three species of freshwater mussels, *Hyridella depressa*, *H. drapeta* and *Velesunio ambiguus* at a small causeway on Paddys River near the Hume Highway and noted that freshwater mussels were also present in the Upper Wollondilly River.

Four sites on the Wollondilly River (three upstream of the Paddys River junction) and two sites in the Wollondilly sub-catchment are included in Water NSW's (formerly Sydney Catchment Authority) Macroinvertebrate Monitoring Program. In spring 2004, the edge and/or riffle habitats at these sites were assessed using the AusRivAS protocol and the majority were found to be ecologically impaired (Ecowise, 2005). The impaired assemblages were predominantly located in agricultural areas characterised by a degraded riparian zone and high levels of sedimentation in edge and riffle habitats.

In autumn 2006, the condition of the aquatic macroinvertebrate fauna associated with edge and riffle habitats was assessed at Archies Island and upstream of 500 Acre Flat on the Lower Wollondilly River (The Ecology Lab, 2006). Both sites are located downstream of the confluence with Paddys River. The fauna associated with the edge habitat was assessed as being equivalent to the AusRivAS reference condition, whereas that associated with the riffle habitat was severely impaired at one site and significantly impaired at the other.

Overall, the results of macroinvertebrate sampling suggest that the macroinvertebrate assemblage of the Paddys River Catchment, including Long Swamp Creek, is in relatively good health.

Fish

Prior to the 2014 survey, 14 native and 7 introduced fish species had been recorded in the Wollondilly sub-catchment, as reported by Cardno Ecology Lab (2010) (**Table 5.21**).

As shown in **Table 5.21**, the survey conducted by Cardno Ecology Lab (2010), suggests the Wollondilly River was the most diverse waterway in the region at that time, supporting 12 native and seven introduced fish species. The diversity of native fish assemblages declined with distance upstream: ten native species have been identified in the lower reaches of the Wollondilly, whereas only five native species have been recorded in each of the upper Wollondilly River and the high elevation Paddys River.

Introduced fish species are widespread throughout the Wollondilly sub-catchment (**Table 5.21**), the most common being the eastern gambusia (*Gambusia holbrooki*) and goldfish (*Carassius auratus*). Carp (*Cyprinus carpio*) are more common in the lower Wollondilly reaches and Lake Burragorang, whereas brown trout (*Salmo trutta*), rainbow trout (*Oncorhynchus mykissii*) and redfin perch (*Perca fluviatilis*) tend to be restricted to the colder waterways found at higher elevations.

Table 5.21
Records of Fish Species occurring in Waterways of the Wollondilly River Sub-catchment Relevant to the Proposal

Common Name	Scientific Name	Long Swamp Creek	Paddys River	Wollondilly River	
				Upper Wollondilly	Lower Wollondilly
Native Fish					
Longfinned eel	*Anguilla reinhardtii*		✓		✓
Climbing galaxias	*Galaxias brevipinnis*				✓
Mountain galaxias	*Galaxias olidus*	✓	✓		
Australian smelt	*Retropinna semoni*		✓	✓	✓
Olive perchlet	*Ambassis agassizi*			✓	
Coxs gudgeon	*Gobiomorphus coxii*			✓	
Flathead gudgeon	*Philypnodon grandiceps*		✓	✓	✓
Dwarf flathead gudgeon	*Philypnodon macrostomus*				✓
Unidentified gudgeon	*Philypnodon* sp.			✓	✓
Empire gudgeon	*Hypseleotris compressa*				✓
Firetailed gudgeon	*Hypseleotris galii*		✓		✓
Unidentified carp gudgeon	*Hypseleotris* sp.	✓			
Macquarie perch	*Macquaria australasica*				✓
Freshwater catfish	*Tandanus*				✓
Non-native Fish					
Oriental weatherloach	*Misgurnus anguillicaudatus*				✓
Goldfish	*Carassius auratus*		✓	✓	✓
Common carp	*Cyprinus carpio*			✓	✓
Eastern gambusia	*Gambusia holbrooki*	✓	✓	✓	✓
Redfin perch	*Perca fluviatilis*		✓	✓	✓
Rainbow trout	*Oncorhynchus mykiss*		✓	✓	✓
Brown trout	*Salmo trutta*		✓	✓	

Source: Cardno (2010) – Reproduced in Cardno (2018) as Table 2.1

Macquarie perch, a species that is listed as threatened under both State and Federal legislation, is also known to occur in waterways of the Wollondilly sub-catchment (DPI NSW, 2005a). Silver perch (*Bidyanus bidyanus*) and exotic brown trout and rainbow trout have been stocked historically in the Wollondilly sub-catchment (NSW Fisheries, 2003). Silver perch are native to the Murray-Darling catchment and do not occur naturally in the Hawkesbury-Nepean system. The practice of introducing trout into the Wollondilly River below Marsden Weir (Goulburn) was ended due to the potential impact they may have on the persistence of local populations of Macquarie perch. Two other introduced species, common carp and redfin perch, recorded in the Wollondilly sub-catchment have been associated with the decline of Macquarie perch populations (Graham *et al*. 2005 and DPI NSW 2009).

5.6.3 Threatened Species and Key Threatening Processes

Threatened species, populations and ecological communities that may occur within the study area were identified by reviewing the current listings on databases maintained by Commonwealth Department of the Environment and Energy (DEE), NSW Department of Primary Industries (DPI) (Fisheries) and NSW Office of Environment and Heritage (OEH). Database searches were initially undertaken on 12 March 2014, reviewed on 10 August 2016 and again on 19 – 20 February 2018.

5.6.3.1 Environment Protection and Biodiversity Conservation Act 1999

The DEE Protected Matters Search Tool was used to determine whether any species listed as threatened or protected under the schedules of the EPBC Act occurred in the study area. The Long Swamp Creek and Paddys River catchments were used as the search area for the Environmental Reporting Tool.

Threatened Species

The Protected Matters Search Tool indicated that one endangered fish species, Macquarie perch (*Macquaria australasica*) may either occur, or suitable habitat for them may occur, in the vicinity of the Site.

There are two distinct populations of Macquarie perch in NSW, a western form found naturally in the Murray-Darling Basin, and an eastern form found naturally in southeast coastal NSW, including the Hawkesbury-Nepean and Shoalhaven catchments. Macquarie perch are known to occur in the Wollondilly River (DPI NSW, 2005a). Macquarie perch have also been translocated into a number of river systems.

Endangered Ecological Community

The EEC Temperate Highland Peat Swamps on Sandstone occur within Long Swamp. This EEC comprises temporary or permanent swamps with a substratum of peat over sandstone and generally occurs at elevations of 600m AHD to 1 200m AHD. The locations of the peat swamps in the southern highlands are discussed in Section 5.2.3. Sphagnum bogs and fens occupy the wetter parts while sedge and shrub association occur in drier parts of the swamps. A variety of native plants and animals are associated with these swamps, included the nationally endangered Giant Burrowing Frog and Wingecarribee Leek Orchid (DEH 2005). The EEC was listed due to its restricted distribution (only 3 000ha remains) and vulnerability to ongoing threats, including damage from feral animals, increased fertiliser runoff, residential development, clearing, weeds, fire and changes to water flow and quality.

5.6.3.2 Fisheries Management Act 1994

The NSW DPI (Fisheries) Threatened and Protected Species Record Viewer was used to search the Long Swamp Creek, Paddys River and Wollondilly River regions for records of threatened and protected species listed within Schedules 4, 4A and 5 of the FM Act.

Threatened Species

The NSW DPI (Fisheries) Threatened and Protected Species Record Viewer included records for five fish species (Macquarie perch, silver perch, Murray cod (*Maccullochella peelii peelii*), trout cod (*Maccullochella macquariensis*) and Australian grayling, or their habitat, could occur Long Swamp Creek, Paddys River and Wollondilly River regions. Three of these (silver perch, Murray cod and trout cod have been translocated into the Hawkesbury-Nepean Catchment. Any populations of these taxa in the Hawkesbury-Nepean Catchment are the result of historical translocations and as such, they were not considered further in the assessment.

The Australian grayling is listed as protected in NSW and vulnerable under the EPBC Act. Historically, the Hawkesbury-Nepean Catchment represented the northern limit of the grayling's range and given that they can inhabit high elevation reaches up to 1000m AHD it is possible that waterways in the region of the Site represented potential habitat for this species. However, the DoEE Protected Matters Search Tool did not identify the Australian grayling as a threatened species that may occur within the defined search area (Long Swamp Creek and Paddys River catchments) and Australian grayling have not been recorded from the Hawkesbury-Nepean River system since the 1950s (Morris *et al*. 2001). Warragamba Dam represents an impassable barrier to juvenile grayling attempting upstream migration into the Wollondilly sub catchment so it is very unlikely there are any grayling populations persisting in freshwater reaches upstream of Lake Burragorang. As such, Australian grayling was not considered further in this assessment.

The Record Viewer also included records of the listed endangered Sydney Hawk dragonfly in the Hawkesbury-Nepean drainage system. This species is extremely rare, having been collected in small numbers at only a few locations in a small area to the south of Sydney, between Audley and Picton. Extensive sampling has failed to discover further specimens in other areas suggesting that it has a highly restricted distribution within the catchment of the Nepean River (NSW DPI 2007). This dragonfly spends most of its life as an aquatic larva, with adults emerging from the water and living for only a few weeks or months. The larvae appear to have specific habitat requirements and have been found only under rocks in deep, cool, shady pools (NSW DPI, 2007). There are no records for Sydney Hawk dragonfly within the Wollondilly River sub-catchment of the Hawkesbury-Nepean system and, given its restricted distribution, it is not expected to occur within the region of the Site. Thus, the Proposal would be most unlikely to affect the Sydney Hawk dragonfly and was not considered further in the assessment.

Key Threatening Processes

Two of the key threatening processes (KTPs) listed under the FM Act, "Degradation of Riparian Vegetation" and "Instream Structures and Mechanisms that Alter Natural Flow" are relevant to the Proposal (DPI NSW 2005b, 2005c). The term "riparian vegetation" refers to the plants that occur on the land that adjoins, directly influences or is influenced by bodies of water, such as creeks, rivers, lakes and wetlands on river floodplains.

Degradation of riparian vegetation has been listed as a key threatening process because of the adverse effects it can have on threatened species, populations and communities and the threat it poses to other species, populations and communities, which are not currently threatened.

5.6.3.3 Listings under the former *Threatened Species Conservation Act 1995* (now *Biodiversity Conservation Act 2016*)

The OEH Geographic Region Search was used to determine whether any threatened aquatic plant species or endangered ecological communities listed under the TSC Act were present in the Survey Area. The search was performed on the Bungonia and Burragorang (Part A) sub-regions of the Hawkesbury-Nepean Catchment Management Authority (H-NCMA) area.

Threatened Species

The Geographic Region Search indicated that Giant dragonfly (*Petalura gigantea*) was present within the Burragorang (Part A) sub-region. The Giant dragonfly is listed as endangered under Schedule 1 of the TSC Act (now BC Act). This species lives in permanent swamps and bogs with some free water and open vegetation (DECC, 2009). The adults emerge in October and live for one summer, spending most of their time settled on low vegetation on or adjacent to the swamp, except when hunting for flying insects. The larvae inhabit long chambered burrows built under swamps and emerge from the burrow entrances at night and in wet weather, in search of insects and other arthropods to eat. Larvae are not known to swim and avoid open water (DECC, 2008). Vegetation within 500m of breeding habitat is utilised for foraging by adults. The larvae grow slowly and may remain in this state for up to 10 to 30 years. Degradation of habitat is the major threat to this species.

This species is known to occur in the Burragorang Part A, Bungonia and Moss Vale sub-regions of the Hawkesbury-Nepean catchment and has been recorded in the nearby Hanging Rock Swamp (Wetland Care, 2008) and Stingray Swamp (NPWS, 2008), two of the nearby areas within the Paddys River wetland complex approximately 2km south, and 3km southeast, respectively, of Long Swamp. The largest population of Giant dragonfly is believed to occur in sphagnum swamp areas within the Wingecarribee Swamp (approximately 12km east of Long Swamp).

However, there is potential for this species, or its habitat, to occur in Long Swamp Creek, downstream of the Site.

Endangered Ecological Community

The EEC Montane Peatlands and Swamps of the South Eastern Highlands occurs within Long Swamp. Much of the native fauna associated with Montane Peat Swamps are terrestrial and the vegetation is characterised by an intergrading mosaic of sedges (*Cyperaceae*), graminoids (grass-like plants), forbs (herbaceous plants) and shrubs (e.g. tea trees, *Leptospermum* spp.) (DEWHA, 2008). Threats to this EEC include land clearing, pollution and eutrophication, erosion and sedimentation and changes to water tables and surface flows caused by drainage works or altered flows in the catchment.

Key Threatening Processes

Alteration to the natural flow regimes of rivers and streams and their floodplains and wetlands is listed as a Key Threatening Process on Schedule 3 of the TSC Act (now Schedule 4, BC Act). Human activities that reduce or increase flows, change the seasonality of flows, change the frequency, duration, magnitude, timing, predictability and variability of flow events, alter surface and subsurface water levels and change the rate of rise or fall of water levels can all alter the natural flow regimes of watercourses.

The introduction of eastern gambusia, *Gambusia holbrooki*, is also listed as a key threatening process under the TSC Act (now BC Act). This species is extremely common in many waterways of NSW. It can potentially compete with native fishes and is known to prey on a wide range of food items, including tadpoles.

5.6.4 Field and Laboratory Investigations

A field survey of Long Swamp Creek in the vicinity of the Proposal (Survey Area) was conducted in March 2014 and stygofauna sampling survey was conducted in May 2016. The Survey Area and stygofauna sampling locations are shown on **Figure 5.19**.

5.6.4.1 Introduction

The objectives of the field investigations were to:

- describe the aquatic habitats, flora and fauna present upstream, downstream and in the immediate area of the Site;
- conduct a targeted search for the presence of threatened and protected species
- assess the health of this reach of Long Swamp Creek based on collection of aquatic macroinvertebrates and use of the Australian River Assessment System (AusRivAS) (Turak *et al*. 2004); and
- establish the presence (or absence) of stygofauna potentially inhabiting the local aquifer system by sampling existing groundwater bores in the proposed extraction area.

5.6.4.2 Methodology

An overview of the sampling methods follows. All methods are fully described in Cardno (2018).

Habitat Characteristics

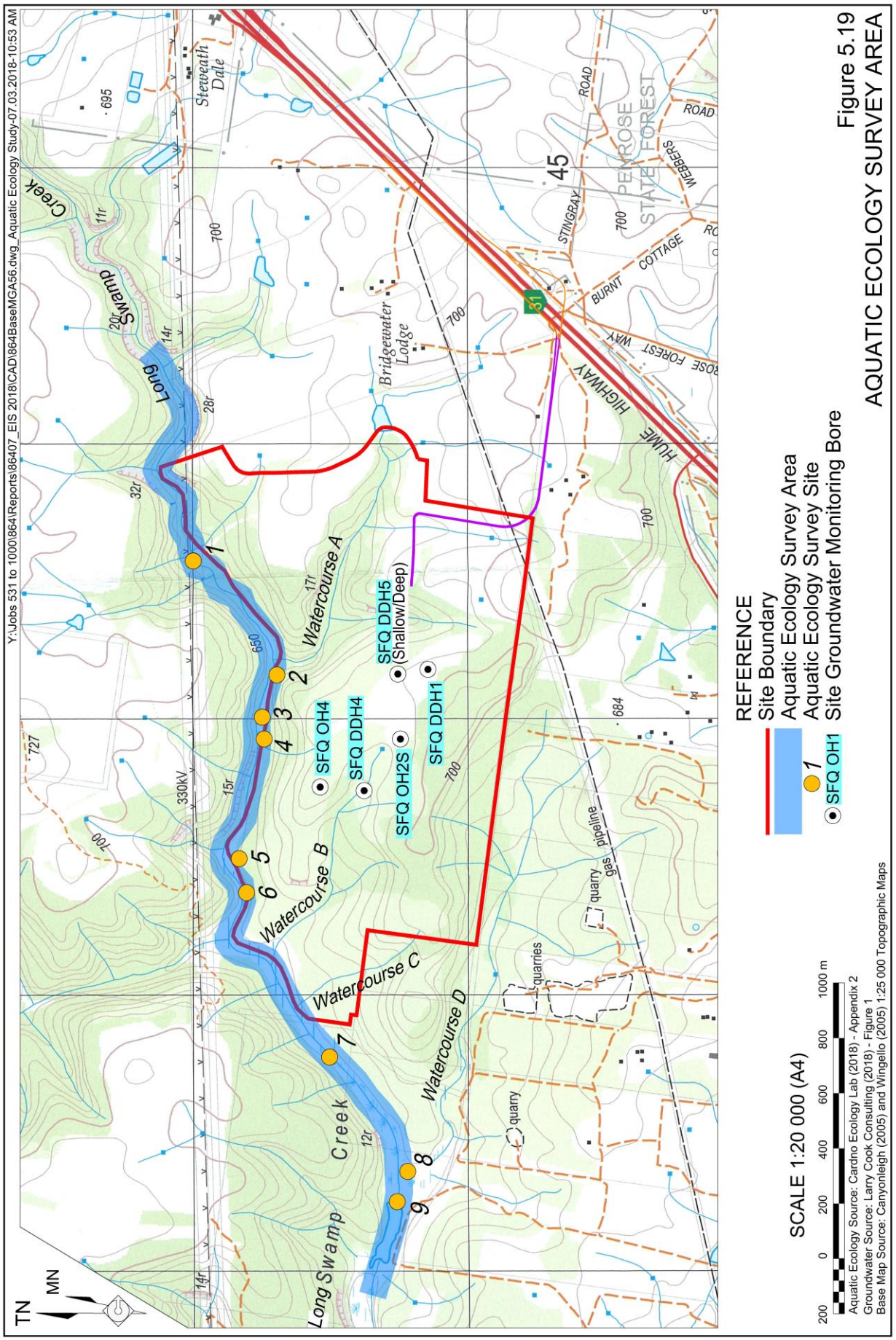
At each site, a standardised description of the adjacent land and the condition of river banks, channel and bed was recorded using a modified version of the Riparian, Channel and Environmental Inventory (Chessman *et al*., 1997). The waterway at each site was classified for fish habitat according to the Policy and Guidelines for Fish Habitat Conservation and Management (Update 2013) (NSW DPI - Fisheries, 2013).

Macrophytes

The percentage cover of macrophyte taxa within the wetted width of the channel was estimated at each site.

Macroinvertebrates

A dip net with a mesh size of 250µm was used to collect macroinvertebrates from pool edge habitat at selected sites.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Long Swamp Creek
Watercourse A
Watercourse B
Watercourse C
Watercourse D
Long Swamp Creek
SFQ OH4
SFQ DDH4
SFQ OH2S
SFQ DDH5 (Shallow/Deep)
SFQ DDH1
Stewarth Dale
Bridgewater Lodge
PENROSE STATE FOREST
HUME HIGHWAY
BURNT COTTAGE ROAD
STINGRAY ROAD
WEBBERS ROAD
ROSE FOREST WAY
330kV
quarry
gas pipeline
quarries
TN
MN
REFERENCE
Site Boundary
Aquatic Ecology Survey Area
Aquatic Ecology Survey Site
Site Groundwater Monitoring Bore
SFQ OH1
SCALE 1:20 000 (A4)
200 0 200 400 600 800 1000 m
Aquatic Ecology Source: Cardno Ecology Lab (2018) - Appendix 2
Groundwater Source: Larry Cook Consulting (2018) - Figure 1
Base Map Source: Canyonleigh (2005) and Wingello (2005) 1:25 000 Topographic Maps
Figure 5.19
AQUATIC ECOLOGY SURVEY AREA

Fish

A dip net with a mesh size of 250µm was used to collect fish from pool edge habitat at selected sites.

Stygofauna

Samples were collected from six bores by lowering and retrieving a disposable, weighted hydra-sleeve / bore water sampler to the bottom of each bore using a tether. Once filled with water, the sleeve was retrieved, the contents rinsed through a 63µm sieve to remove excess fine sediment and preserved with 70% ethanol in a sample container for laboratory analysis. Samples were sorted under a binocular microscope (at 40x magnification), and animals within each sample were removed from the sediment and identified to genus and species level with the exception of Copepoda (to order), Ostracoda (to subclass), and Nematoda (to phylum).

5.6.4.3 Results

Long Swamp Creek Survey

Long Swamp Creek showed distinct changes over the length of the section adjacent to and near the Site. The upper reach was narrow with long, shallow runs and short riffles, with a narrow riparian strip, a small number of aquatic plants and shading from the overhanging vegetation. Freshwater crayfish and mountain galaxias, but not eastern gambusia, were observed. In the lower reaches of Long Swamp Creek, the habitat transitioned into a broad, swampy channel, with long pools of slow-flowing water and extensive riparian vegetation including rushes. Native gudgeon and large numbers of eastern gambusia were observed.

The watercourses entering Long Swamp Creek from the south were, with one exception, narrow depressions with no water present at the time of the visit. Watercourse D entering Long Swamp Creek at Site 8 (see **Figure 5.19**) had no observable channel but was a large extension of the swamp habitat within Long Swamp Creek. The Site boundary is adjacent to this watercourse with the extraction area located approximately 200m to the north. No listed threatened fish species were observed within Long Swamp Creek during the inspection.

Stygofauna Survey

No stygofauna taxa were identified from the samples. One non-stygofauna taxa was found in the samples from bore SQF-OH2S (see **Figure 5.19**). This was a springtail (Order: Collembola, Family Isotomidae), a terrestrial arthropod that is often found in soils and leaf litter.

5.6.5 Mitigation Measures

Sediment and erosion controls implemented prior to, or immediately following, clearing activities as part of a Water Management Plan would minimise impacts that would influence water quality in Long Swamp Creek. In particular, the construction of the sediment control dams to manage mobilised sediments generated by disturbance with construction of the larger water storage dams would commence following the installation of downstream sediment controls (SEEC, 2018a).

Due to the potential for downstream impacts on Long Swamp, identified EECs and, the Giant dragonfly (if present), a swamp monitoring program is proposed. The primary aim of the monitoring program would be to identify potential changes in swamp habitat that may be associated with the Proposal and would include characterisation of baseline conditions prior to construction. Any subsequent changes in swamp habitat, such as vegetation die back and changes in plant community, would be assessed in relation to measurable changes in groundwater levels to ensure that appropriate management actions are taken to prevent or minimise any further changes.

5.6.6 Potential Environmental Impacts

Two primary potential impacts to aquatic ecology due to the Proposal were identified. The first is a potential reduction in water quality in Long Swamp Creek following mobilisation and release of sediments (and other potential contaminants, such as fuels and herbicides) during construction and operation. The second is the potential for loss of swamp habitat (and, thus, identified EECs and habitat for the Giant dragonfly) following reductions in groundwater and surface water contribution to receiving aquatic ecosystems as a result of the Proposal.

5.6.6.1 Changes to Water Quality in Long Swamp Creek

Surface earthworks such as the clearing of soil and vegetation in the extraction area and prior to construction of the surface infrastructure, including first order watercourse crossings and during construction of the water storage dams, have potential to impact upon the aquatic environment. Potential reductions in water quality in Long Swamp Creek could occur due to the mobilisation and release of sediments during these works, particularly via first order watercourses and surface runoff during rainfall. Mobilised sediments could be transported to Long Swamp Creek, and potentially Paddys River, where it may be then be deposited. An increase in sediment load may result in loss of habitat as increased turbidity may result in a decline in light penetration and primary productivity, including macrophyte beds. Contaminants (if present) bound to sediments could be also be released during earthworks and transported into receiving waters via surface drainage lines where they could be detrimental to aquatic biota. In addition, introduced species such as *Gambusia holbrooki* are extremely tolerant to degraded and disturbed conditions and can outcompete more sensitive native species. Increased turbidity and/or sedimentation potentially as a result of surface run-off from construction and operational works could therefore create conditions that favour introduced pest species such as *Gambusia holbrooki*. It should be noted, however, that this species is currently highly abundant in Long Swamp Creek.

5.6.6.2 Changes to in Groundwater and Surface Water Input to Aquatic Ecosystems

The construction of the water storage dams, sediment dams and waterway crossings would alter natural flow in first order watercourses of Long Swamp Creek and potential sections downstream. The construction of the water storage dams and water management infrastructure would isolate approximately 1km of the first order Watercourse A from the Long Swamp Creek Catchment, which would reduce the amount of runoff to Long Swamp Creek.

The waterway crossing of first order watercourses for access to Fines Storage Area 1 may also alter flow. However, these watercourses have historically been intercepted for capture of surface runoff with the proposed access utilising the existing dam embankment. Furthermore, these watercourses would only have historically flowed after rainfall events.

Subsequently the effect on the natural flow regime in Long Swamp Creek due to installation of waterway crossings, water storage dams and water management infrastructure would be negligible.

Groundwater interception within the extraction area would reduce the baseflow and alter the natural flow regime of the Long Swamp Creek Catchment. However, a calibrated transient groundwater modelling assessment (Coffey, 2016) has predicted that the maximum reduction in baseflow of 2.6% as a result of groundwater interception would be unlikely to result in substantial reductions in pool water levels or flow.

5.6.7 Assessment of Impacts

No direct displacement of, or physical disturbance to, Long Swamp Creek or the associated swamp habitat is proposed. The Proposal would not require abstraction of water from the creek or direct discharge of water from the Site into the creek. Several ephemeral first and second order watercourses would be disturbed, including some displacement under water storage and sediment dams and road crossings. However, only a relatively small areas of limited aquatic ecology value would be affected.

5.6.7.1 Changes to Water Quality in Long Swamp Creek

Potential reductions in water quality could be managed by development and implementation of a Water Management Plan that includes the measures described in SEEC (2018a). Following successful implementation, residual impacts to aquatic ecology due to changes in water quality would be negligible.

5.6.7.2 Changes to in Groundwater and Surface Water Input to Aquatic Ecosystems

The primary potential impact to aquatic ecology associated with the Proposal is related to alterations to surface and groundwater availability and associated indirect effects to these habitats and also the TSC Act (now BC Act) listed Giant dragonfly, which occurs in nearby local swamps and potentially also Long Swamp Creek. These could arise due to interception of groundwater in the extraction area, associated with a small 2.6% reduction in baseflow to Long Swamp Creek and a maximum 0.1m reduction in the depth to water table in the eastern most section of Long Swamp. Any subsequent changes in swamp habitat, such as vegetation die back and changes in plant community, should be assessed in relation to measurable changes in groundwater levels to ensure that appropriate management actions are taken to prevent or minimise any further changes.

5.7 ABORIGINAL CULTURAL HERITAGE

5.7.1 Introduction

The DGRs for the Proposal identified "*Heritage*" as a key issue requiring that the "*EIS include:*

- *an Aboriginal cultural heritage assessment (including both cultural and archaeological significance) which must:*
  - *demonstrate effective consultation with Aboriginal communities in determining and assessing impacts, and developing and selecting mitigation options and measures; and*
  - *outline any proposed impact mitigation and management measures (including an evaluation of the effectiveness and reliability of the measures).*

The Applicant commissioned Landskape Natural and Cultural Heritage Pty Limited to undertake an Aboriginal Cultural Heritage Assessment of the Proposal. The full assessment is presented in Part 7 of the *Specialist Consultant Studies Compendium* and is referenced throughout this section as Landskape (2018). This section reviews the Aboriginal heritage context of the Site, the identified Aboriginal heritage sites and proposes an approach to management of these identified sites and the potential to uncover unknown sites during development of the Proposal.

Consultation undertaken with the local Aboriginal community is summarised and the views of the community concerning the identified sites is recorded. An assessment of the significance of the sites is also presented and the significance of unavoidable impacts to three of the sites presented.

The specific objectives of the Aboriginal cultural heritage assessment were to:

- consult the local Aboriginal community to identify the cultural knowledge of the study area and any concerns they may have about the Proposal;
- conduct a desktop assessment to delineate areas of known and predicted Aboriginal cultural heritage within the Site;
- undertake a stratified archaeological survey of known and predicted Aboriginal cultural heritage identified in the desktop assessment with representatives of the local Aboriginal community;
- record any Aboriginal cultural heritage sites within proposed disturbance areas and assess their significance;
- identify the nature and extent of potential impacts of the Proposal on Aboriginal cultural heritage; and
- identify options in consultation with the local Aboriginal community to avoid or mitigate potential impacts of the Proposal on Aboriginal cultural heritage places and items.

Based on the risk assessment undertaken for the Proposal (**Appendix 4**), the potential impacts relating to Aboriginal cultural heritage and their risk rankings (in parenthesis) after the adoption of pre-existing or standard mitigation measures are as follows.

- Removal or destruction of known Aboriginal sites and/or artefacts (low).
- Removal or destruction of currently unidentified Aboriginal sites and/or artefacts (low).

The following subsections present a summary of the assessment undertaken by Landskape (2018), identifying specific Aboriginal cultural heritage-related constraints and opportunities that might affect the Proposal's design, establishment, operation and post-operative rehabilitation.

5.7.2 Stakeholder Consultation

Relevant stakeholders from the Aboriginal community were identified using a process consistent with the "*Aboriginal Cultural Heritage Community Consultation Requirements for Proponents*" (DECCW 2010a). Following the completion of Steps 4.1.2 and 4.1.3 of these *Consultation Requirements*, six Aboriginal stakeholders registered as groups that may hold cultural knowledge relevant to determining the Aboriginal cultural values of the Site. The six registered Aboriginal stakeholders were:

- Bellambi Indigenous Corporation;
- Cubbitch Barta Native Title Claimants Aboriginal Corporation;
- Illawarra Local Aboriginal Land Council;
- Gundungurra Aboriginal Heritage Association Inc.;
- Gundungurra Tribal Council Aboriginal Corporation; and
- Peter Falk Consulting.

The registered Aboriginal parties were provided with information about the Proposal and the proposed Aboriginal cultural heritage assessment process in the form of a proposed methodology. The purpose of the proposed methodology was to explain the Proposal and consultation process in detail, define the roles of the registered Aboriginal parties and the Applicant, identify any protocols for obtaining and using sensitive cultural information and to give the registered Aboriginal parties an opportunity to comment on the proposed assessment method and provide any relevant information on the cultural significance of the Site.

Written correspondence received from the Aboriginal community is presented in full as Appendix 4 of Landskape (2018) including requests for the management and salvage of the defined cultural heritage sites. These requests have been included in the design and operational safeguards described in Section 5.7.5.

A request that subsurface investigations occur for removed sites was considered unnecessary as the shallow nature of topsoil and subsoil and extensive past disturbance means stratified cultural deposits are unlikely. Any knowledge that may be gained by excavation is likely to have limited scientific value.

5.7.3 Existing Environment

Previously Recorded Aboriginal Cultural Heritage Sites

There are no previously recorded Aboriginal cultural heritage sites recorded within the Site on the NSW OEH Aboriginal Heritage Information Management System (AHIMS) database. This excludes those Aboriginal cultural heritage sites identified during field surveys for the Proposal and since listed with AHIMS.

Searches for sites listed on the AHIMS database in the vicinity of the Site were conducted on 2 August 2012 (AHIMS search 76370), 4 December 2013 (AHIMS search 118676), 2 September 2016 (AHIMS search 242297) and on 3 March 2018 (AHIMS search 331487). Searches were conducted over a 20km x 20km area centred on the extraction area, sufficient to allow adequate landscape interpretation and also provided a large number of registered Aboriginal sites to assist in an understanding of the distribution of Aboriginal cultural heritage across the landscape.

The distribution of sites in the AHIMS database is a reflection of where site surveys have been previously completed. Other sites may be present, but in areas that have not been previously examined. A total of 117 sites have been previously recorded within the search area centred upon the Site with stone artefact scatters being the most common site type. Grinding grooves were the second-most prevalent site type.

Field Surveys

Archaeological field surveys of the Site were conducted based on the sampling strategy developed in accordance with the *Guide to Investigating, Assessing and Reporting on Aboriginal Cultural Heritage in NSW* (OEH 2011) and Requirement 5a of the *Code of Practice for Archaeological Investigation of Aboriginal Objects in NSW* (DECCW 2010b).

An assessment of the Site was made based on the level of disturbance from previous land uses, survey variables (ground visibility and archaeological visibility) and the potential archaeological sensitivity of the area.

The methodology for the field surveys involved:

- the identification of landforms and areas of potential archaeological sensitivity;
- a focus on areas that had a high probability of containing Aboriginal objects, including sandstone outcrops, creek banks, and eroded areas; and
- representative coverage of all survey units, including those with a lower probability of containing Aboriginal cultural heritage.

Surveys were conducted on 20 and 21 November 2012 by archaeologists Mr Josh Symons and Mr Jack Hinde of Artefact Heritage and on 8 November 2013 and 1 September 2016 and 7 February 2018 by Dr Matt Cupper and Ms Jaime Swift of Landskape. Representatives from the Aboriginal community groups were engaged on a roster such that each team comprised one or two archaeologists with one to three Aboriginal community representatives.

The initial archaeological surveys undertaken in 2012 and 2013 covered a corridor proposed at that time for the Quarry Access Road. Subsequently, the Quarry Access Road was realigned by the Applicant to avoid impact to sites identified within this corridor (and to limit ecological

impacts) with this realigned route being the subject of additional field survey on 1 September 2016. The Applicant further re-assessed the corridor of the Quarry Access Road and identified a more suitable alignment, including a new interchange with the Hume Highway that would minimise ecological impacts and avoid the use existing infrastructure at the Sallys Corner Interchange with this route being surveyed on 7 February 2018.

5.7.4 Survey Results

A total of nine Aboriginal cultural heritage sites were identified during the four cultural heritage surveys of the Site as set out in **Table 5.22** and shown on **Figure 5.20**. These comprise eight stone artefact scatters and one rock shelter with art and stone artefacts.

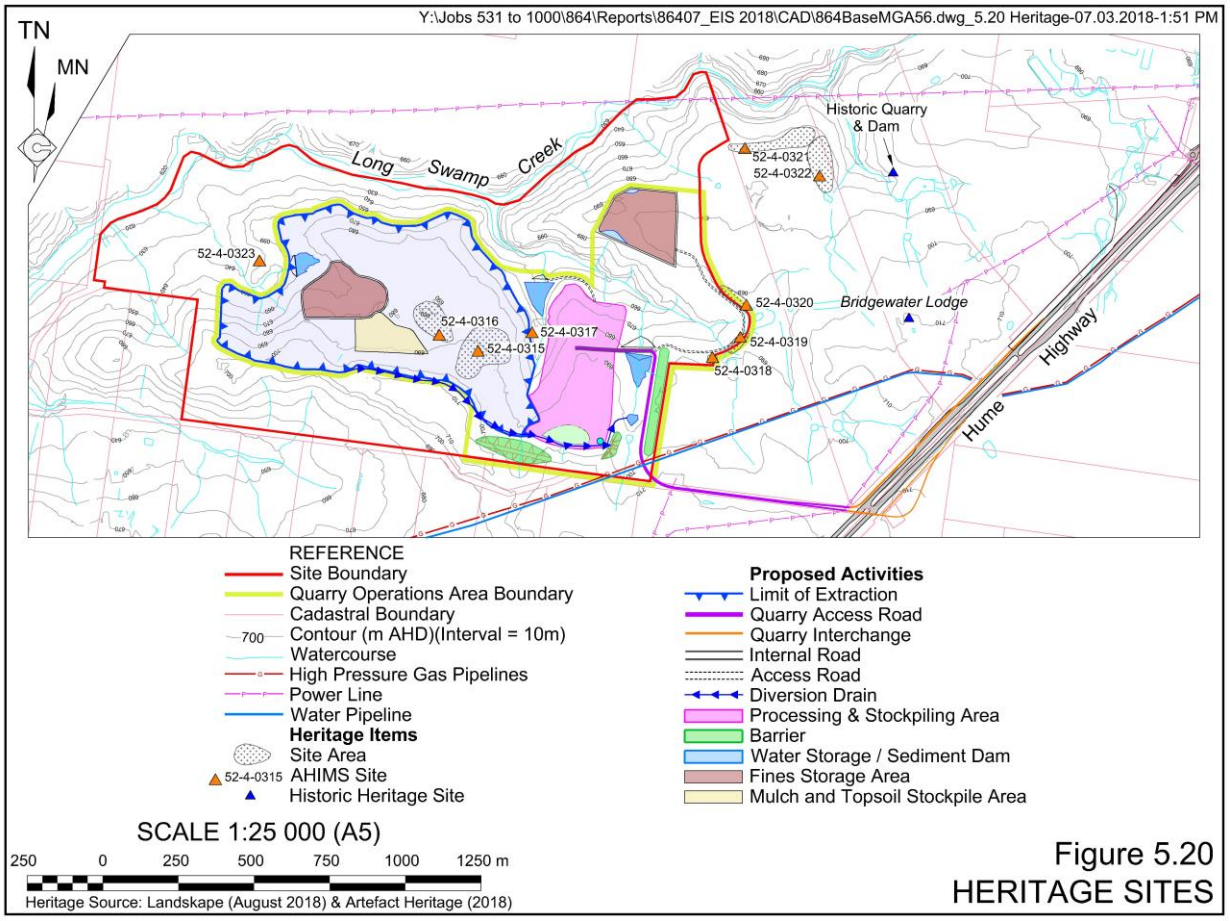
Table 5.22
Aboriginal Cultural Heritage Places at the Site

AHIMS Site Number	Field Code	Feature	Location GDA94 56 mE	Location GDA94 56 mN	Site Contents
52-4-0315	SFQ AS1	Stone artefact scatter	243165	6166200	7 silcrete flakes, cores and flaked pieces, 4 quartz flakes, cores and flaked pieces
52-4-0316	SFQ AS2	Stone artefact scatter	243037	6166253	2 silcrete flakes and cores
52-4-0317	SFQ AS3	Stone artefact scatter	243344	6166261	2 silcrete flakes
52-4-0318	SFQ AS4	Stone artefact scatter	243940	6166179	5 silcrete flakes, cores and flaked pieces, 3 quartz flakes and flaked pieces
52-4-0319	SFQ AS5	Stone artefact scatter	244032	6166246	10 silcrete flakes, cores and flaked pieces, 2 quartz flaked pieces and cores
52-4-0320	SFQ AS6	Stone artefact scatter	244052	6166352	5 silcrete flakes and flaked pieces, 2 quartz flakes and flaked pieces
52-4-0321	SFQ AS7	Stone artefact scatter	244047	6166869	3 quartz flakes, cores and flaked pieces
52-4-0322	SFQ AS8	Stone artefact scatter	244294	6166779	7 quartz flakes and flaked pieces, 1 silcrete flake, 1 volcanic core
52-4-0323	SFQ SH1	Rock shelter	242443	6166498	Red pigment hand stencils, charcoal motifs and pecked images, 6 silcrete flakes, flaked pieces and cores, 2 quartz flakes
Source: Landskape (2018) – Table 7					

All of the sites located at the study area were associated with the margins of Long Swamp Creek and an unnamed tributary of the creek. Stone assemblages are generally small in size ranging from two artefacts to 12 artefacts encountered in one scatter.

Lithics were generally sourced from locally available raw materials such as silcrete and quartz. Most were cores and waste flakes and flaked pieces from knapping, with few formal implements encountered.

The findings of the survey confirm the predictive model provided in Section 7.1 of Landskape (2018).



Three stone artefact scatter sites (AHIMS Sites 52-4-0315, 52-4-0316 and 52-4-0319) would be removed under the Proposal with partial loss of another stone artefact scatter site (AHIMS Site 52-4-0320).

5.7.5 Design and Operational Safeguards

The principal safeguard that would be implemented to avoid impacts to identified sites of Aboriginal cultural heritage is the design of the Quarry Access Road. The initial archaeological field surveys covered a corridor proposed for the Quarry Access Road at the time. The Quarry Access Road was subsequently re-aligned to avoid impacts to five identified sites.

Based on the results of the Aboriginal Cultural Heritage Assessment undertaken by Landskape (2018) and consultation with representatives of the local Aboriginal community, the Applicant would implement the following recommendations.

- The Applicant would maintain a record of known Aboriginal heritage sites and mark these sites on relevant site plans and documentation. A protocol would be implemented to ensure surface works avoid the risk of accidental damage to the known Aboriginal Heritage sites outside the proposed areas of disturbance.
- The Applicant would arrange for a suitably qualified archaeologist and representatives of the local Aboriginal community to be engaged to record and collect the Aboriginal objects. All relevant documentation would be prepared and

submitted in the Cultural Heritage Management Plan for the Quarry. These items would be properly curated and stored in a "Keeping Place" at the Illawarra Local Aboriginal Land Council office. Following decommissioning of the Quarry, artefacts would be replaced within rehabilitated areas in consultation with local Aboriginal groups and the OEH. The Applicant proposes either full or partial salvage of Aboriginal objects at the following locations.

  – Full salvage of two Aboriginal cultural heritage sites located within the proposed extraction area (AHIMS Sites 52-4-0315 and 52-4-0316).

  – Full salvage of Aboriginal cultural heritage site (AHIMS Site 52-4-0319) which is located within the alignment of the access track to Fines Storage Area 1.

  – Partial salvage of Aboriginal cultural heritage site (AHIMS Site 52-4-0320) located adjacent to the alignment of the access track to Fines Storage Area 1.

- Access to the AHIMS Site 52-4-0317, located adjacent to the proposed extraction area, would be restricted during the site establishment and construction stage and ongoing operations. The location would be marked with flagging to limit unintentional damage to the site. The marking would be maintained throughout the life of the Proposal and the location included in induction procedures to ensure all personnel and contractors are aware of the site and the need for sensitivity and care when operating in this area.

- In the unlikely event that human skeletal remains are encountered during the course of the development associated with the Proposal, all work with the potential to impact the remains would cease in the area of the remains. The remains would not be handled or otherwise disturbed except to prevent further disturbance. If the remains are thought to be less than 100 years old, the Police or the State Coroner's Office (Ph: 02 9552 4066) would be notified. If there is reason to suspect that the skeletal remains are more than 100 years old and Aboriginal, the Applicant would contact the OEH's Environmental Line (Ph: 131 555) for advice. In the unlikely event that an Aboriginal burial is encountered, strategies for its management would need to be developed with the involvement of the local Aboriginal community.

- The Applicant would coordinate and implement these proposed management strategies by integrating them into a single program and document in the form of an *Aboriginal Cultural Heritage Management Plan* (ACHMP). The ACHMP would remain active for the life of the Proposal and define the tasks, scope and conduct of all Aboriginal cultural heritage management activities. The ACHMP would be developed in consultation with the registered Aboriginal parties.

- The Applicant would provide training to all on-site personnel regarding the ACHMP strategies relevant to their employment tasks.

- The Applicant would continue to involve the registered Aboriginal parties and any other relevant Aboriginal community groups or members in matters pertaining to the Proposal. In particular, the recording, collection, curation, storage and replacement of Aboriginal objects should occur with the invited participation of local Aboriginal community representatives.

5.7.6 Significance Assessment

All Aboriginal objects located in NSW are afforded protection under the *National Parks and Wildlife Act 1974*, but decisions about appropriate management of individual artefacts or sites are usually based on their assessed significance as well as the likely impact in the context of the proposed development. *The Guide to investigating, assessing and reporting on Aboriginal cultural heritage in NSW* (OEH 2011b) and *Code of Practice for Archaeological Investigation of Aboriginal Objects in NSW* (DECCW 2010b) requires that a significance assessment be undertaken in accordance with the processes set out in the *Burra Charter* (Australia ICOMOS 1988, 1999). This is not only for the purpose of determining whether sand extraction can proceed as proposed, but also to provide quarry management with the information for future management of the area.

Cultural Significance

The Aboriginal cultural heritage significance of artefacts and sites can only be assessed by the Aboriginal community, and in particular, the Elders. It is the responsibility of the archaeologist to ensure that the Elders, or elected representatives of the Aboriginal community are advised of the survey results and are consulted as to their knowledge and opinion of the significance of the area, and to transcribe and present those expressions in report form.

A number of Aboriginal representatives expressed concern about developments that might impact upon Aboriginal cultural heritage and other values on land that is traditionally theirs. All land has high cultural significance for Aboriginal people. It should also be noted that development upon, or disturbance of land is often contrary to principal Aboriginal beliefs regarding land, its values and its inherent cultural significance.

A number of Aboriginal community representatives involved in the study identified the Quarry Operations Area as a place that Aboriginal people had occupied in the past. Comments received regarding the cultural significance of the Study Area from the registered Aboriginal parties are documented in the Aboriginal consultation log (contained as Appendix 2 of Landskape (2018)) and provided in full in the written correspondence received from the Aboriginal parties (contained as Appendix 4 of Landskape (2018)).

Generally, the Aboriginal representatives viewed all the Aboriginal cultural heritage sites as significant because they preserve a record of how and where people lived in the past. Such Aboriginal cultural heritage sites also stand as testimony to the continuation of Aboriginal culture and association with the land.

Archaeological Significance

A number of criteria are used to assess the scientific or archaeological significance of a site. These include the integrity of a site, its structure and contents. All of these criteria combine to give a site its value as a research tool for archaeologists. In addition to the above criteria, a site may also be of scientific significance because of its representativeness or rarity.

In terms of site integrity, the sites comprising stone artefact scatters located during the surveys would rate moderate to low. This assessment is based on the degree of disturbance noted during the investigation. The stone artefact scatters were typically identified in modified contexts within cleared areas, particularly in places with past earthworks such as along graded tracks and near dams. They have also been disturbed by repeated ploughed cultivation, traffic of hooved animals and vehicles, coupled with erosion by wind and water. Conversely, the rockshelter site (AHIMS Site 52-4-0323) is in an area of less disturbed forest and is well preserved.

Most of the stone artefact scatters are small in size and have a low site structure. The rockshelter site has the potential for intact floor deposits and rates high in terms of physical dimensions.

When considered for the range and type of occupation debris found, most of the stone artefact rate low to moderate by the site contents criterion. They could be useful for studies of human subsistence strategies. The rockshelter rates highly, containing painted and engraved art and stone artefacts. There is also the potential that any intact floor deposits may contain other cultural materials such as charcoal from hearths.

On the basis of the results of previous archaeological investigations and information held on the OEH AHIMS site register, it is clear that stone artefact scatters are widespread in the region. These types of archaeological sites located during this study are therefore not unique and are well represented outside the Site. Alternatively, the rockshelter site (AHIMS Site 52-4-0323), contains a diversity of painted and engraved art relatively uncommon to the region and rates moderate.

The stone artefact sites rank low in terms of educational value. They are generally small, isolated and unlikely to attract particular interest in Aboriginal cultural heritage. The rockshelter's painted and engraved art is of high educational value.

The stone artefact scatters are subdued features in the landscape and lack high aesthetic value. The aesthetic significance of the Aboriginal cultural heritage sites mainly relates to their setting along the Long Swamp Creek corridor. The rockshelter's setting and its painted and engraved art in particular have high aesthetic qualities.

The historic value of the Aboriginal sites in the study area largely stems from their importance in providing evidence of Aboriginal peoples' association with the area. It is within a region that was occupied by the Gundungurra tribal group at the time of first contact with Europeans. Archaeological and ethno-historical sources show that past Aboriginal people frequented specific places within the region such as the stone artefact scatter and rockshelter sites in the Study Area for habitation, to manufacture lithic implements and ritual, mythological and artistic activities.

The overall study area is assessed as containing low to moderate significance due to the number of sites present and the way in which this information contributes to the nature of Aboriginal land use in the region. **Table 5.23** provides significance ratings for the identified Aboriginal sites within the Study Area.

Table 5.23
Significance Ratings for Recorded Sites

AHIMS Site Number	Site Code	Significance Rating for Individual Criterion				Overall Archaeological Significance Rating
		Scientific	Aesthetic	Social	Historical	
52-4-0315	SFQ AS1	Low	Low	Low	Low	Low
52-4-0316	SFQ AS2	Low	Low	Low	Low	Low
52-4-0317	SFQ AS3	Low	Low	Low	Low	Low
52-4-0318	SFQ AS4	Low	Low	Low	Low	Low
52-4-0319	SFQ AS5	Low	Low	Low	Low	Low
52-4-0320	SFQ AS6	Low	Low	Low	Low	Low
52-4-0321	SFQ AS7	Low	Low	Low	Low	Low
52-4-0322	SFQ AS8	Low	Low	Low	Low	Low
52-4-0323	SFQ SH1	High	High	High	High	High
Source: Landskape (2018) – Table 17						

5.7.7 Assessment of Impacts

Table 5.24 presents a summary of impacts to the identified sites within the area of the Landskape (2018) study. The Proposal would result in a total loss of value for three known sites (AHIMS Sites 52-4-0315, 52-4-0316 and 52-4-0319) and a partial loss of value for a further site (AHIMS Site 52-4-0320).

Table 5.24
Impacts on Recorded Sites

AHIMS Site Number	Site Code	Type of Harm	Degree and Consequence of Harm
52-4-0315	SFQ AS1	Direct	Total loss of value
52-4-0316	SFQ AS2	Direct	Total loss of value
52-4-0317	SFQ AS3	Nil	No loss of value
52-4-0318	SFQ AS4	Nil	No loss of value
52-4-0319	SFQ AS5	Direct	Partial loss of value
52-4-0320	SFQ AS6	Direct	Partial loss of value
52-4-0321	SFQ AS7	Nil	No loss of value
52-4-0322	SFQ AS8	Nil	No loss of value
52-4-0323	SFQ SH1	Nil	No loss of value
Source: Landskape (2018) – Table 18			

The Applicant has designed the extraction area and Quarry Access Road to avoid impacts to the remaining five sites comprising stone artefact scatters.

Importantly, the rock shelter site (AHIMS Site 52-4-0323) would not be directly impacted (i.e. subject to surface disturbance) by the Proposal as a buffer area of at least 100m has been incorporated in the design of the western section of the extraction area. This site has also been assessed by Spectrum (2018) in relation to potential ground vibration impacts and would satisfy all relevant criteria for potential vibration impact. (see Section 5.4.8.3). The preservation of the site would also retain the outlook of the rock shelter towards Long Swamp Creek.

5.7.8 Conclusion

While the Proposal would result in removal and salvage of three sites and partially remove a fourth site from the landscape, these sites are not considered to be archaeologically or culturally significant and are relatively common in the vicinity of the Site. The Applicant acknowledges the significance of these sites to the Aboriginal community and would implement the management recommendations of Landskape (2018) to protect identified sites in the landscape and to appropriately manage unknown sites that may be identified.

The consideration of the identified rock shelter in the design and planning for the Proposal would ensure this culturally important site is not damaged as a result of the Proposal.

The preparation of an Aboriginal Cultural Heritage Management Plan would ensure that Aboriginal cultural heritage sites and values would be protected in accordance with the requirements of OEH.

5.8 HISTORIC HERITAGE

5.8.1 Introduction

The DGRs for the Proposal identified "*Heritage*" as a key issue requiring that the "*EIS include:*

- *a historic heritage assessment (including archaeology) including a statement of heritage impact (including significance assessment) for any State significant or locally significant historic heritage items and outline any proposed mitigation and management measures."*

Based on the risk assessment undertaken for the Proposal (**Appendix 4**), the potential impacts relating to historic heritage and their risk rankings (in parenthesis) after the adoption of pre-existing or standard mitigation measures are as follows.

- Removal or destruction of sites of historic (European) heritage significance due to disturbance associated with the Proposal (low).

This subsection of the EIS provides a summary of the impact of the Proposal on the historic heritage of the Site and surrounds, concentrating on those matters raised in the DGRs. A consolidated list of the identified requirements relating to historic heritage and where each is addressed is presented in **Appendix 2**.

5.8.2 Methods

The *Heritage Act 1977* (the Act) is a statutory tool designed to conserve environmental heritage in NSW. It is used to regulate development impacts on the state's historical heritage assets. The Act defines a heritage item as 'a place, building, work, relic, moveable object or precinct'. The Act also distinguishes between items of local and State heritage significance.

In order to assist with the assessment of the environmental heritage, the Heritage Manual 1996 provides guidelines endorsed by the NSW Heritage Council which explain the three steps to manage historic heritage items in the NSW context. These steps are:

- investigate significance;
- assess significance; and
- manage significance.

In order to assess the significance of potential historic heritage items located within the Site and surrounds, a desktop search of heritage listed items was completed, as well as a search of the recorded history of the land on which the Site is located. Finally, a field survey of the Site was completed to provide a physical assessment of the area for potential items of historic heritage significance.

5.8.3 Desktop Review

5.8.3.1 Heritage Register Searches

A search of statutory heritage database and listings was completed on 5 March 2018. The following databases were included.

- NSW State Heritage Register.
- *National Parks and Wildlife Act 1974*
- NSW State Heritage Inventory.
- Australian Heritage Database.
- *Wingecarribee Local Environmental Plan 2010* – Environmental Heritage Schedule.

There are currently no listed non-Indigenous heritage items within or near the Site.

5.8.3.2 Site History

A comprehensive review of the history of the land on which the Site is located and the surrounding area was undertaken. The following provides a brief overview of this history.

From 1819, following the establishment of the area as suitable for grazing, and the clearance of roads through the region, Governor Macquarie distributed a number of land grants, including 1 000 acres to Charles Throsby at Sutton Forest. Roads formed an important connection between the newly established grazing land and markets in Sydney. The road to Goulburn overseen by Throsby formed the main Government Road through the region until c. 1825.

Until the 1830s, the study area and immediate surrounds were located to the west and southwest of the major land grants in the area, and away from the two main roads servicing the area. By 1830, Thomas Mitchell, the Surveyor-General of the colony of New South Wales, had marked out the route of a new road and a new township at Berrima (Jervis,1975: 11; Umwelt, 2005: 21). The road, which was called the Great South Road, heralded the end of the Government Road to Goulburn through Canyonleigh, and established new centres of grazing land and towns in the area, including Berrima, Marulan, and Murrimba. The Great South Road was renamed as the Hume Highway in 1928, after Hamilton Hume who was an early explorer of the southern highlands region and accompanied Charles Throsby on at least one expedition.

The earliest Murrimba parish map available for the study area dates to 1894. The land boundaries on the map show that the study area is located across four lots that were registered to Joseph Saul. An access track from the Great South Road is indicated across the southern boundary of Joseph Saul's property. The Site was located at the mid-point between the towns of Sutton Forest and Murrimba / Paddys River, with Sutton Forest approximately 11km to the northeast and Murrimba / Paddys River 9km to the southwest. The cross-roads, where the Great South Road (Hume Highway) and old Goulburn Government Road (Illawarra Highway / Canyonleigh Road) was located 5km northeast of the Site. A number of inns were located along the Great South Road, the closest was the Black Horse Inn, which is located on the western side of the Hume Highway approximately 3km northwest of the study area.

Later, three of the four portions were purchased by A. A. Fox, and by 1963 all were owned by Reed, Hanigan and Turner, a firm of Law Stationers based in Sydney (Lands Department: Status Charting Map for Murrimba; Plan Lodgement Book for DP253435 and DP219595).

A house was built on Portion 100 during the late 19th century and is still standing. This house is now named "Bridgewater Lodge" (see **Figure 5.14 –** Residence 3). It is not known whether structures located on any other areas of the Site were occupied.

5.8.4 Field Survey

5.8.4.1 Methodology

A survey of the study area was undertaken concurrently with the initial Aboriginal cultural heritage field survey by archaeologists Mr Josh Symons and Mr Jack Hinde of Artefact Heritage on 20 and 21 November 2012.

5.8.4.2 Results

A small sandstone quarry and small sandstone lined dam were identified during the site survey, these are identified on **Figure 5.20** and are assessed not to be of heritage significance.

One potential heritage item, "Bridgewater Lodge" house (c. late 19th century), is located on Lot 2 DP 253435. This building is not listed on any heritage registers but may be of some heritage value as an early surviving residence of the area. The house is built of sandstone and surrounded by gardens. This property is owned by a company associated with the Applicant.

5.8.5 Assessment of Impacts

There are no sites or locations with statutory historic heritage located within the vicinity of the Site.

It is not anticipated that there would be any impacts to "Bridgewater Lodge", which is the only item of potential heritage significance in the vicinity of the Site. Because of the distance from the Quarry Operations Area to the house (approximately 610m), and the presence of screening vegetation within the garden of "Bridgewater Lodge", it is not expected that the Proposal would have any substantial impacts on the views from the residence or its setting.

5.9 AIR QUALITY

5.9.1 Introduction

The DGRs for the Proposal identified "Air Quality and Greenhouse Gases" as key issues requiring that the *"EIS include a quantitative assessment of the potential:*

- *construction and operational impacts;*
- *reasonable and feasible mitigation measures to minimise dust;*
- *monitoring and management measures; and*
- *Scope 1, 2 and 3 greenhouse gas emissions and the assessment of reasonable and feasible measures to minimise greenhouse gas emissions and ensure energy efficiency."*

Additional matters for consideration in preparing the EIS were also provided in the correspondence attached to the DGRs from the EPA which related to air quality impacts and requested that: "*the Proponent must carry out an Air Quality/Odour Assessment and Modelling that addressed:*

- *Point source emissions from plant and equipment and potential impacts.*
- *Fugitive source emissions from exposed areas and other surfaces.*
- *Mitigation and management strategies."*

Based on the risk assessment undertaken for the Proposal (**Appendix 4**), the potential impacts relating to air quality and their risk rankings (in parenthesis) after the adoption of pre-existing or standard mitigation measures are as follows.

- Dust from operational activities (extraction, processing or product transport) resulting in nuisance/amenity or health impacts for nearby residents or businesses including (medium).
- Dust levels attributable to the Proposal resulting in exceedance of nominated air quality criteria and complaints from the local community (medium)
- Deposited dust levels attributable to the Proposal resulting in impacts to surface water bodies, local vegetation or its value as fauna habitat (low).
- Increased greenhouse gas emissions (medium).
- Concentrations of respirable silica resulting in a respirable disease affecting residents on adjoining landholdings (low)[4].

The DGRs require that the assessment of air quality is undertaken with reference to the *Approved Methods for the Modelling and Assessment of Air Pollutants in NSW* (DEC, 2005), however it is noted that the updated version of this guideline *Approved Methods for the Modelling and Assessment of Air Pollutants in NSW* (NSW EPA, 2016) has been relied upon for assessment purposes.

[4] The risks relating to respirable silica are assessed from the perspective of environmental effects beyond the Site. It is acknowledged in the literature that environmental effects are extremely low with no records of disease caused by sand quarries such as that proposed by the Applicant.

The air quality assessment of the Proposal was undertaken by Pacific Environment Pty Ltd (PE). The full assessment is presented in Part 8 of the *Specialist Consultant Studies Compendium* and is referenced throughout this section as PE (2018), with a summary of the assessment presented in the following subsections.

5.9.2 Existing Air Quality

In order to capture data on existing air quality conditions at the Site, the Applicant installed five dust deposition gauges and a High Volume Air Sampler (HVAS) in November 2013 (see **Figure 5.21**). Monitoring of dust concentrations (as PM_{10}) and deposited dust were undertaken between November 2013 and August 2014.

In order to supplement the data available at the Site, additional air quality monitoring data has been reviewed from the Holcim operated Lynwood Quarry located approximately 22km southwest of the Site. Data from Lynwood Quarry includes the measurement of dust deposition and dust concentration (as PM_{10}) spanning January 2013 to June 2016. As the Lynwood Quarry is an operating quarry, the data from this site is considered to provide a conservative estimate in characterising the local air quality environment.

PE (2018) completed an analysis of the data available at the Site using the Lynwood Quarry as a secondary reference. A summary of the analysis and conclusions relating to assumed background levels is provided in the following subsections.

Dust Deposition

Sources of deposited dust emissions on and around the Site include traffic on unsealed roads, local building and construction activities, animal grazing activities and, to a lesser extent, traffic from the Hume Highway.

Deposited dust monitoring at the five dust gauges recorded average monthly deposited dust levels no greater than 1g/m^2/month over the 10 months of recorded data. The highest monthly record was 7.3g/m^2/month measured at dust gauge DG3, located within the Shrine of Our Lady of Mercy – "Penrose Park". Field notes accompanying this monitoring event indicate that bugs and debris contributed to this result. The average monthly deposited dust levels across all sites was 0.4g/m^2/month.

Eight dust deposition gauges located in the vicinity of the Lynwood Quarry site were also used as a reference to assist in establishing background dust deposition levels. The dust deposition data indicates that annual average monthly results typically range from 0.6 to 3.3g/m^2/month. The annual average deposited dust levels at each gauge was 1.6g/m^2/month and complies with the EPA annual average criterion of 4.0g/m^2/month. Several individual months returned levels above 4g/m^2/month, often coinciding with recorded contamination within the gauge.

From the above data, PE (2018) conservatively assumed an average dust deposition rate in the vicinity of the Site of 1.6g/m^2/month, consistent with the average of all results at the Lynwood Quarry dust gauges.

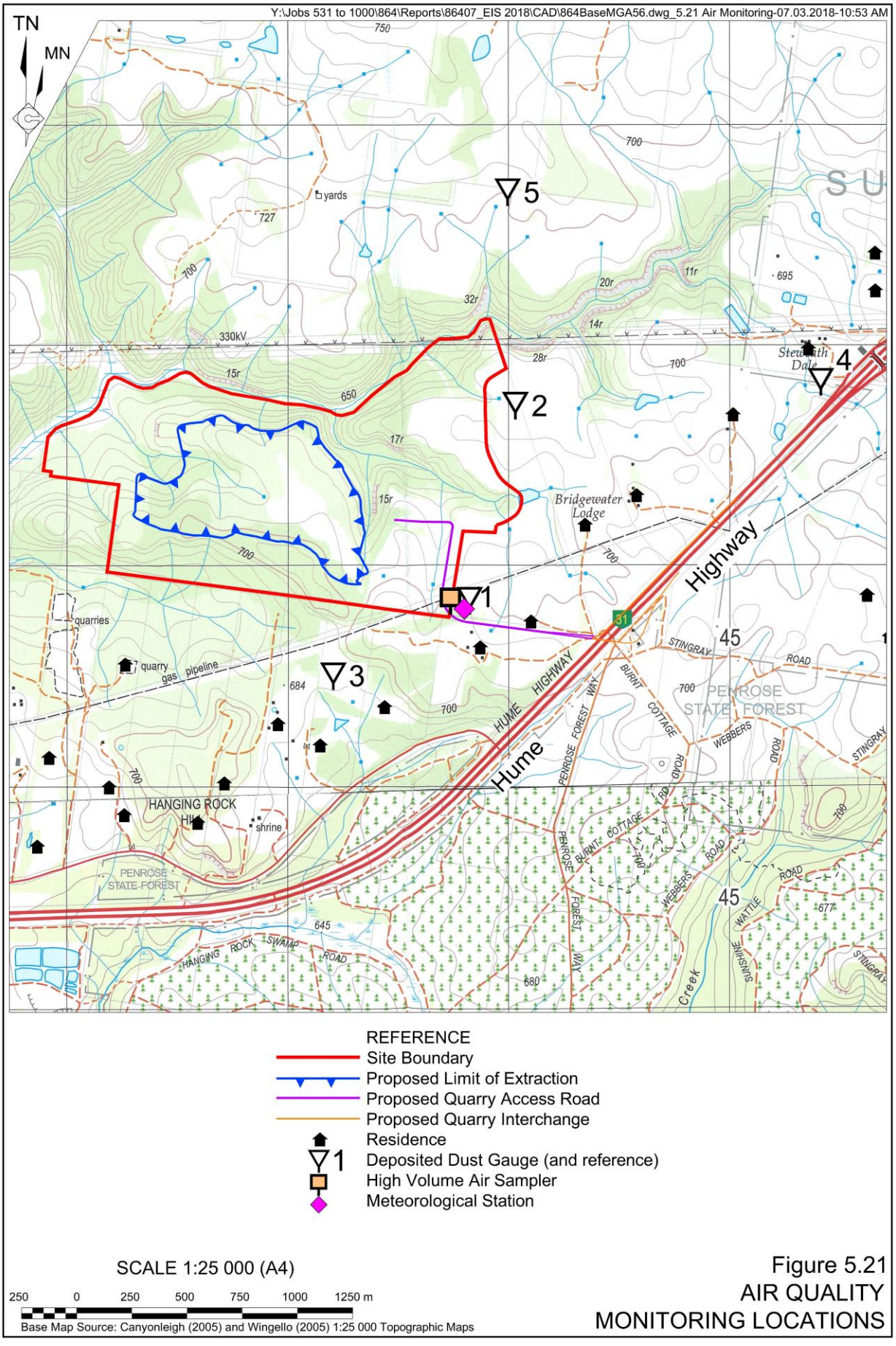


Figure 5.21
AIR QUALITY
MONITORING LOCATIONS

PM_{10} and Total Suspended Particulate Concentrations

Records of PM_{10} have been measured at the Site from November 2013 to January 2015 with measurements of a 24 hour average sample, taken generally every six days. After excluding erroneous records, the average of all records of 24-hour average PM_{10} was 12.9µg/m^3. The records varied between 2.2µg/m^3 and 38.7µg/m^3.

Measurements of PM_{10} concentrations are available for the Lynwood Quarry site from two high volume air samplers (HVAS), namely HVAS1 or HVAS2 each recording a 24 hour average sample, every six days. The period from January 2013 to June 2016 was considered by PE (2018). When combined with the available site data from the Sutton Forest HVAS, the data indicates that annual average particulate matter levels are relatively low. The annual average PM_{10} level at HVAS1 and HVAS2 was 10.1µg/m^3 and 8.7µg/m^3 respectively. The average PM_{10} level recorded at the Sutton Forest HVAS was used as a conservative annual average for the PE (2018) assessment.

The maximum 24-hour PM_{10} concentration measured at the Sutton Forest HVAS, HVAS1 and HVAS2 was 38.7µg/m^3, 50.9µg/m^3 and 43.4µg/m^3 respectively, though it is noted that the exceedance at HVAS1 occurred during a period of local roadworks. It is difficult to accurately predict cumulative 24-hour impacts due to the day to day variability in ambient particulate matter levels and the influence from other activities in the vicinity such as agricultural activity or bush fires.

Assuming that PM_{10} constitutes approximately 40% of the Total Suspended Particulates (TSP), the annual average background TSP level would be 32.3µg/m^3.

$PM_{2.5}$ Concentration

The PM_{10} data have also been extrapolated to provide an estimate of background $PM_{2.5}$ concentrations. A ratio of 0.4 has been applied to the PM_{10} data to give an annual average $PM_{2.5}$ concentration of 5.2µg/m^3. The adopted ratio is based on simultaneous measurements of PM_{10} and $PM_{2.5}$ concentrations at a rural EPA monitoring site (Wagga Wagga North 2013 – 2015; NSW EPA, 2016).

The derived background, based on this ratio, is below the NEPM goal of 8µg/m^3.

Adopted Background Concentrations

From the monitoring data available, it has been assumed that the following background concentrations apply at the nearest residences to the Site.

- Annual average TSP of 32.3µg/m^3
- Annual average PM_{10} of 12.9µg/m^3
- Annual average $PM_{2.5}$ of 5.2µg/m^3
- Annual average dust deposition of 1.6g/m^2/month
- 24-hour average PM_{10} – daily varying
- 24-hour average $PM_{2.5}$ – daily varying

5.9.3 Potential Sources of Air Contaminants

5.9.3.1 Particulate Emissions

The development and operation of the sand extraction and processing operation would generate particulate emissions, the main sources of which would include:

- vegetation clearing and soil stripping;
- sandstone ripping, handling and loading to off-road trucks;
- occasional blast hole drilling activities and blasts;
- road and hardstand area construction (on-site);
- road construction and delivery of road construction materials;
- dry screening activities (brickie's sand plant, front-end loader);
- wind erosion off areas within the extraction area and soil and sand stockpiles; and
- general movement of heavy vehicles on unsealed roads within the Site (haul truck wheel dust).

Combustion of diesel due to the operation of extraction equipment and product trucks would result in emission of fine fractions of particulate matter (PM_{10} and $PM_{2.5}$), oxides of nitrogen (NO_x), carbon monoxide (CO), sulfur dioxide (SO_2) and organic compounds. The emissions from the diesel-powered mobile earthmoving equipment associated with the Quarry would be relatively small and are unlikely to result in significant off-site concentrations of these compounds. In comparison to vehicle emissions from the nearby Hume Highway, combustion emissions from the Proposal would be relatively small and therefore have not been considered further.

5.9.3.2 Greenhouse Gases

The primary source of greenhouse gas emissions from the Proposal would be the result of combustion of fuel by diesel-powered equipment and vehicles, including mobile screening plant, front-end loaders, excavators, bulldozers and off-road haul trucks. Minor levels of greenhouse gas emissions would be generated by the combustion of diesel fuel for temporary on-site power generation for lighting towers, etc.

5.9.4 Air Quality Standards/Criteria

5.9.4.1 Health Effects

Particulate matter has the capacity to affect health and to cause nuisance effects, and potential impacts may result from factors of size and/or chemical composition. The particulate size ranges are commonly described as:

- TSP – refers to all suspended particles in the air. In practice, the upper size range is typically 30μm to 50μm.

- PM_{10} – refers to all particles with equivalent aerodynamic diameters of less than 10μm, that is, all particles that behave aerodynamically in the same way as spherical particles with diameters less than 10μm and with a unit density. PM_{10} are a sub-component of TSP.
- $PM_{2.5}$ – refers to all particles with equivalent aerodynamic diameters of less than 2.5μm diameter (a subset of PM_{10}). These are often referred to as the fine particles and are a sub-component of $PM_{10.}$
- $PM_{2.5-10}$ – defined as the difference between PM_{10} and $PM_{2.5}$ mass concentrations. These are often referred to as coarse particles.

Evidence suggests that health effects from exposure to airborne particulate matter are predominantly related to the respiratory and cardiovascular systems (WHO, 2011). The human respiratory system has in-built defensive systems that prevent larger particles from reaching the more sensitive parts of the respiratory system. Particles larger than approximately 10μm, while not able to affect health, can impact soil materials and generally degrade aesthetic elements of the environment. For this reason, air quality criteria make reference to measures of the total mass of all particles suspended in the air. This is referred to as TSP. In practice, particles larger than 30μm to 50μm settle out of the atmosphere too quickly to be regarded as air pollutants.

Both natural and anthropogenic processes contribute to the atmospheric load of particulate matter. Coarse particles ($PM_{2.5-10}$) and larger are derived primarily from mechanical processes resulting in the suspension of dust, soil, or other crustal[5] materials from roads, farming, extraction operations, dust storms, and so forth. Coarse particles also include sea salts, pollen, mould, spores, and other plant parts. Dust generated by extraction operations is composed of predominantly coarse particulate matter (and larger).

Fine particles or $PM_{2.5}$ are derived primarily from combustion processes, such as vehicle emissions, wood burning, coal burning for power generation, and natural processes such as bush fires. Fine particles also consist of transformation products, including sulphate and nitrate particles, and secondary organic aerosols from volatile organic compound emissions. $PM_{2.5}$ may penetrate beyond the larynx and into the thoracic respiratory tract and evidence suggests that particles in this size range are more harmful than the coarser component of PM_{10}.

The size of particles determine their behaviour in the respiratory system, including how far the particles are able to penetrate, where they deposit, and how effective the body's clearance mechanisms are in removing them. Additionally, particle size is an important parameter in determining the residence time and spatial distribution of particles in ambient air, key considerations in assessing exposure.

The health-based assessment criteria used by NSW EPA have, to a large extent, been developed by reference to epidemiological studies undertaken in urban areas with large populations where the primary pollutants are the products of combustion (NSW EPA, 1998; National Environment Protection Council [NEPC], 1998a; NEPC, 1998b). This means that, in contrast to dust of crustal origin, the particulate matter from urban areas would be composed of smaller particles and would generally contain acidic and carcinogenic substances that are associated with combustion.

[5] Crustal dust refers to dust generated from materials derived from the earth's crust.

5.9.4.2 Assessment Criteria

In its modelling and assessment guidelines, the EPA specifies air quality assessment criteria relevant for assessing impacts from dust generating activities (EPA, 2016).

These criteria are consistent with the now superseded National Environment Protection Measures for Ambient Air Quality (referred to as the Ambient Air-NEPM) (NEPC, 1998b). However, the EPA's criteria include averaging periods which are not included in the Ambient Air-NEPM, and also reference other measures of air quality, namely dust deposition and total suspended particulate matter.

In January 2016, the NEPC released an amended Ambient Air NEPM (NEPC, 2016). The 2016 NEPM for $PM_{2.5}$ standards have been used for comparison against dispersion modelling results.

Table 5.25 summarises the air quality goals for particulate matter that are relevant to the Proposal.

Table 5.25
Air Quality Impact Assessment Criteria for Particulate Matter Concentrations

Pollutant	Standard / Criteria	Averaging Period	Agency
Total suspended particulate matter (TSP)	90μg/m^3	Annual mean	NSW EPA impact assessment criteria (EPA, 2016)
Particulate matter < 10μm (PM_{10})	50μg/m^3	24-hour maximum	
	25μg/m^3	Annual mean	
Particulate matter <2.5μm ($PM_{2.5}$)	25μg/m^3	24-hour maximum	
	8μg/m^3	Annual mean	
Source: PE (2018) – Table 2			

Table 5.26 shows the dust deposition criteria set out in the EPA procedures for modelling air pollutants from sources (EPA, 2016).

Table 5.26
NSW DECC Criteria for Dust (insoluble solids) Fallout

Pollutant	Averaging period	Maximum increase in deposited dust level	Maximum total deposited dust level
Deposited dust	Annual	2g/m^2/month	4g/m^2/month
Source: PE (2018) – Table 3			

The *Voluntary Land Acquisition and Mitigation Policy* (VLAMP) (NSW Government, 2014) applies to all State Significant extractive industry developments and sets out the rights of a landowner with respect to requests for the negotiation of mitigation measures or land acquisition as result of excessive noise and air quality (particulate matter) impacts. The policy is applied through conditions of development consent where assessment has determined that the provision of the VLAMP would still be triggered after implementation of all reasonable and feasible avoidance and/or mitigation measures. An updated version of the VLAMP is presently under consideration with a draft version released in November 2017 (NSW Government, 2017). This draft VLAMP proposes an annual average PM_{10} criteria that is reduced to 25 μg/m^3.

Subsequently for conservatism, the assessment criteria used in this assessment for TSP, PM_{10} and deposited dust (**Table 5.25** and **Table 5.26**) are aligned with the draft VLAMP, with triggers for various actions dependent on the extent that the criteria is exceeded. It should be noted that the VLAMP also applies to vacant land, which is considered to be impacted if air quality is predicted to exceed the impact assessment criteria over an area greater than 25% of the land holding, regardless of whether there is a residence on that property or not.

5.9.4.3 Diesel Fumes

Details of the air quality assessment methodology is presented in Section 5.9.5 and in Section 6 of PE (2018).The emission factors applied in the emissions inventories include particulate matter emissions from both the mechanical processes (i.e. crustal material) and the diesel exhaust (combustion).These two sources are not distinguished in this process and therefore it is difficult to establish specific impacts relating to diesel exhaust without undertaking stand-alone modelling.

As described in Section 5.1.2.2, the Site is located approximately 0.8km from the Hume Highway which carries approximately 21 000 vehicles per day, of which almost 6 000 vehicles per day are heavy vehicles. In comparison, the Proposal is expected to reach a maximum of 166 laden trucks per day (332 vehicle movements) at maximum production. Therefore, the maximum traffic that would be generated by the Proposal is less than 6% of the heavy vehicles that travel daily on the Hume Highway. When combined with the fact that the majority of the sensitive receptors are located closer to the Hume Highway than they are to the Site, it is considered that impacts relating to diesel fumes are expected to be minor. Any contribution of diesel fumes to the predicted cumulative air quality impacts have been accounted for through the emissions factors used for the assessment. No separate modelling of diesel emissions has been completed.

5.9.4.4 Blast Fumes

As described in Section 2.5.3, the Applicant anticipates that in any one year it may be necessary to initiate between six and twelve blasts. Each blast would use a maximum of 200kg of ANFO, resulting in a total annual ANFO usage of 2.4t under the most conservative scenario. PE (2018) considered this level of explosive use against information provided in research CSIRO completed for an ACARP monitoring study in 2013 that assessed emissions from blasting from open cut coal mines (Day et.al, 2013). PE (2018) concluded that there would be minimal risk of any adverse NO_2 impacts due to blasting from the Proposal based on the anticipated level of explosive use and given that about 80% of the blast plumes considered in the CSIRO research did not show NO_2 levels above ambient levels (Day et al., 2013). As such no further assessment of blasting fumes has been completed.

Blast fumes would be managed through an adaptive approach to blast design that would be described in an approved *Noise and Blasting Management Plan*.

5.9.4.5 Crystalline Silica

Silica (SiO_2) is a naturally occurring mineral composed of silicon and oxygen. It exists in crystalline and amorphous forms depending on the structural arrangement of the oxygen and silicon atoms. Only the crystalline forms are known to be fibrogenic (causes the formation of fibres) and only the respirable particles (those which are capable of reaching the gas exchange region of the lungs) are considered in determining health effects of crystalline silica.

Human exposure to crystalline silica invariably occurs during occupational activities that involve the working of materials containing crystalline silica products (e.g. masonry, concrete, sandstone) or use or manufacture of crystalline silica-containing products. Activities that involve cutting, grinding or breaking of these materials can result in the liberation of particles in multiple size ranges. The sand grains within the friable sandstone within the Site are predominantly silica, although it is noted their grain size is substantially greater than that which causes health problems. The generation of fine grained silica would occur within the Site during the extraction operations involving either drilling or ripping. In both cases, the sand grains are reduced in size and increase in angularity, both factors that increase the risk of impacting health.

Crystalline silica dust is found everywhere in the environment (i.e. not in an occupational context) due to natural, industrial and agricultural activities as it comprises 12% of the earth's crust (EOG Resources, 2014). Whilst the long term inhalation of silica dust may lead to the formation of scar tissue in the lungs, which can result in the serious lung disease silicosis, this is regarded exclusively as a work place exposure issue that is associated with long-term exposure to high levels of respirable crystalline silica (RCS).

The EPA has not set any impact assessment criteria for crystalline silica. The Victorian EPA has adopted an ambient assessment criterion for mining and extractive industries of 3µg/m^3 (annual average as $PM_{2.5}$) (VEPA, 2007). This has been derived from the Reference Exposure Level set by the California EPA Office of Environmental Health Hazard Assessment of 3µg/m^3 (annual average as PM_4) (OEHHA, 2005), at or below which "no adverse effects are expected for indefinite exposure".

Crystalline silica is assessed for the Proposal through reference to predicted annual average particulate matter concentrations at the most affected residence.

5.9.5 Assessment Methodology for Particulate Matter Emissions

The approach taken in the assessment used the AERMET/AERMOD advanced modelling system. The EPA has accepted AERMOD as a suitable atmospheric dispersion model for assessments of proposals for extractive industries. Details of the modelling parameters and emission factors used are presented in Section 6 PE (2018).

Two operational scenarios were chosen for quantitative dispersion modelling. The stages modelled (Stage 2 and Stage 4 of extraction operations) are respectively the average and based on maximum sand extraction rates of 820 000tpa and 1Mtpa and represent when the Quarry would be operating in closest proximity to the nearby residences. Total dust emissions resulting from activities under the Proposal have been estimated by analysing the activities that would take place during these representative extraction stages.

The estimated particulate matter emissions for the two extraction stages are given in PE (2018) for all the activities associated with the Proposal. The key sources of particulate emissions would include the following.

- Bulldozers or other mobile equipment ripping the sandstone.
- Transportation of the ripped sandstone from the extraction area to the processing plant.
- Transportation of sand products from the product stockpiling area.
- Dry screening within the brickie's sand plants.
- Wind erosion across exposed surfaces.
- Occasional blasting activities.

As the maximum daily production rates can vary from week to week using a daily average production rate based on the annual throughput would underestimate potential short term impacts. Therefore, a maximum daily production extraction rate of 4 000t per day was assessed for the 24-hour averaging periods for PM_{10} and $PM_{2.5}$. Air quality predictions are based upon a daily throughput for the wet processing plant of 4 000t per day and 800t per day in the brickie's sand plant.

In estimating emissions, consideration has been given to best practice management and controls, including watering of internal haul roads. The effectiveness of surrounding vegetation to reduce concentrations and levels of airborne and deposited dust has not been included in the modelling predictions. In addition, for the purposes of assessment, it was assumed that extraction activities take place between 5:00am and 10:00pm, seven days a week, while it was assumed that all other activities occur 24 hours per day, seven days per week. Hence, the predicted concentrations and levels are considered conservative.

It is noted that for the purpose of assessment, Residence 1and Residence 3 are project-related and subject to agreements with the Applicant. The air quality criteria do not apply at these residences. However, the Applicant has included these locations in the assessment and summary of results in order that the amenity and health risks at these locations is considered and understood.

5.9.6 Proposed Management and Monitoring Measures

The Applicant would employ a number of best practice mitigation measures on site to ensure that dust impacts are minimised. These measures would be summarised in an Air Quality Management Plan and include:

- use of a water cart to control emissions from internal haul roads (unsealed);
- implementation of a wheel wash to limit material tracking from the Site (during the site establishment and construction stage);
- sealing of the Quarry Access Road;
- enforcement of speed limits on site and on the Quarry Access Road;

- training and implementation of standard operating procedures;
- progressive rehabilitation of exposed areas;
- minimising drop height of material during truck loading and unloading where possible;
- sheltering of stockpiles and transfer points, where possible;
- management of dust generating activities during unfavourable meteorological conditions; and
- recommencing the monitoring of ambient air quality with PM_{10} HVAS and dust deposition gauges as detailed in Section 5.9.8.

The following measures would be implemented to minimise greenhouse gas (GHG) emissions from the Proposal.

- Consider opportunities to continually improve energy use and efficiency such as minimise haul distances and therefore fuel use and limit double handling of materials.
- Ongoing scheduled and preventative maintenance to ensure that diesel and electrically powered plants operate efficiently.
- Monitor energy usage to ensure GHG emissions are limited as much as practical.

5.9.7 Assessment of Impacts

5.9.7.1 Site Establishment and Construction

PE (2018) considered the potential impact of site establishment and construction activities, focusing on the first 12 months during which these activities would be at their most intensive.

Emissions are likely to result from activities such as vegetation clearing and soil stockpiling, construction of the Quarry Operations Area, Quarry Access Road and Quarry Interchange, extraction of friable sandstone within the Quarry Operations Area and construction of dams and administrative facilities.

Construction particulate matter emissions would be a comparatively short-term impact and would be managed through consideration of truck speeds on unsealed surfaces, limits to activities during adverse weather conditions, water spraying of unsealed surfaces and management of mud tracking from the Site.

Dust emissions during the site establishment and construction stage of the Proposal would be considerably less than emissions during operation of the Quarry.

5.9.7.2 Annual Average Particulate Matter Emissions

Figures 5.22 to **5.25** display the predicted cumulative annual average TSP, PM_{10} and $PM_{2.5}$ concentrations and deposited dust levels for Stages 2 and 4.

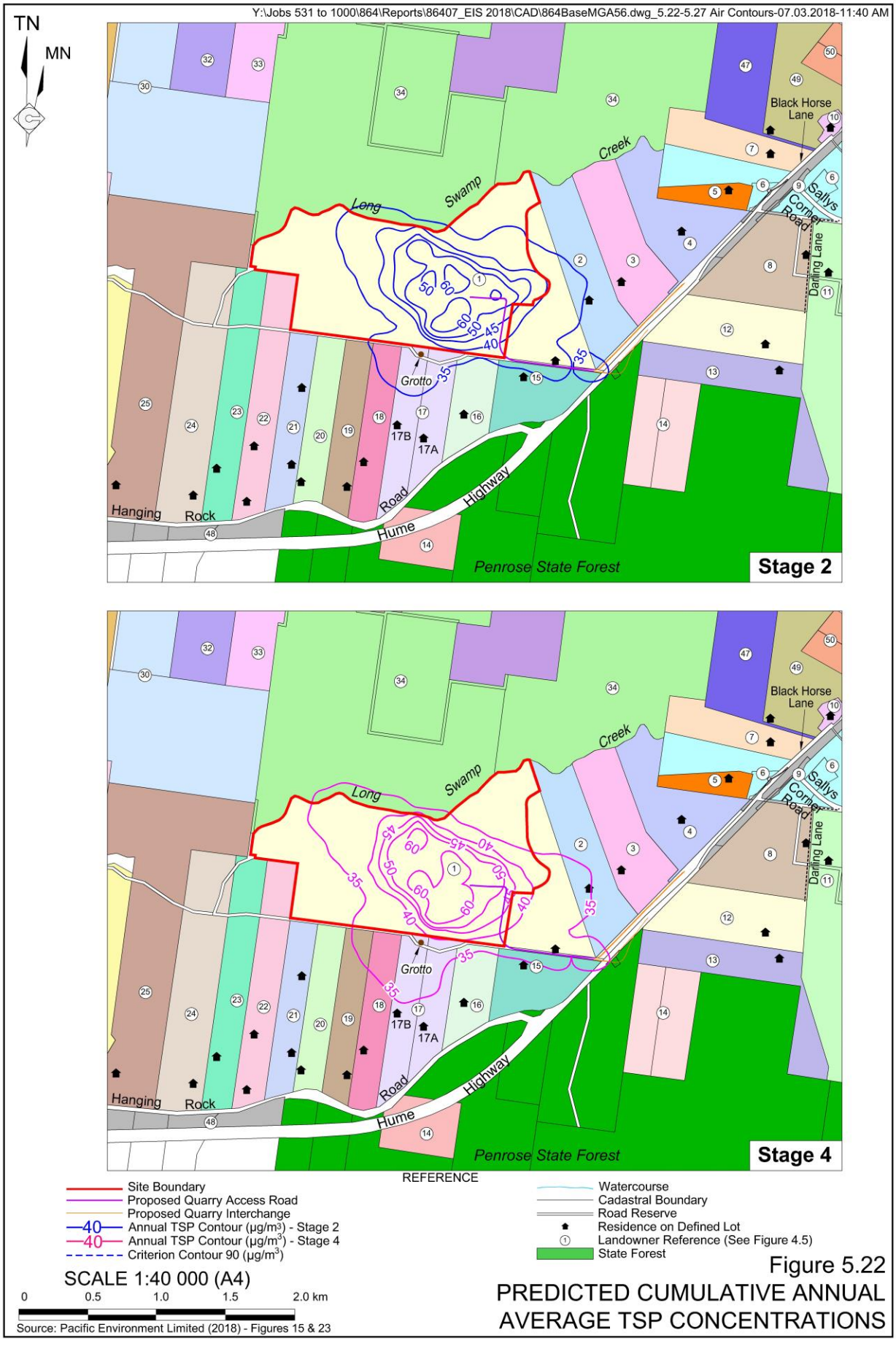


Figure 5.22
PREDICTED CUMULATIVE ANNUAL AVERAGE TSP CONCENTRATIONS

Figure 5.23
PREDICTED CUMULATIVE ANNUAL AVERAGE PM_{10} CONCENTRATIONS

Figure 5.24
PREDICTED CUMULATIVE ANNUAL AVERAGE $PM_{2.5}$ CONCENTRATIONS

Figure 5.25
PREDICTED CUMULATIVE ANNUAL AVERAGE DUST DEPOSITION LEVELS

Stage 2

Modelling results for Stage 2 indicate no exceedances of the relevant annual average TSP, PM_{10}, $PM_{2.5}$ and dust deposition impact assessment criteria or NEPM goal at any residence.

Residents are expected to experience a maximum increment of:

- <0.1 to 1.8µg/m^3 annual average PM_{10} concentrations resulting in a cumulative maximum concentration of 14.7µg/m^3 which is well below the EPA criterion of 25µg/m^3 assuming existing background levels of 12.9µg/m^3;
- <0.1 to 2.4µg/m^3 annual average TSP resulting in a cumulative maximum concentration of 34.7µg/m^3 which is well below the EPA criterion of 90µg/m^3, assuming an existing background levels of 32.3µg/m^3;
- <0.1 to 0.4µg/m^3 annual average $PM_{2.5}$ resulting in a maximum cumulative concentration of 5.5µg/m^3. This is below the EPA cumulative criterion of 8µg/m^3 assuming a background level of 5.2µg/m^3; and
- <0.1 to 0.3g/m^2/month annual average dust deposition levels. Compliance with the incremental increase criteria of 2.0g/m^2/month would easily be achieved as well as the cumulative criterion of 4.0g/m^2/month assuming existing background levels of 1.6g/m^2/month.

Stage 4

Modelling results for Stage 4 indicate no exceedances of the annual average TSP, PM_{10}, $PM_{2.5}$ and dust deposition impact assessment criteria or NEPM goal at any residence.

Surrounding residents and visitors would experience an increment of:

- <0.1µg/m^3 to 2.3µg/m^3 annual average PM_{10} concentrations resulting in a cumulative maximum concentration of 15.2µg/m^3 which is well below the EPA criterion of 25µg/m^3 assuming and existing background levels of 12.9µg/m^3;
- <0.1µg/m^3 to 2.7µg/m^3 annual average TSP resulting in a cumulative maximum concentration of 35.0µg/m^3 which is well below the EPA criterion of 90µg/m^3, assuming an existing background level of 32.3µg/m^3;
- <0.1µg/m^3 to 0.4µg/m^3 annual average $PM_{2.5}$ concentrations resulting in a maximum cumulative concentration of 5.5µg/m^3 which is well below the EPA criterion of 8µg/m^3 assuming a background level of 5.2µg/m^3; and
- <0.1g/m^2/month to 0.4g/m^2/month annual average dust deposition levels resulting in a cumulative maximum concentration of 2.0g/m^2/month. Compliance with the incremental increase criteria of 2.0g/m^2/month would easily be achieved as well as the cumulative criterion of 4.0g/m^2/month assuming existing background levels of 1.6g/m^2/month.

5.9.7.3 24 Hour Particulate Matter Emissions

Figures 5.26 and **5.27** display the predicted maximum 24 hour average PM_{10} and $PM_{2.5}$ concentrations for Stages 2 and 4.

Stage 2

Surrounding residents and visitors would experience an increment attributable to the Proposal of 0µg/m^3 to 21µg/m^3 in the 24 hour PM_{10} concentration and 0µg/m^3 to 6µg/m^3 in the 24 hour $PM_{2.5}$ concentration.

Stage 4

Surrounding residents and visitors would experience an increment attributable to the proposal of 1µg/m^3 to 17µg/m^3 in the 24 hour PM_{10} concentration and 0µg/m^3 to 6µg/m^3 in the 24 hour $PM_{2.5}$ concentration.

In both stages, the predicted 24 hour PM_{10} concentrations satisfy the assessment criterion of 50µg/m^3. Similarly for the 24 hour $PM_{2.5}$ concentrations, the predicted concentrations satisfy the 25µg/m^3 EPA criteria.

PE (2018) assessed the cumulative 24 hour impacts, recognising the day to day variability in ambient particulate matter levels and the local variations due to a wide range of other factors such as farming activities and bush fires. PE (2018) used the recognised Monte Carlo Simulation, a statistical modelling approach to assess the cumulative impacts. Details of the simulations are provided in PE (2018) all of which confirm that with the addition of the Proposal, there would be no additional days that the assessment criterion for PM_{10} (50µg/m^3) and $PM_{2.5}$ (25µg/m^3) would be exceeded.

5.9.7.4 Vacant Land

Based on a review of the relevant air quality contours and land ownership information for the Proposal, no potential impacts to privately-owned vacant land have been identified for the Proposal, including land where a dwelling exists. Voluntary land acquisition and mitigation rights would not be triggered as a result of predicted dust impacts.

5.9.7.5 Crystalline Silica

PE (2018) has reviewed the potential impact of crystalline silica through consideration of annual average particulate matter concentration at the most affected residence (Residence 17b) due to the Proposal-only. The annual average for total suspended particulates (TSP), as a result of the Proposal-only, is predicted to be less than 2.5µg/m^3 in the worst-case. Given that crystalline silica would be a small fraction of this concentration, any PM_4 crystalline silica levels would be significantly below levels that may be of concern.

Figure 5.26
PREDICTED 24 HOUR PM_{10} CONCENTRATIONS PROPOSAL ALONE

Figure 5.27
PREDICTED 24 HOUR $PM_{2.5}$ CONCENTRATIONS PROPOSAL ALONE

5.9.7.6 Greenhouse Gas Emissions

Greenhouse gas (GHG) emissions have been estimated based on the methods outlined in the following documents.

- The World Resources Institute/World Business Council for Sustainable Development (WRI/WBCSD) Greenhouse Gas Protocol The Greenhouse Gas Protocol – A Corporate Accounting and Reporting Standard Revised Edition ("the GHG Protocol"; WRI/WBCSD, 2004).
- National Greenhouse and Energy Reporting (Measurement) Determination 2008.
- The Commonwealth Department of Climate Change and Energy Efficiency (DCCEE) National Greenhouse Accounts (NGA) Factors August 2015 (DCCEE, 2015).

Details of the methodology employed and emission factors used in the calculations of greenhouse gas emissions, in terms of t CO_2-e/year, are described in Section 9.2 and Appendix 2 of PE (2018). The calculations have been based on the maximum sand extraction rate of 1Mt/year, and that the annual electricity usage would be 3.3 kWh per tonne of product.

Proposal-related GHG sources included in the assessment are as follows.

- Fuel consumption (diesel) during extraction, processing and transportation – Scope 1 emissions.
- Indirect emissions associated with on-site electricity use – Scope 2 emissions.
- Indirect emissions associated with the production of transport fuels – Scope 3 emissions.

It is assumed that diesel and electricity usage would not vary significantly between the years of operation throughout the first 30 years of the Quarry's operation.

A summary of GHG emissions arising from the source noted above and classified as Scope 1, Scope 2 and Scope 3 (expressed as t CO_2-e/year) for the Proposal are shown in **Table 5.27**.

Table 5.27
Summary of Estimated GHG Emissions

Type of fuel and activity	Scope 1	Scope 2	Scope 3	Total Scope 1 and Scope 2 (t $CO_{2\text{-}e}$ per year)	Total All Scopes (t $CO_{2\text{-}e}$ per year)
Diesel - non-transport	9 470	0	486	9 470	9 955
Diesel - transport	16 485	0	842	16 485	17 326
Electricity usage	0	2 752	393	2 752	3 145
Total	**25 954**	**2 752**	**1 721**	**28 706**	**30 427**
Source: PE (2018) – Table 19					

The GHG emissions from the Proposal would be approximately 0.029 Mt CO_2-e. This would represent approximately 0.005% of Australia's commitment for annual emissions under the Kyoto Protocol (591.5 Mt CO_2-e/annum) and a very small portion of global GHG emissions,

given that Australia contributed approximately 1.15% of global GHG emissions in 2014 (PBL Netherlands Environmental Assessment Agency, 2015). It should be noted that >50% of these emissions are associated with the transportation of the product.

5.9.8 Cumulative Impact Assessment

In addition to the cumulative impacts due to existing particulate levels in the area, consideration has been given to additional extractive industries in the vicinity of the Site. It has been assessed, given the comparative distance from the proposed Green Valley Sand Quarry to the Site (approximately 6km) that it is appropriate to only consider the Penrose Sand Quarry owned by Hy-Tec Industries Pty Limited which is located (2km southwest of the Site). As well as accounting for background dust levels around the Site the potential for cumulative impacts with the Penrose Sand Quarry should also considered.

A dispersion modelling assessment was undertaken by Holmes Air Sciences (1997) which assessed the potential air quality impacts of the Penrose Sand Quarry. A different meteorology data set was used in the Penrose Sand Quarry assessment compared with the assessment of the Proposal, therefore impacts on nearby residents cannot be directly correlated.

However, the modelling completed for the Penrose Sand Quarry showed a maximum cumulative increment at the nearest residence of no more than 5µg/m^3 for annual average PM_{10} and no more than 0.5g/m^2/month for annual average dust deposition. When considered with the predicted impacts from the Applicant's proposal and existing background levels, the combined concentrations are still below the relevant impact assessment criteria.

It is difficult to accurately predict cumulative 24-hour impacts that incorporate activities in addition to industrial or extractive operations for which assessments have been undertaken. This is due to the day to day variability in ambient particulate matter levels and the spatial and temporal variation in any other anthropogenic activity e.g. agricultural activity, bush fires, etc. in the future.

PE (2018) evaluated cumulative air quality impacts using a statistical approach known as a Monte Carlo Simulation. The Monte Carlo Simulation is a statistical modelling approach that combines the frequency distribution of one data set (in this case background 24-hour PM_{10} and $PM_{2.5}$ concentrations) with the frequency distribution of another data set (in this case, the Proposal's modelled impacts at a given point).

PE (2018) assessed cumulative impacts for residences that were predicted to have the highest contribution of particulate matter from the Proposal and concluded that the cumulative impacts would be unlikely to result in additional days for which criteria was exceeded. In fact, the cumulative impact would largely be indistinguishable from background concentrations.

5.9.9 Monitoring

The Applicant would recommence monitoring of deposited dust and PM_{10} using the existing deposited dust gauges and High Volume Air Sampler following the receipt of development consent.

Details of the proposed monitoring program would be included in the Quarry's Air Quality Management Plan. The results of the monitoring would be reviewed at the end of Stage 0 of extraction operations and evaluated to determine the appropriate level of ongoing monitoring.

5.9.10 Conclusion

The results of the air quality assessment undertaken by PE (2018) using two operational scenarios (Year 2 and Year 4) has concluded that the Proposal is predicted to comply with all impact assessment criteria for each relevant averaging period for TSP, $PM_{2.5}$, PM_{10} and dust deposition.

Construction particulate matter emissions would be a comparatively short-term but high intensity impact with dust emissions during this period appropriately managed and considerably less than emissions during operation of the Quarry.

The greenhouse gas assessment concluded that average annual scope 1 and 2 emissions from the Proposal (0.029Mt CO_2-e) would represent approximately 0.005% of Australia's commitment under the Kyoto Protocol (591.5 Mt CO_2-e) and a very small proportion of global greenhouse emissions.

5.10 SOILS AND LAND CAPABILITY

5.10.1 Introduction

The DGRs for the Proposal identified "*Soil and Land Capability*" as a key issue requiring that the "*EIS include:*

- *a detailed assessment of the potential impacts on soils and land capability (including land contamination)."*

Based on the risk assessment undertaken for the Proposal (**Appendix 4**), the potential impacts relating to soil and land capability and their risk rankings (in parenthesis) after the adoption of pre-existing or standard mitigation measures are as follows.

- Loss of soil resources as a result of land preparation activities (medium).
- Degradation of soils resources as a result of stockpiling (medium).
- Erosion as a result of vegetation clearing, from stockpiles or following soil replacement during rehabilitation resulting in:
  - loss of soil resources; (medium); and/or
  - sedimentation of on-site and local surface water bodies resulting in poor water quality (medium).

The soils assessment of the Proposal was undertaken by Strategic Environmental & Engineering Consulting (SEEC) Pty Ltd. The full assessment is presented in Part 10 of the *Specialist Consultant Studies Compendium* and is referenced throughout this section as SEEC (2018b). It is noted that the Soil Landscapes identified and discussed within the assessment undertaken by SEEC (2018b) and below have been superseded by the publication of maps showing the Soil and Land Resources of Central and Eastern NSW (OEH, 2018). Notwithstanding this, the conclusions, classifications and mitigation measures presented within the assessment undertaken by SEEC (2018b) and below are based on the interpretation of the results of detailed site investigations, soil sampling and laboratory analyses and that the methodology applied to the interpretation remains current and appropriate for this assessment.

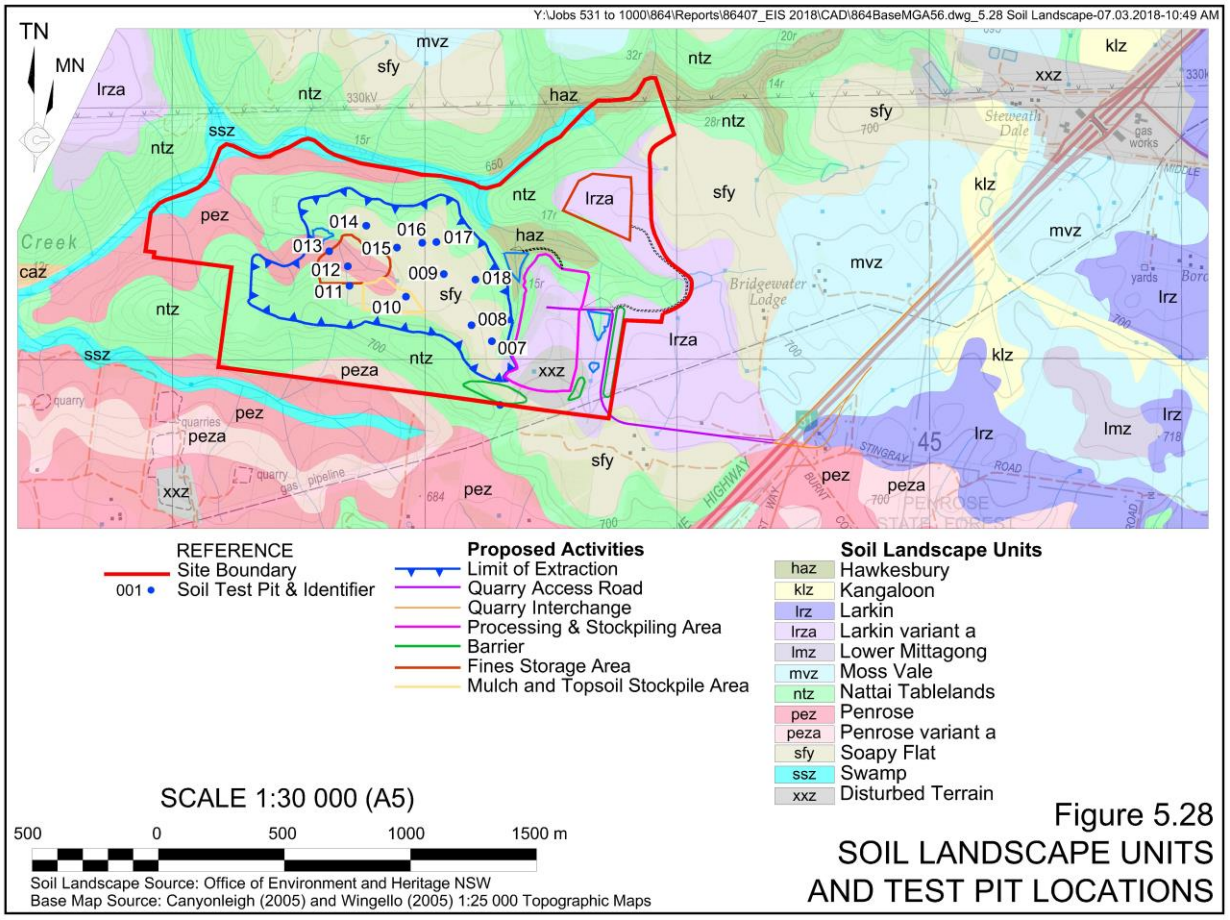
The following sub-sections present a summary of the assessment undertaken by SEEC (2018b), identifying specific soils-related constraints and opportunities that might affect the proposed design, establishment, operation and post-operative rehabilitation of the Proposal.

5.10.2 Regional Setting

The study area covers five different soil landscapes.

- Soapy Flat Soil Landscape.
- Penrose Soil Landscape.
- Nattai Tablelands Soil Landscape.
- Larkin Soil Landscape (variant a).
- Disturbed Terrain.

Figure 5.28 shows the soil landscape mapping and study area overlain on the 1:25 000 topographic map. A description of each of the soil landscapes is provided, including an indication of the anticipated soil types.



Soapy Flat Soil Landscape

This landscape occurs on gently undulating rises to undulating low hills on Hawkesbury Sandstone in the Moss Vale Tablelands. There are four landscape facets comprising:

- imperfectly drained hills: Yellow Kurosols and Chromosols (Yellow Podzolic soils);
- well drained hillslopes and crests: Brown Dermosols (Brown Podzolic soils);
- ridges and footslopes: Orthic Tenosols (Earthy Sands); and
- swampy areas: Hydrosols (Acid Peats).

Penrose Soil Landscape

This landscape occurs on undulating rises to undulating low hills formed on Hawkesbury Sandstone. There are four landscape facets comprising:

- upper slopes and gentle slopes: Kandosols (Yellow Earths);
- mid-slopes: Orthic Tenosols (Earthy Sands);

- lower slopes: Sodosols (Solodic Soils); and
- poorly drained areas: Grey Kurosols (Grey Podzolic Soils).

The Nattai Tablelands Soil Landscape

This Landscape occurs on undulating to rolling elevated hills on Hawkesbury Sandstone. There are three landscape facets comprising:

- broad crests and inside benches: Yellow Kandosols (Yellow Earths);
- narrowcrests and sideslopes: Tenosols (Earthy Sands), Rudosols (Lithosols); and
- soil on shale lenses: yellow Kurosols and Chromosols (Yellow Podzolic Soils).

The Larkin Soil Variant a Soil Landscape

This landscape predominantly occurs as a residual soil derived from lateritic substrate. There are three landscape facets comprising:

- gentle slopes: Ferrosols (Lateritic Red Earths).
- change in slopes and substrate material: Ferrosols (Lateritic Red Podzolic Earths).
- areas with higher clay content: Ferrosols (Lateritic Krasnozems).

5.10.3 Site Soils

Extensive site and soil investigations involving 18 test pits and laboratory analyses were undertaken to ground truth the accuracy of the soil landscape mapping over the study area. Twelve test pits were excavated within the extraction area and the remaining six test pits were excavated within, or in the proximity of, the processing and stockpiling area and the Quarry Access Road. The corresponding Soil Landscapes are listed in **Table 5.28**.

Table 5.28
Test Pits and Soil Landscapes

Soil Landscape	Test Pit Numbers (TP)
Soapy Flat	1, 7, 8, 9, 10, 11, 14, 15, 16, 17, 18
Penrose	12, 13
Larkin	3, 4
Nattai Tablelands	2,5,6
Source: SEEC (2018b) – Table 2	

The individual soil logs from the various test pits are provided in Appendix 2 of SEEC (2018b). Investigations undertaken by SEEC showed the soils conform to the expectations of the soil landscape mapping. In the Extraction Area, very sandy, acidic, soils (earthy sands) were encountered. The Larkin Soil Landscape that occurs in the processing and stockpiling area and most of the Quarry Access Road comprises soils with a slightly higher fraction of clay and silt but the soils are still very sandy (sandy clay loam). Soils on the Nattai Tablelands Soil Landscape were visually thin and often absent. Topsoil depth varies throughout the Site from 0 to 200mm.

5.10.4 Soil Physical Attributes

Soil samples from specific layers in representative profiles were sent to the Department of Lands' Scone Research Centre for testing. The results of the physical analyses are presented below.

- **Soil Erodibility – K-Factor**

  Soil erodibility (K-factor) ranged from 0.013 (low) to 0.027 (moderate) (Rosewell and Edwards, 1988).

- **Soil Erodibility – Wind Erosion**

  Most soils have high susceptibility (Hazelton and Murphy, 2007). This is a reflection of their granular, non-cohesive, nature.

- **Soil Loss and Erosion Hazard**

  Under the guidelines and recommendations contained in Landcom (2004), construction activities in rainfall zone 7 can occur at any time of year using the standard suite of Best Management Practices (BMPs) for erosion and sediment control if the soil loss class is 4 or less. This is the case across the Site except where slope is greater than 20 percent (which is rare).

  All lands mapped as Soapy Flat or Penrose are soil loss class 4 or less. The results show special measures such as the timing of works, covering soils during rainfall, etc. would only be required if the works are on either the Larkin or Nattai Tablelands Soil Landscapes and where exposed soils occur on lands sloping more than 20 percent. This would rarely occur but, if it did, special measures for erosion and sediment control as described in Chapter 4 of Landcom (2004) would apply.

- **Dispersion**

  Emerson Aggregate Testing (EAT) of samples from four test pits indicate that all samples are either non-dispersible or only slightly dispersible and are unlikely to be sodic.

5.10.5 Soil Chemical Attributes

- **Electrical Conductivity and Salinity**

  Testing shows that the soils within the Site are non-saline.

- **Soil pH**

  pH varied from 6.0 (moderately acidic) to 4.5 (strongly acidic).

- **Cation Exchange Capacity and Exchangeable Cations**

  All samples sent to the laboratory for testing were found to have a very low Cation Exchange Capacity (CEC). This indicates that the natural soils within the Site have a low capacity to retain any nutrients applied (e.g. in fertilizers). Efforts to raise fertility should be done by incorporating organic matter and slow release organic fertilisers, otherwise nutrients would likely leach from the soil.

- **Base Saturation and Leaching**

  Base saturation provides an indication of how closely nutrient status approaches potential fertility and the extent of leaching that has occurred of base cations from the soil (Hazelton and Murphy, 2007). Fourteen samples were analysed from six Test Pits. Base saturation was found to range from 29% to 75%.

- **Available Phosphorus and Organic Content**

  Organic matter is largely responsible for the physical and chemical fertility of a soil. The results obtained from four Test Pits show the topsoils have moderate to high organic matter content but the subsoils have very low to extremely low organic matter (Hazleton and Murphy, 2007).

5.10.6 Soil Structure

Field investigations undertaken by SEEC (2018b) of the soils in the extraction and processing and stockpiling area showed they are generally massive with apedal structure. This is to be expected because of their sandy texture. Where silt and clay content is a little higher (loamy), a weak structure was observed.

5.10.7 Soil Drainage and Permeability

Soils in the extraction area and the processing and stockpiling area and for much of the Quarry Access Road corridor have high infiltration rates and soil drainage is rapid because of the sandy texture. Surface runoff would be low to moderate and is estimated to be no more than 8 percent of mean annual rainfall (SEEC, 2018a). The groundwater recharge rate would be relatively high (see Cook (2018)).

5.10.8 Land Capability Assessment

The Site's Land and Soil Capability (LSC) is assessed by considering its biophysical features and individual hazards (OEH, 2012). For all lands the most limiting hazard is acidification so almost all the site has an LSC Class 5. Class 5 lands are described as having severe limitations for high impact management such as cropping. There are some management practices available but the land is best suited to grazing with some limitations and only occasional cropping for pasture improvement. Fertility is low. Class 5 lands are not prime agricultural land.

5.10.9 Soil Management

5.10.9.1 Soil Stripping

Extraction Area

Soils in the extraction area mainly represent the Soapy Flat Soil Landscape with minor occurrences of the Penrose and Nattai Tablelands Soil Landscapes. The soils on the Soapy Flat Soil Landscape generally have a thin (200mm) but well-defined, topsoil layer (A-Horizon) that has a relatively high organic content. The B1 horizon varies from about 300mm to 500mm in thickness.

The Penrose and Nattai Tablelands Soil Landscapes have an overall shallower total soil thickness, significantly so in the case of the Nattai Tablelands. However, the A1 horizon is a similar thickness (150 to 200mm).

The A and B horizons of each of the Soil Landscapes are sufficiently dissimilar to require separation, so topsoil stripping is proposed to be no more than 300mm depth. Topsoil would be stockpiled separately in low (less than 2m high) stockpiles. Weeds are not expected to be problematic in the natural soil but to prevent their potential proliferation stockpiles would be immediately vegetated with appropriate grass cover. The subsoil would not be stripped as it is effectively friable sandstone targeted for extraction.

Quarry Access Road

The Quarry Access Road would predominantly be on the Larkin Soil Landscapes with a minor occurrence of the Soapy Flat Soil Landscape. The topsoils of both Soil Landscapes are well-defined and approximately 200mm thick however, the subsoil thickness varies. Subsequently the topsoil layer of each Soil Landscape would be stripped separately to the subsoil. The A and B horizons are sufficiently dissimilar to require separation, so topsoil stripping would be done to no more than 200mm depth.

Any subsoil stripped within the footprint of the quarry access road (i.e. subsoil not targeted for extraction) would be stockpiled separately to topsoil. Topsoil would either be stored temporary stockpiles or used to stabilise roadside batters. Weeds might be more problematic in the natural soil but to prevent their potential proliferation they would be sprayed prior to land clearing and stockpiles would be immediately vegetated with appropriate grass cover. Any subsoil recovered would be stockpiled and covered with topsoil.

5.10.9.2 General Soil Handling Practices

Soil would be handled when moist only (not too dry or too wet). That would not be difficult for most of the soils present because of their sandy texture. Subsoil and topsoil would be replaced in their correct stratigraphic order, generally in their correct relative thicknesses, and in a method that ensures the two are keyed together (there must be no compacted, smooth, surface between the two).

5.10.9.3 Use of Soil Materials for Rehabilitation

Topsoil and subsoil that has been stripped and/or stockpiled would be suitable for use in rehabilitation activities. Soils across the Site are fairly homogenous and, as such, soil materials from one part of the Site can readily be used on another part for rehabilitation. Note that factors such as the presence of weeds might limit this in some areas.

The soils are not close to their base saturation levels but they have low CEC. There would be an opportunity to use fertilisers but they should preferably be slow release organic types (e.g. Dynamic Lifter or similar). Organic matter would also improve moisture retention and raise CEC if incorporated into the topsoil. Organic matter may be sourced from composted, mulched, cleared vegetation or from off-site. A re-vegetation specialist would advise further.

5.10.10 Assessment of Impacts

Vegetation clearing, soil stripping and stockpiling, plus rehabilitation activities all have the potential to impact on soils as follows.

- Loss of soil biota and fertility due to incorrect stockpiling procedures.
- Potential for soil erosion through extended exposure without effective ground cover.
- Potential soil erosion due to ineffective vegetation establishment during rehabilitation activities.
- Alterations to the natural soil moisture regime and nutrient availability.
- Wind erosion of soils when exposed.

Management regimes would be required to address potential impacts during soil handling, stripping, stockpiling and rehabilitation.

5.11 VISIBILITY

5.11.1 Introduction

The DGRs for the Proposal identified "*Visual*" as a key issue requiring that the "*EIS include a detailed assessment of the:*

- *changing landforms on the site during the various stages of the proposal;*
- *potential visual impacts of the development on private landowners in the surrounding area as well as key vantage points in the public domain; and*
- *a detailed description of the measures that would be implemented to minimise the visual impacts of the development."*

Based on the risk assessment undertaken for the Proposal (**Appendix 4**), the potential impacts relating to visual amenity and their risk rankings (in parenthesis) after the adoption of pre-existing or standard mitigation measures are as follows.

- Increased visibility of the Quarry from local residences resulting in decreased visual amenity of local setting (medium).
- Increased visibility of the Quarry from local roads resulting in decreased visual amenity of the LGA as a whole (low).

The visual impact assessment for the Proposal was undertaken by R.W. Corkery and Co Pty Limited. This subsection of the EIS provides a summary of the visual impact assessment, concentrating on those matters raised in the DGRs and the correspondence attached to the DGRs provided by various government agencies. A consolidated list of the identified requirements relating to visibility and where each is addressed is presented in **Appendix 2**.

5.11.2 The Existing Visual Landscape

The visual landscape within and surrounding the Site is influenced largely by the natural topography and remnant vegetation. The areas from where the proposed extraction area and other operational areas are currently visible are limited to elevated areas to the north and east of the Site. Views from areas to the south and west of the Site are obscured by the ridgeline to the south of the Site, which would be retained throughout the life of the Proposal. There are no views of the Quarry Operations Area from public vantage points such as the Hume Highway. Whilst there are residences where the proposed operational areas are not shielded by topographic features, in the majority of cases remnant vegetation in these locations acts to obscure and limit any impacts to the visual amenity.

5.11.3 Changes to the Visual Amenity of the Site

The principal changes to the landform and vegetation throughout the life of the Quarry would involve the following.

1. The construction and use of the Quarry Interchange and the Quarry Access Road.
2. Vegetation clearing for the development of the Quarry Operations Area.

3. Construction of the processing and stockpiling area and the southern, eastern and northeastern amenity barriers;
4. Development of the extraction area;
5. Use of the Quarry Access Road and Quarry Interchange by a range of heavy and light vehicles, including vehicle headlights after sunset and before sunrise.
6. Security and operational lighting from operational areas around the extraction area, processing plant and administration area.

5.11.4 Environmental Controls and Management

The principal environmental controls the Applicant would adopt to minimise visual impacts from its operations would include the following.

1. A *Lighting Management Plan* would be prepared for lights required for night - time operations to minimise light spill from the operations and to limit lighting impacts caused by mobile equipment, haul trucks and product trucks on site.
2. Clearing for construction purposes would be confined only to the areas required for site infrastructure and thereby retaining much of the existing natural vegetation, particularly around the margin of the Quarry Operations Area.
3. The southern, eastern and northeastern amenity barriers would be constructed to limit views towards the Site (as well as mitigating noise). These barriers have been strategically located in saddles or gullies where visual access would occur without the barriers.
4. The southern, eastern and northeastern amenity barriers would be landscaped and vegetated upon completion to soften the visibility of the earthworks from surrounding residences and properties. Vegetation of these barriers would commence during Stage 0 of development. The southern amenity barrier would be incorporated into the on-site biodiversity offset area once vegetation has been suitably established. The northeastern amenity barrier would be removed at the completion of operations.
5. Areas adjacent to the Quarry Access Road would be landscaped with emphasis placed upon the growth of tree screens, where necessary, to limit the visibility of vehicle headlights when travelling to and from the Site.
6. All operational areas on site would be maintained in a clean and tidy state.
7. Security and operational lighting would be directed away from surrounding residences, wherever possible, to minimise any evening glow and light spill from the Site.

5.11.5 Assessment of Residual Impacts

Figure 5.29 displays five representative visibility sections across the proposed processing and stockpiling area from a north/south oriented perspective whilst **Figure 5.30** presents four representative visibility sections from the east/west oriented perspective. The following conclusions have been made based on review of likely views from all directions and nearby residences and publicly accessible areas.

- Disturbed areas of the Site would not be visible from the south due principally to the prominent ridge that lies between these residences and the extraction area / processing and stockpiling area.
- There would be no views of the Site from the Hume Highway due to intervening topography and the existing vegetation.
- It is not anticipated that construction of the Quarry Interchange on the Hume Highway would significantly change amenity (that is, create an obstruction or obscure views towards the highway) and would not cause a traffic hazard, given that interchanges of this kind are common along the highway.
- Localised glimpses of the upper section of the extraction area may be possible at locations at least 2km north of the extraction area based upon the Section AA[1] in **Figure 5.29**. Restriction of views would be largely due to the extent of vegetation or topography near those residences adjacent to Canyonleigh Road and the fact most residences are orientated to the north.
- Residence 2 on Lot 3 DP 253435 is elevated compared to the surrounding topography (approximately 710m AHD). Whilst there is some remnant vegetation on the western side of the property that obscures views towards the Site, this vegetation is sparse and would not fully obscure views of some of the activity areas within the Site. The northeastern amenity barrier and the retained 12m high eastern face would obscure views of the processing and stockpiling area (cross section I-I1' on **Figure 5.30**). However, after Stage 2 of development, the exposed areas of the extraction area would be partially visible from this location until the exposed faces have been rehabilitated. Vegetation that would be established on the northeastern amenity barrier would soften views of the barrier itself from this location. It would be expected that by Stage 2 of development (approximately Year 4 of operations, plants on the northeastern amenity barrier would have reached a height of 3m to 4m.
- The Quarry Operations Area and extraction area would be obscured by existing vegetation from vantage points further to the east (cross sections J-J' and K-K' on **Figure 5.30**).

5.11.6 Conclusion

Views towards the Site from the majority of privately-owned residences surrounding the Site would be obscured be topographic features and/or vegetation that would therefore not be impacted by the Proposal. Glimpses of the Site from the north would be limited and as the residences are at least 1.3km from the operational areas within the Site, residents would notice only a minor change below the horizon. It is anticipated that changes to visual amenity at these locations would not significantly change overall amenity at these locations. Views of the Site, including the processing and stockpiling area from Residence 2 would largely be obscured by the northeastern amenity barrier and the retained eastern face of the processing and stockpiling area. It is predicted that views of disturbed areas of the extraction area would become visible by Stage 2 of development. However, it would be expected that by that time, vegetation on the northeastern amenity barrier would have established and would be at a height of approximately 3m to 4m and would therefore soften views from this location.

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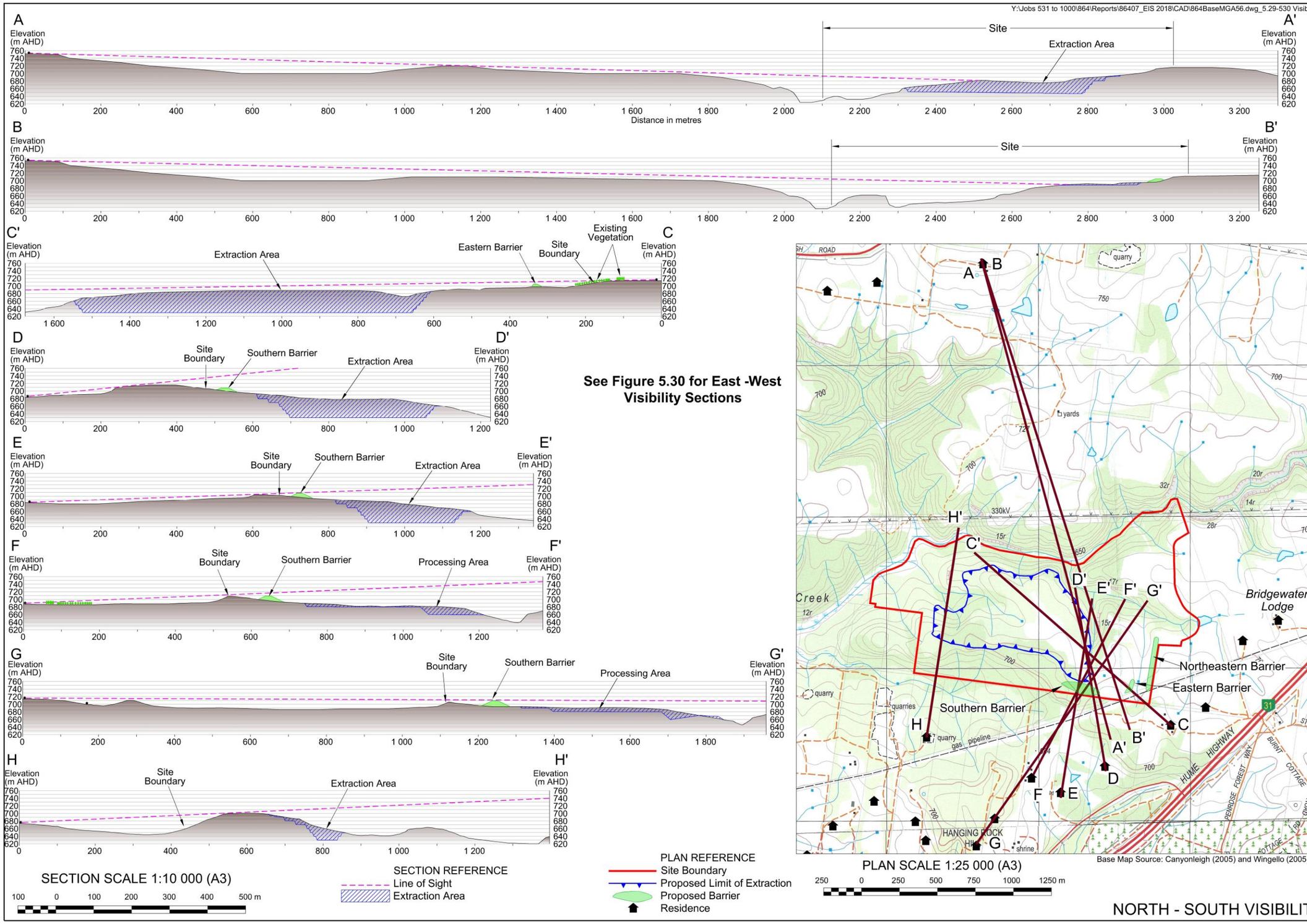

See Figure 5.30 for East -West Visibility Sections

Figure 5.29
NORTH - SOUTH VISIBILITY SECTIONS

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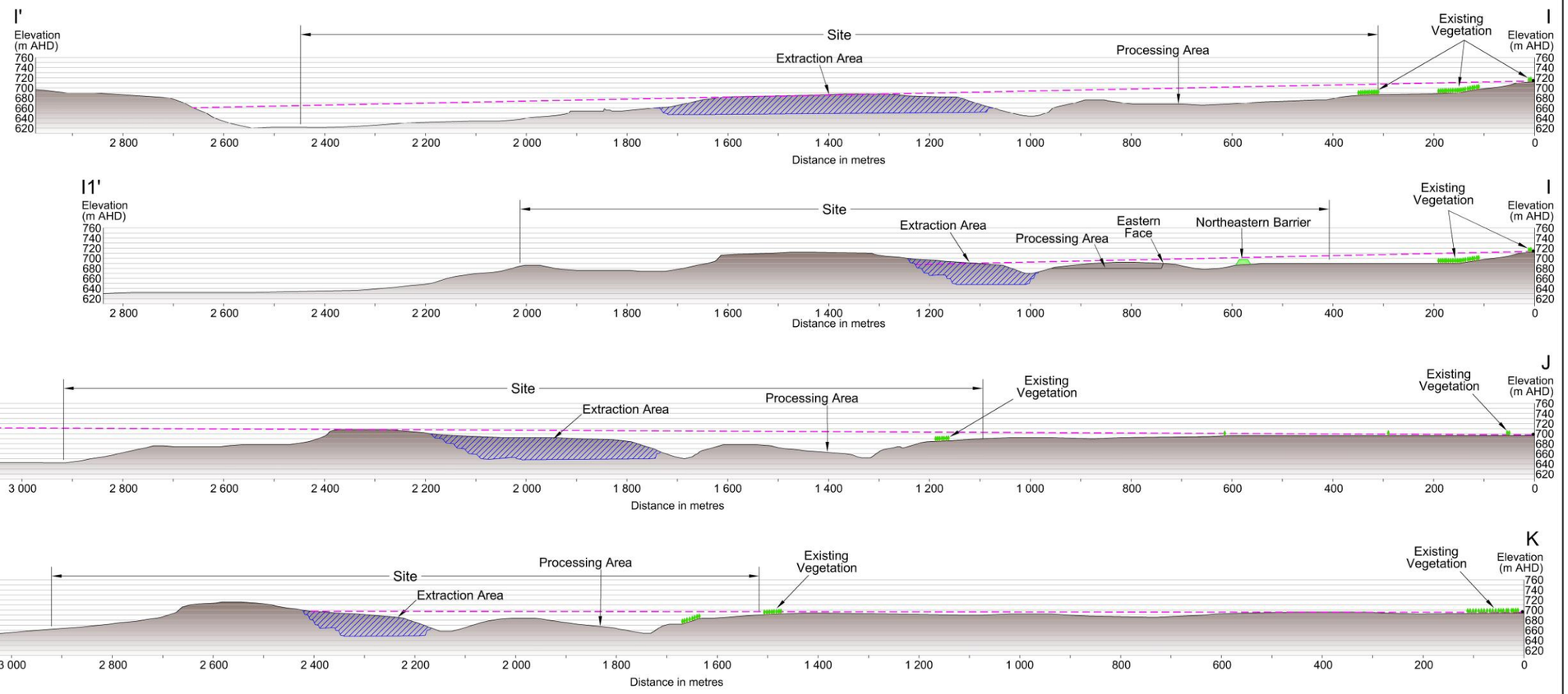
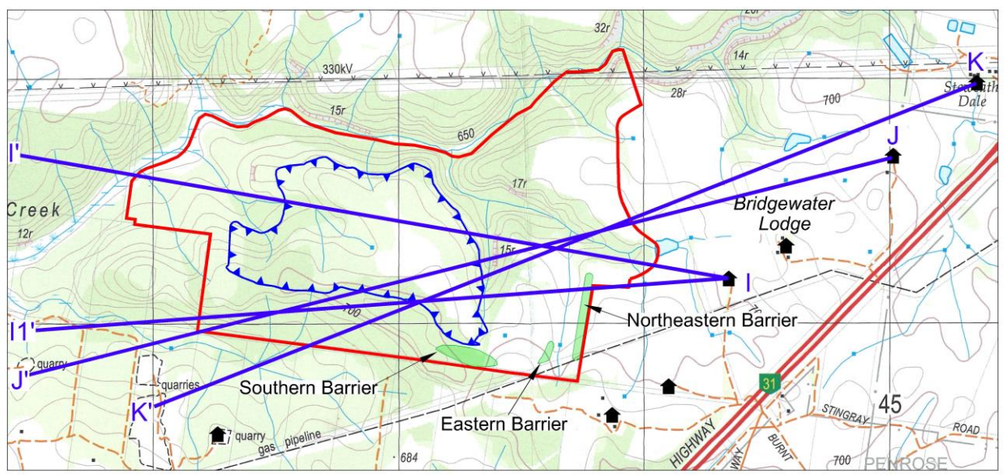


See Figure 5.29 for North - South Visibility Sections



PLAN SCALE 1:25 000 (A3)

250 0 250 500 750 1000 1250 m

Base Map Source: Canyonleigh (2005) and Wingello (2005) 1:25 000 Topographic Maps

PLAN REFERENCE
- Site Boundary
- Proposed Limit of Extraction
- Proposed Barrier
- Residence

SECTION SCALE 1:10 000 (A3)

100 0 100 200 300 400 500 m

SECTION REFERENCE
- Line of Sight
- Extraction Area

Figure 5.30
EAST - WEST VISIBILITY SECTIONS

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5.12 AGRICULTURAL RESOURCES

5.12.1 Introduction

The development of extractive industries needs to be balanced with the continued use and preservation of productive agricultural resources. The term 'agricultural resources' is used here to describe the land upon which agriculture is dependent, the water that is used to sustain it and the industry and secondary businesses that develop to directly supply and support agriculture.

The DGRs for the Proposal identified "Land Resources" as a key issue requiring that the "*EIS include a detailed assessment of the potential impacts on:*

- *agricultural resources and/or enterprises in the local area, including:*
  - *any change in land-use arising from requirements for biodiversity offsets; and*
  - *a detailed description of the measures that would be implemented to avoid and/or minimise the potential impacts of the project on agricultural resources and/or enterprises;*

In addition, the Department of Primary Industries provided input to the DGRs requesting that the EIS identify impacts on rural enterprises and landholders, assess relative risks and consider possible cumulative effects.

As the Proposal is for the purposes of an extractive industry, the following assessment of the potential impact of the Proposal on agricultural resources has been based upon the key issues identified by *Agriculture Issues for Extractive Industry Development* prepared by the Resources Planning & Development Unit of the NSW Department of Primary Industries (DPI, 2012b).

5.12.2 Agricultural Planning Principles

The following considers the Proposal in relation to the principles identified in DPI (2012b) for coexistence of sustainable agriculture and extractive industries.

Extractive industry developments are consistent with strategic plans and zone objectives

Development for the purpose of extractive industry is prohibited on land zoned Environmental Management (E3), however, as outlined in Section 3.2.3.6 of this document, the proposed extractive industry is a permissible use in accordance with the provisions of Clause 7(3)(a) of *State Environmental Planning Policy (Mining, Petroleum Production and Extractive Industries) 2007.*

It is also noted that the Biophysical Strategic Agricultural Land (BSAL) map covering the Site does not identify the Site or any lands surrounding this as BSAL.

Extractive industry developments are designed and managed to minimise environmental impacts

The assessments completed throughout Section 5 of this document confirm that, with the adoption of the various operational safeguards, controls, management and mitigation measures and impact offsets proposed, the Proposal would be developed in compliance with relevant criteria and with minimal and managed impacts on the surrounding environment where specific criteria are absent.

Land use conflicts are minimised, amenity values are protected and the expectations of local communities are managed

The majority of the areas of Lot 4 DP253435 and the Crown Road Reserve proposed for development are currently not actively managed for commercial agriculture. As discussed in Section 4.5.2, the only potential land use conflict is associated with passive biodiversity conservation, with this suitably mitigated and offset by the proposed rehabilitation program and preliminary biodiversity offset strategy.

As assessed in Sections 5.3 and 5.9, the Proposal would result in minimal change to the local noise environment and air quality. The visibility of the extraction area and overburden emplacement from private land is noted, however, as discussed in Section 5.11, this impact would be reduced as far as practically possible by the rehabilitation plans and existing vegetation surrounding the Site that would be retained. Overall, the Proposal would have a limited impact on the amenity of the local setting.

Rehabilitation is undertaken progressively and any permanent changes to productive capacity are clearly justified

Section 2.13 provides a detailed rehabilitation plan for the Site, with the proposed extraction sequence designed to allow for early rehabilitation of the extraction area through the emplacement of fines recovered from the sand washing process, i.e. in Fines Storage Area 1. As nominated in Section 5.10.8, the land and soil capability of those areas be disturbed is low (Class 5) and the final landform in that area would be returned to an equivalent capability upon rehabilitation.

Proposals are clearly justified in a regional context and identify the merits and community benefit of the proposal

The relative merit of the Proposal from a socio-economic perspective is considered in further detail in Section 5.14. In summary, however, when considering the minimal impact of the Proposal on the local and regional community against the benefits generated through local employment and provision of important construction materials, it is considered the Proposal provides a net socio-economic benefit.

Consider the following potential impacts and identify suitable mitigation responses for the following

- Impacts on agricultural resources

  The land to be disturbed within the Site has limitations for agriculture (Class 5).

- Transport and access changes

  The Proposal would result in improvements to the local road network through the construction of the Quarry Access Road and Quarry Interchange providing access to the Site and the residences of Lot 12 DP241054 and Lots 3 and 4 DP253435.

- Rehabilitation plans

  As discussed in Section 2.13, the Site would be progressively rehabilitated with land returned to a land capability equivalent to the pre-disturbance environment and an emphasis placed upon a nature conservation land use with a proportion of land used for agricultural activities.

- Consultation with rural stakeholders

  Section 3.2.2 documents the consultation program undertaken by the Applicant.

- Mitigation and monitoring

  The various mitigation measures and monitoring strategies of the Proposal are documented throughout Section 5.

5.12.3 Consultation

Consultation with the adjoining landowners and users has been undertaken (see Section 3.2.2), however, no issues were raised in relation to agricultural resources or production.

5.12.4 Mitigation and Monitoring

As noted above, the Proposal would have minimal impact on agricultural resources and/or production. This notwithstanding, various mitigation measures and monitoring programs to manage the following are provided throughout the EIS.

- Rehabilitation (see Section 2.13)
- Dust generation and dispersal (see Section 5.9).
- Erosion and sediment control (see Section 5.10).
- Water quality (see Section 5.2 and 5.3).
- Bush fire and other hazards (see Section 5.13).

5.12.5 Assessment of Impacts

Based on the above assessment, the Proposal would satisfy the key issues identified by the document *Agriculture Issues for Extractive Industry Development* (DPI, 2012b).

As noted in the assessment of land capability (Section 5.10.8) the Site has been assessed to have a land capability of Class 5 indicating limited capability for grazing activity. Rehabilitation of the Site (described in Section 2.13) would return a portion of the final landform to agricultural land. This final landform was developed to permit the landowner to continue the productive use of the land following the end of quarrying activities. Therefore, the Proposal would not result in significant changes to existing use of agricultural land or limit use of nearby agricultural land.

The proposed on-site biodiversity offset and off-site biodiversity offset area would not remove land from productive agricultural use.

As a result, impacts from the development of the Site (when considered with the nearby operation of the Penrose Sand Quarry) are not considered likely to result in a cumulative loss of productive agricultural land.

5.13 BUSH FIRE HAZARD

5.13.1 Introduction

The DGRs for the Proposal identified "Hazards" as a key issue requiring that the "*EIS pay particular attention to public safety and bush fires.* Public safety matters are addressed in Section 2.12. This section identifies the bush fire hazard associated with the Proposal and the proposed management measures.

Section 4.14 of the EP&A Act 1979 details the requirement for developments to conform to the specifications and requirements of the document entitled "*Planning for Bush Fire Protection*" (RFS, 2006), however Sub-section (1B) states Section 4.14 does not apply to State significant development. While the requirement for a bush fire assessment in accordance with RFS (2006) is not required, the procedure detailed in that document has been adopted to identify the potential hazard for the Proposal. The addendum to Appendix 3 of RFS (2006) published by the Rural Fire Service in 2010 has also been considered for assessment of the bush fire attack level (RFS, 2010). Proposed management of the identified hazards is also described.

The objectives of RFS (2006) considered in this assessment are to:

- afford occupants of any building adequate protection from exposure to a bush fire;
- provide for a defendable space to be located around buildings;
- provide appropriate separation between a hazard and buildings which, in combination with other measures, prevent direct flame contact and material ignition;
- ensure that safe operational access and egress for emergency service personnel and residents is available;
- provide for ongoing management and maintenance of bush fire protection measures, including fuel loads in the Asset Protection Zone (APZ); and
- ensure that utility services are adequate to meet the needs of fire fighters (and others assisting in bush fire fighting).

Based on the risk assessment undertaken for the Proposal (**Appendix 4**), the potential impacts relating to bush fire and their risk rankings (in parenthesis) after the adoption of pre-existing or standard mitigation measures are as follows.

- Loss of life, assets and property on site and in surrounding area (medium).
- Property damage and impacts on production (medium).
- Reduced biodiversity value of the site (low).

The bush fire assessment was prepared by R.W. Corkery & Co. Pty Limited based, in part, on information on local vegetation provided in KMA (2018) and Niche (2018). Vegetation communities identified within the Site are described further in Section 5.5.2.4.

5.13.2 Assessment of Bush Fire Hazard

5.13.2.1 Introduction

The following sections use the RFS (2006) and RFS (2010) procedure to determine the Category of Bush Fire Attack (or bush fire hazard).

5.13.2.2 Vegetation Formation

As discussed in Section 5.5.2, forest and woodland are the dominant vegetation types on the Site although there are also areas of cleared land or regrowth vegetation.

Using the vegetation descriptions provided in KMA (2018), the vegetation has been classified into the following four formations based on the classifications provided in RFS (2006).

- Wet sclerophyll forest (Tall open forest) – maximum fuel load of 30t/ha.
- Dry sclerophyll forest (Open forest) – maximum fuel load of 25t/ha.
- Grassy woodlands (Woodlands) – maximum fuel load of 15t/ha.
- Freshwater wetlands – maximum fuel load of 15t/ha.

Figure 5.31 provides the classification of the vegetation within the Site based upon the classifications provided in RFS (2006) and the field surveys undertaken by KMA (2018) and Niche (2018).

5.13.2.3 Effective Slope

As discussed in Section 4.1.2, the Site covers a variety of landforms, from gently-inclined (<5% slope) crests and ridges to moderately inclined (up to 30%) short hill slopes. Within the vicinity of the Quarry Operations Area, where all administrative and workshop buildings would be constructed, the slopes are no greater than 15°. Small cliff lines with drops of between 5m and 10m are present within the Site but beyond the proposed extraction area. The proposed extraction area occupies a series of gentle crests and ridges, lying mostly at or near the top of the local catchments. A substantial ridge is located on the southern side of the extraction area.

5.13.2.4 Fire Weather

The Wingecarribee LGA occurs within the Illawarra/Shoalhaven NSW Fire Area and is designated a Fire Danger Index of 100 (RFS, 2006).

5.13.2.5 Hazard Assessment

It is possible to calculate the bush fire hazard (referred to as the Bush Fire Attack Category in RFS, 2006 and RFS, 2010) for activities within 100m of vegetation from a combination of the Fire Danger Index, vegetation formation, the maximum slope and the proximity of activities to the bush fire hazard. The assessment of Bush Fire Attack level for the Site is displayed within **Table 5.29**. **Figure 5.31** identifies the areas and infrastructure that are located within 100m of vegetation and therefore have a potential for heightened bush fire hazard.

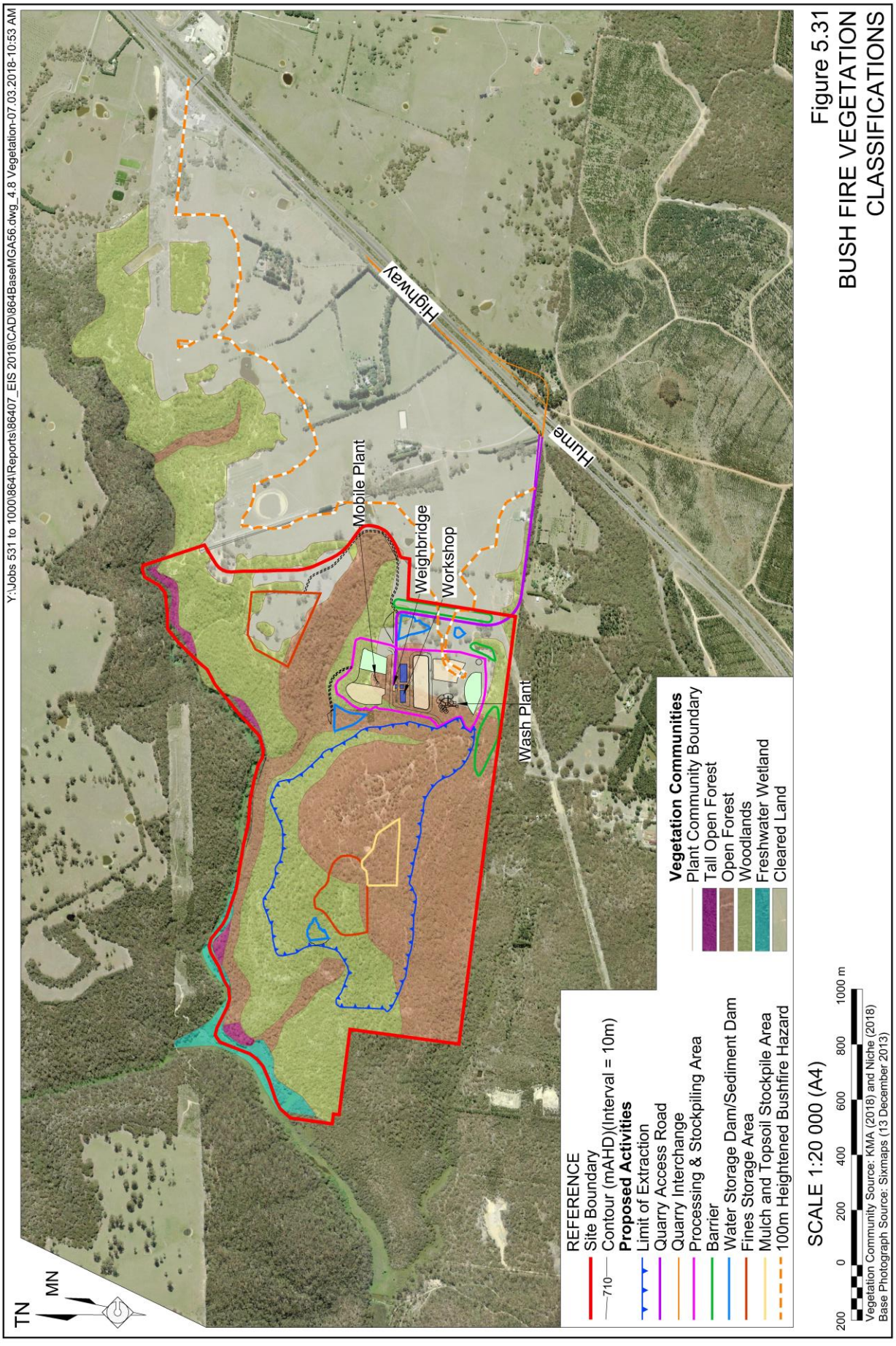
Y:\Jobs 531 to 1000\864\Reports\86407_EIS 2018\CAD\864BaseMGA56.dwg_4.8 Vegetation-07.03.2018-10:53 AM
Figure 5.31
BUSH FIRE VEGETATION CLASSIFICATIONS
Highway
Hume
Mobile Plant
Weighbridge
Workshop
Wash Plant
TN
MN
REFERENCE
Site Boundary
710 Contour (mAHD)(Interval = 10m)
Proposed Activities
Limit of Extraction
Quarry Access Road
Quarry Interchange
Processing & Stockpiling Area
Barrier
Water Storage Dam/Sediment Dam
Fines Storage Area
Mulch and Topsoil Stockpile Area
100m Heightened Bushfire Hazard
Vegetation Communities
Plant Community Boundary
Tall Open Forest
Open Forest
Woodlands
Freshwater Wetland
Cleared Land
SCALE 1:20 000 (A4)
200 0 200 400 600 800 1000 m
Vegetation Community Source: KMA (2018) and Niche (2018)
Base Photograph Source: Sixmaps (13 December 2013)

Table 5.29
Bush Fire Hazard Assessment

Vegetation Classification	Slope[1]	Distance to Activities (m)	Category of Bush Fire Attack
Forest (Tall open forest and Open forest)	>10 ° to 15°	64-<82	19
		82-<100	12.5
	>5 ° to 10°	53-<69	19
		69-<100	12.5
	>0° to 5°	43-<57	19
		57-<100	12.5
	Upslope/flat	35-<48	19
		48-<100	12.5
Woodlands	>10 ° to 15°	56-<60	19
		60-<100	12.5
	>5 ° to 10°	37-<50	19
		50-<100	12.5
	>0° to 5°	29-<41	19
		41-<100	12.5
	Upslope/flat	24-<33	19
		33-<100	12.5
Note: [1] Slope refers to the direction of the activity from the vegetation.			
Source: Based on RFS (2010) and AS3959.2009			

Activities located further than 100m have a Category of Bush Fire Attack classification of "low".

The following descriptions of the predicted bush fire attack and levels of exposure are provided for the Category of Bush Fire Attack (or bush fire hazard) in AS3959.2009.

- BAL-Low: There is insufficient risk to warrant specific construction requirements.
- BAL-12.5: Ember attack.
- BAL-19: Increasing levels of ember attack and burning debris ignited by windborne embers together with increasing heat flux.

From the consolidated information, **Table 5.29** and **Figure 5.31**, the area of disturbance is generally classified as low hazard due to the distance between the vegetation and operational activities. Activities that could experience a higher hazard would occur within 100m of vegetation. Of particular note is the Quarry Operations Area as this area would contain infrastructure susceptible to bush fire attack and falls within the area of potential higher hazard. Given the vegetation adjoining this area is classed as Forest, and the vegetation would be downslope or level with the infrastructure, this area would be rated as a bush fire attack category of 19 (consistent with an estimated radiant heat flux of 19 kW/m^2), where it would likely be subject to ember attack and burning debris ignited by windborne embers together with increasing heat flux. According to Table A2.4 of Appendix 2 of RFS (2006), an Asset Protection Zone (APZ) of 25m between the processing and stockpiling area and the vegetation is recommended. It should be noted that any buildings constructed within the processing and stockpiling area would be greater than 100m from any vegetation.

5.13.3 Operational Safeguards, Controls and Management Measures

It is recognised that, even after vegetation is cleared from the Site, the area is directly adjacent to a heavily wooded area, and therefore the potential for bush fire to spread both within the Site and adjacent to the Site would be high if management measures are not adopted to mitigate this hazard.

In terms of potential impacts, the assets considered at risk include employees and the local community. In order to protect these assets, a proposed bush fire management would be documented in a *Landscape and Rehabilitation Management Plan* that would be prepared in consultation with the local Rural Fire Service. The bush fire management section of the *Landscape and Rehabilitation Management* would include the following.

- A review of bush fire hazards and identification.
- A summary of controls and management measures including fire response equipment and locations.
- Emergency contact details.
- Training requirements.

In the preparation of the *Landscape and Rehabilitation Management Plan* and operation of the Sutton Forest Sand Quarry, the Applicant would consider the relevant guidelines and adopt controls and safeguards including but not limited to the following to manage the potential impact of a bush fire on the personnel and infrastructure on the Site, and the potential for a bush fire to be initiated on the Site.

- Asset Protection Zones would be maintained with a tree canopy of less than 15% with trees located greater than 25m from any part of the roofline. Garden beds of flammable shrubs would not be located under trees and would not be closer than 10m from an exposed window or door. Trees would have lower limbs removed up to a height of 2m above the ground.
- Consideration of Asset Protection Zones would be included in decision making regarding the locations chosen for mobile brickie's sand plant.
- All employees would be trained in the proper use of fire fighting equipment held on site.
- Water would be especially set aside for fire fighting on site and a water cart made available for fire fighting purposes.
- A protocol would be developed for restricting work in forested areas during high fire danger periods of the bush fire season (in accordance with the hazard category notifications).
- Procedures for hot works would be developed to prevent ignition sources for a bush fire.
- The local Rural Fire Service would be consulted prior to each bush fire season.
- Site fire fighting equipment would be made available to the local Rural Fire Service, if required, in the event of a bush fire on the land surrounding the Site.

- Firebreaks would be developed and maintained within the Site at the edge of forested areas as required and in consultation with the local Rural Fire Service.
- The local Rural Fire Service would be consulted regarding any controlled burns planned by these agencies for asset protection and / or ecological management.

Emergency and Evacuation Management Procedures would be developed that would include procedures in the event of a local bush fire.

5.13.4 Assessment of Impacts

With the implementation of the proposed safeguards and controls, it is considered that the bush fire hazard associated with the Proposal would be acceptable and would not significantly contribute to raising the risk of bush fires impacting the community, property or environmental assets.

5.14 SOCIO-ECONOMIC SETTING

5.14.1 Introduction

Based on the risk assessment undertaken for the Proposal (**Appendix 4**), the potential social and economic risks and their risk rankings (in parenthesis) after the adoption of pre-existing or standard mitigation measures are as follows.

- Employment for the Proposal changing local community structure as a result of income disparity (low).
- Disruption of social activities in local communities and impact on feelings of well-being or sense of place derived from associated location (medium).
- Implications of the increased workforce on the ability of existing services and infrastructure to meet the needs of the community (medium).
- Real or perceived reductions in land values due to the presence of the quarrying operation (medium).
- Loss of income generated from tourist activities (medium).
- Loss of income generated from land-based production (agricultural or water extraction) (medium).

The DGRs particularly request an assessment of socio-economic impacts. The statistical data referenced in this section is drawn from the census data compiled by the Australian Bureau of Statistics for 2016 and the Wingecarribee Shire Community Profile 2016 (WSC, 2016) - hosted through the .id website[6]).

The following assessment of the social and economic impacts and benefits of the Proposal was undertaken by R.W. Corkery & Co. Pty Limited and includes a review of social baseline information in the form of community profile and social context gathered from publicly available data resources and through the consultation program (described in Section 3.2), review of relevant management measures and commitments and a final summary of potential social and economic changes that would arise as a result of the Proposal.

5.14.2 Community Profile

Urban development in the Wingecarribee Local Government Area (LGA) is concentrated in the LGA's three main towns of Mittagong, Bowral and Moss Vale which lie in close proximity to one another and home to 60% of the population. Moss Vale, the closest town to the Site, is approximately 22km to the northeast along the Hume and Illawarra Highways. The Site is located in the Wingello-South West District of the LGA which has an estimated resident population of 1 975 people and a population density of 3 persons per km^2 which demonstrates the rural nature of this location. In comparison, the Wingecarribee LGA has a population of 47 882 people as of 2016 and population density of 18 persons per km^2 (WSC, 2016). The Site is also located partially within the State Suburb of Paddys River and partially within the State Suburb of Sutton Forest. However, given the low resident population of these areas (31 and 477 respectively), the assessment only considered relevant statistics for within the Wingecarribee LGA.

[6] http://profile.id.com.au/wingecarribee/home

In order to gain an appreciation for the structure of the local community and surrounding district, **Table 5.30** presents a summary of the 2016 population statistics for Wingecarribee LGA and NSW as a whole. The population distribution for the Wingecarribee LGA is consistent with evidence across many regional communities in NSW that are observing progressively younger working age people leave in search of work opportunities and increases in the numbers of persons of an older age due to retirement and 'tree-change' lifestyle changes. This may result in impacts from an aging population such as increased need for health care and other services.

Table 5.30
Population Statistics

	Wingecarribee LGA		NSW	
Age (years)	**Persons**	**Percentage of Persons in Age Category % Persons**	**Persons**	**Percentage of Persons in Age Category % Persons**
0-4	2,358	4.9	465,135	6.2
5-14	6,050	12.6	921,193	12.3
15-19	3,037	6.3	448,425	6.0
20-24	1,896	4.0	489,673	6.5
25-34	3,966	8.3	1,067,521	14.3
35-44	5,066	10.6	1,002,893	13.4
45-54	6,473	13.5	977,986	13.1
55-64	6,645	13.9	889,770	11.9
65-74	7,100	14.8	677,026	9.1
75-84	3,867	8.1	373,114	5.0
85+	1,428	3.0	167,505	2.2
Total	**47,882**	**100.0**	**7,480,228**	**100.0**

Source: Australian Bureau of Statistics - 2016 Census

Since the mid 1980s, population growth, urbanisation and other changes have led to a declining number of people working in the primary industry sector and to the development of secondary and tertiary industries. In 2016, only 3.3% of Wingecarribee LGA's labour force was engaged in agriculture, forestry or fishing (see **Table 5.31**).

The most common industries of employment characterising Wingecarribee LGA's labour force were health care and social assistance (12.5%), construction (10.0%), retail trade (9.7%) and education and training (9.4%). Mining, which would include extractive industries, accounted for only 1.1% of employment in the Wingecarribee LGA. In comparison to NSW, the Wingecarribee LGA features more accommodation and food services industry activity that may result from rural tourism attractions and B&B style accommodations in the region.

Table 5.31
Industry Employment Statistics

	Wingecarribee LGA		NSW	
	Persons	**Percentage**	**Persons**	**Percentage**
Agriculture, forestry & fishing	680	3.3	72,623	2.5
Mining	225	1.1	31,735	1.7
Manufacturing	1,437	7.0	197,335	6.4
Electricity, gas, water & waste services	179	0.9	31,881	1.1
Construction	2,061	10.0	282,493	8.5
Wholesale trade	513	2.5	103,720	2.9
Retail trade	1,995	9.7	326,394	9.9
Accommodation & food services	1,852	9.0	239,221	6.9
Transport, postal & warehousing	892	4.3	158,763	4.7
Information media & telecommunications	230	1.1	73,402	1.7
Financial & insurance services	466	2.3	167,257	3.6
Rental, hiring & real estate services	431	2.1	59,650	1.7
Professional, scientific & technical services	1,374	6.7	274,081	7.3
Administrative & support services	813	3.9	117,484	3.4
Public administration & safety	901	4.4	204,171	6.7
Education & training	1,931	9.4	282,567	8.7
Health care & social assistance	2,582	12.5	422,201	12.6
Arts & recreation services	310	1.5	51,776	1.7
Other services or not described	81,780	48.6	1283,586	38.1
Total	**20,652**	**100.00**	**3,380,340**	**100.00**

Source: Australian Bureau of Statistics - 2016 Census

Labour force participation statistics are presented in **Table 5.32**. The level of participation in the labour force is slightly lower in Wingecarribee LGA (54.3%) when compared to NSW (59.2%). However, the percentage of unemployed people looking for work is lower in Wingecarribee LGA (3.8%) than NSW (6.3%). The percentage of people in Wingecarribee LGA in part-time employment (35.6%) is significantly higher than NSW (29.7%). The higher population of people in part-time employment and lower unemployment rate is consistent with employment trends or in some cases, under-employment. However, it also indicates an ability and willingness of people to gain part-time employment rather than remain unemployed. This may also reflect the high number of young people leaving the area to search for work and an ageing population, consistent with those age distribution statistics in **Table 5.30**.

Table 5.32
Labour Force Statistics

	LGA		NSW	
	No.	**%**	**No.**	**%**
Full-time[1]	12,027	56.1	2,134,521	59.2
Part-time	7,630	35.6	1,071,151	29.7
Employed, away from work[2]	982	4.6	174,654	4.8
Total	20,639		3,380,326	
Looking for work	810	3.8	225,546	6.3
Total labour force	21,449		3,605,881	
Not in labour force	15,354		2,088,240	
Labour force status not stated	2,666		399,773	
Total Persons	**39,473**		**6,093,895**	
Labour force participation	**54.3%**		**59.2%**	
Source: Australian Bureau of Statistics - 2016 Census				

Median individual, household and family incomes within the Wingecarribee LGA are slightly lower than that for the State. The median income of households within the Wingecarribee LGA is $1,335 per week compared to $1,486 for NSW (see **Table 5.33**). Median family income of $1,639 per week is similarly lower compared to $1,780 for families State wide.

Table 5.33
Income Statistics

	Wingecarribee LGA	**NSW**
Median individual income ($/weekly)	645	664
Median family income ($/weekly)	1,639	1,780
Median household income ($/weekly)	1,335	1,486
Source: Australian Bureau of Statistics - 2016 Census		

While average household size and percentage of family households within the Wingecarribee LGA is comparable to NSW, median housing loan repayments and rent paid reflect the lower median family income compared to families state wide (see **Table 5.34**).

Table 5.34
Housing Statistics

	Wingecarribee LGA	**NSW**
Median housing loan repayment ($/monthly)	1,842	1,986
Median rent ($/weekly)	350	380
Percentage of family occupied dwellings	71.8	72.0
Average household size	2.4	2.6
Source: Australian Bureau of Statistics - 2016 Census		

5.14.3 The Socio-economic Indexes for Areas

The Socio-economic Indexes for Areas (SEIFA) (ABS 2011b), is a suite of four summary measures prepared by the ABS from the 2011 Census information that provide a reference for a given area on issues of relative disadvantage, education and opportunity, and access to economic resources. For each index, geographic areas in Australia are given a SEIFA number which demonstrates how disadvantaged that area is compared with other areas of Australia. The ABS defines relative socio-economic advantage or disadvantage in terms of people's access to material and social resources, and their ability to participate in society, with the designated numbers indicating how disadvantaged that area is compared with other areas in Australia. The SEIFA is a relative measure. Areas are placed in deciles with the 10th decile containing the most advantaged areas and the 1st decile containing the most disadvantaged.

The Wingecarribee LGA is in the 8th or 9th decile for each of the SEIFA categories indicating that the LGA has a relatively low level of disadvantage. It should be noted that this index does not indicate advantage but low levels of relative disadvantage. This is consistent with previously identified trends towards an ageing or 'tree-change' population and the relatively low levels of underemployment in the LGA.

5.14.4 Community Engagement

Consultation with the community is described in detail in Section 3.2 and land use in the local area is reviewed in Section 4.5. Both of these sections refer to information gathered during community engagement processes and have been relied upon for the assessment of potential social and economic impacts of the Proposal. **Appendix 5** provides a summary of all consultation activities.

Land in the vicinity of the Site consists of generally large (15ha to 60ha) rural-residential or agricultural blocks. Land uses in the vicinity of the Site are described in detail in Section 4.5, however it is noted that land to the south and southwest of the Site supports industrial business ventures such as bulk water production, on-line design services, historic quarrying and the facilities of the Shrine of Our Lady of Mercy – "Penrose Park". Properties to the south and southwest of the Site have a greater proportion of the property covered with existing vegetation, which was valued by residents at these locations. Agricultural enterprises are generally located to the north and west of the Site. In all instances where landowners were generating income from their property, they expressed concern that this would be disrupted by the Proposal. There are several properties that are owned by people that are not full-time residents and only visit on weekends, while many people residing in the area travel to work at other locations in the Southern Highlands. There are no tourism-related properties that have been identified in the vicinity of the Site.

During the consultation program, it was apparent that many of the people consulted were aware of the concerns expressed by their neighbours or others in the area, but others did not appear to have a lot of direct contact with their neighbours outside of family or business connections. Many of the people consulted spoke of their attendance at meetings regarding the Hume Coal proposal which indicates a general interest in their local community. It is evident there is a degree of neighbourly relations in the area, however residents did not seem concerned that the Proposal would disrupt these social connections.

Each of the residents involved in the consultation program expressed their concern regarding the potential impacts to groundwater availability and quality. Most properties rely on groundwater for domestic purposes, however many in the area also need a reliable supply of groundwater for their livelihoods. Some residents supply commercial quantities of water to beverage companies such as Schweppes, while Coca-Cola owns property in the region from which water is extracted. Other residents rely of groundwater to support agricultural or other enterprises such as the Sutton Forest Estate Winery and a nearby truffle farm that is in the early stages of establishment.

It was also apparent from the consultation that road traffic noise from the Hume Highway is a feature of the area and most residents were concerned that currently experienced noise levels may be exacerbated. The Hume Highway is a significant presence in the area given that it is a significant noise source and is also required for general access to properties and between the larger villages or towns used for shopping. However, many of the local residents commented that they value the area for the relative 'peace and quiet' especially when traffic levels were reduced, such as on a Sunday. This was also apparent in resident's concern of the potential impact of 24/7 operations and product despatch noise and traffic levels.

Many of the residents queried potential impacts to Long Swamp Creek, with most aware of the ecological value of the swamp. Issues around sediment laden flows to the creek and impacts to the groundwater contribution (baseflow) were also discussed, indicating that residents were aware of the importance of groundwater and the local environment.

It is clear that the most significant potential land use conflict for the Proposal is with the use of the Shrine of Our Lady of Mercy – "Penrose Park". As described in Section 4.5, the religious events at the property can attract up to 7 000 visitors for key events as well as between 1 000 to 4 000 visitors for other events. The property hosts international chapels that attract visitors from an area between Canberra, Wollongong and Sydney. While it is an attraction for possibly large crowds, the property also attracts visitors who use the site for quiet reflection and prayer. The Pauline Fathers have plans for development of the property that include an approved Retreat Centre and isolated residences on the property. The Pauline Fathers consider that the operation of the Quarry would be inconsistent with the setting of the Shrine of Our Lady of Mercy – "Penrose Park".

5.14.5 Management and Mitigation Measures

In addition to the mitigation measures and management procedures relating to amenity aspects such as transportation, visibility, noise and air quality described previously in Section 5, the Applicant would implement the following management and mitigation measures to ensure that benefits to the community arising from the Proposal are maximised and adverse impacts are minimised. Where possible, these measures have been categorised to reflect the particular aspect that would be addressed by each.

Social and Community

- Continue to engage with local community members in accordance with an approved Community Engagement Plan, developed in consultation with the local community, and an 'open door' policy for any member of the local community who wishes to discuss any aspect of the Proposal.

- Consult with the Pauline Fathers to establish times when large crowds are expected so that potential conflicts between Quarry-related vehicles and visitors can be minimised.
- Restrict blasting to areas outside a buffer of 0.5km from the Grotto of the Shrine Our Lady of Mercy – "Penrose Park".
- Undertake a voluntary noise reduction program to further mitigate noise sources from the Proposal (as described in Section 5.4.5).
- Form and maintain a Community Consultative Committee (CCC), including representative members of the local community and Wingecarribee Shire Council. The CCC would be an important forum for reviewing and discussing environmental monitoring and performance and discussing possible improvements that could be made to operations relating to environmental (and social) performance.
- Regularly brief the CCC on activities at the Quarry and seek feedback in relation to Proposal-related impacts whether real or perceived. In addition, seek advice in relation to the most appropriate manner in which to provide assistance to the community in an effective, fair and equitable manner.
- Implement a blast notification protocol and pre-emptively discuss planned blasting with the residents of the monastery at the Shrine Our Lady of Mercy – "Penrose Park".
- Implement and maintain a community complaints investigation and response protocol.
- Support community organisations, groups and events, as appropriate, and review any request by a community organisation for support or assistance throughout the life of the Proposal.

Responsible Road Use

- Implement a Driver's Code of Conduct to ensure the safety of all road users and the communities through which product transport trucks would pass.
- Require each truck driver (and their representative contracting company) to confirm (through signature) understanding as to expectations with respect to:
  - driver compliance with all road laws, and on-site requirements, alertness, driving behaviour, response to other motorists and the use of all relevant equipment e.g. truck covers;
  - requirements to minimise the use of compression braking unless required for an emergency;
  - the possible conflicts that may occur during duty and the appropriate behaviour at locations such as the Sallys Corner Interchange;
  - compliance of the vehicle with all relevant laws and guidelines with respect to safety checks, noise levels and emissions of them; and
  - acknowledgement and agreement to the Applicant's program of random checks of both the driver's and vehicles records.

Employment and Training

- Where appropriate, give preference when engaging new employees to candidates who live within the Wingecarribee LGA over candidates with equivalent experience and qualifications based elsewhere.
- Encourage and support participation of locally-based employees and contractors in appropriate training or education programs that would provide skills and qualifications that may be of use at the Site (and potentially elsewhere within the extractive, mining or related industries).

Economic Contribution and Development

- Give preference, where practicable, to suppliers of equipment, services or consumables located within the Wingecarribee LGA.

General

- Continue to adhere to all operating conditional commitments, e.g. restrictions on hours of operation and the required standard of facility.
- Implement the recommendations provided in each of the specialist assessments of the Proposal.

5.14.6 Assessment of Impacts

5.14.6.1 Potential Social and Economic Benefits of the Proposal

A major benefit of the Proposal would be to provide for an increased supply of quality sand products for the construction markets in the Sydney metropolitan area, Illawarra, Southern Highlands and the Canberra region. Through easing the supply shortage, the potential flow-on impacts associated with a shortage of the critical construction material would be substantial.

Economic benefits of the Proposal to the local community would mostly arise through the employment of the bulk of the full-time positions based at the Quarry. This would amount to approximately 22 persons once the Proposal reaches maximum capacity. It is likely that the majority of the workforce for the Quarry would be sourced from the Southern Highlands. Increased employment would have flow-on effects through the payment of wages and the subsequent purchase of housing or rent, groceries and spending of disposable income in the Southern Highlands. This would provide an impetus for growth or establishment of other local businesses.

A proportion of the truck drivers to be employed could also be domiciled in the Southern Highlands, however, it is likely that the bulk of the truck drivers would be based outside the Southern Highlands.

The operations of the Quarry would also have additional flow-on benefits for the local community including local spending on fuel, parts and consumables as well as the Proposal's support of local community services and projects through sponsorship or other contributions.

At a broader scale, it is anticipated that the Applicant would pay payroll tax to the State of NSW and income tax to the Federal government. A proportion of income taxes would be effectively received by the State of NSW and the local community through the Federal funding of infrastructure, health and education services.

Social benefits of the Proposal would also be evident from the flow-on effects of employment for the local communities and the subsequent expenditure at local businesses.

5.14.6.2 Potential Social and Economic Costs of the Proposal

It is unlikely that the employment of 22 predominantly-local people would noticeably increase the demand for social infrastructure in the Wingecarribee LGA, such as education and housing, reaching capacity. Additionally, it is not likely that the Proposal would interrupt social cohesion or cause conflicts between local residents. It is likely that neighbourly relations would continue as they are presently and that the Proposal would not disrupt these social connections. The assessment of environmental impacts has concluded that the Proposal would not adversely impact local groundwater availability and therefore those residents that rely on water resources for their livelihood would not be impacted. In addition, it is concluded that the option to remove potential road conflicts by constructing a grade-separated interchange would reduce impacts between local users of the Hume Highway and heavy vehicles. People in the area value the amenity experienced in a predominantly rural area, with those residents along Hanging Rock Road also expressing concerns for biodiversity values such as the remnant native vegetation and fauna such as native birds and the Koala.

Ultimately, the degree of impact on the values of the local community would reflect the Applicant's commitment and adherence to the operational safeguards and management measures proposed throughout this document. This in turn would reflect overall amenity impacts and would influence potential impacts to property value in the area. However, it is difficult to estimate the influence that any stigma associated with the presence of the Proposal would have on property values for nearby residents and to differentiate these from market influences, trends in living arrangements and other factors. The presence of the nearby Penrose Quarry and the approved Green Valley Quarry have not resulted in identifiable impacts to property values in the area.

The proposed 24/7 operations remain a concern for local residents, however this may be a factor of the perception and expectation of significant and constant noise impacts. However, in reality, approved 24/7 operations would not result in a constant activity but provide the Applicant with flexibility to satisfy customers' demands. The extent of impact due to 24/7 operations would not be likely to be clear and justifiable to the community until the Applicant can demonstrate impacts in practice.

The Applicant acknowledges the potential social impacts arising from the salvage of artefacts from sites of Aboriginal cultural heritage significance within the areas to be disturbed for the Proposal. An agreement to salvage the artefacts within sites that would be disturbed as a result of the Proposal and commitments to protect the rock shelter has been developed in consultation with registered Aboriginal parties and is considered to suitably mitigate impacts to Aboriginal cultural heritage.

The potential impacts that would be experienced at the Shrine of Our Lady of Mercy – "Penrose Park" have been comprehensively assessed and mitigation measures directed at minimising intrusive impacts from the Proposal described. The assessments and conclusions include the following.

- Groundwater availability and quality would not change at this location as a result of the Proposal. The Pauline Fathers would be able to continue sourcing water from the existing bore. It is likely that a groundwater monitoring program would be required under any Water Management Plan. If the Pauline Fathers agree to provide access, the bore on the property may be included in this program.
- The Quarry Interchange would separate Quarry-related traffic from traffic generated by high attendance feast days at the property.
- During worst-case temperature inversion conditions and peak operations, noise levels at the Grotto would remain at or below 34dB(A) and at or below 27dB(A) at the Monastery.
- Maximum noise level events are predicted to be less than 35dB(A) during worst-case temperature inversion conditions at peak operations which is not likely to result in sleep disturbance at the Monastery areas of the property.
- Blasting would not occur within 500m of the Grotto with predicted airblast overpressure and blast vibration well within human comfort and building structure protection criteria.
- Predicted dust levels (TSP, PM_{10}, $PM_{2.5}$ and deposited dust) would remain within criteria levels at the Grotto and other areas of the property.
- The Site would not be visible from the property at any time during the life of the Quarry.
- The Proposal would not increase bush fire hazard in the area to the extent that the Grotto or international chapels would be at significant additional risk. In fact, the presence of water trucks, sediment dams and other equipment may be of assistance in the case of bushfire in the local area. It is common for quarry operations to be called upon to assist the Rural Fire Service where it is safe to do so.

It is acknowledged that the residents and visitors to the Shrine of Our Lady of Mercy – "Penrose Park" may be more sensitive to amenity impacts than other nearby residents due to the nature of activities at this location. Impacts may also be experienced during short term visits and for permanent residents, indicating, for example, that short term high-impact noise and more common but lower level noise may have impacts for different groups, at different times and for different durations. Perceptions of noise, dust and traffic impacts that would be experienced at this property would continue to concern the Pauline Fathers until such time as the predicted impacts may be experienced. It is also acknowledged that visitors to the property may experience industrial noise from the Quarry, which is different to the noise currently experienced from the Hume Highway. The Applicant has committed to measures that would monitor and mitigate impacts where they may occur, including a voluntary noise reduction program once the processing plant has been commissioned. The design of the Proposal,

ongoing management and rehabilitation has considered potential impacts at the Shrine of Our Lady of Mercy – "Penrose Park" and the Applicant would continue to consult with the Pauline Fathers to minimise and/or avoid conflicts between the operation of the Proposal and the visitors and residents at the property. Assuming the ongoing consultation with the Pauline Fathers around sensitive times of the year, it is considered unlikely that the operation of the Proposal would significantly intrude on use of the Shrine of Our Lady of Mercy – "Penrose Park" such that it would lose its value as a place of religious reflection and celebration.

5.14.7 Conclusion

The proposed Sutton Forest Sand Quarry has, to the extent feasible, been designed to minimise the social and economic impacts of the Proposal on the local community. The Proposal provides for the extraction, processing and despatch of sand products recognised to be in short and diminishing supply within the Sydney hinterland. The Proposal would assist in generating local employment and improving the local economy, while drawing revenue to local businesses in the area. The economic benefits of a Proposal of this size are experienced locally and for the State of NSW.

Feedback from the local community through consultation indicates that community members are aware of the need for resource projects such as the Proposal, however they would like to ensure that potential impacts are minimised or mitigated to the greatest extent possible. This would be achieved under the Proposal, while feedback via monitoring, reporting and compliance auditing would provide a degree of accountability to these commitments.

The Applicant has made a range of commitments over-and-above requirements to satisfy standard criteria in order to minimise conflicts between the public and private use of the Shrine of Our Lady of Mercy – Penrose Park and the operation of the Quarry. Ongoing consultation with the Pauline Fathers would play an important role in further mitigating impacts at this location.

The overall environmental impact assessment process has assisted the Applicant to design the Proposal to avoid and mitigate potential impacts to social amenity. It is acknowledged that there would be changes to the local setting and residual impacts as result of the Proposal. A range of potential social impacts have been identified and measures proposed to minimise or mitigate these changes. It is considered unlikely that the Proposal would significantly change the existing amenity experienced by the community and visitors alike and that the economic benefits would be significant to the local and regional economy.