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5 October 2021
Stephen O'Donoghue
Director Resource Assessments
Department of Planning Industry and Environment
12 Darcy St, Locked Bag 5022
Parramatta NSW 2124

Dear Stephen,

We refer to your letters dated 12 and 18 August 2021, requesting further information in relation to the Bulli Seam Operations (MP08_0150) Modification 3 Application.

The following are provided in response to the requests:

- Summary of the response to each request (Attachment A)
- Memorandum on Noise Criteria (RWDI September 2021) (Attachment B)
- Memorandum on Overpressure (RWDI September 2021) (Attachment C)
- Groundwater Assessment (Hgeo September 2021) (Attachment D)
- Modification Report photomontage location plan (Attachment E)
- 30 Finns Road photomontages (Attachment F)

If you have any queries or require additional information, please contact the undersigned.

Yours sincerely,

Gary Brassington
Manager Approvals
0438 042 897

Attachment A – Summary of Responses

Out of Hours Construction Noise

> ***Department comment:***
> *The Noise and Vibration Impact Assessment (NVIA) (Wilkinson Murray, June 2021) predicts significant exceedances of the Interim Construction Noise Guideline (ICNG) (DECC, 2009) noise management levels (NMLs) for out of hours (OOH) construction works prior to the construction of the proposed acoustic sheds (ie. exceedances of up to 22 dB(A) at 13 sensitive receivers). The Department considers these exceedances unacceptable for any extended period of time, and requests additional information in relation to:*
> - *at what point in the construction schedule the acoustic sheds are proposed to be constructed;*
> - *any practical implications of constructing the sheds in the initial stage of construction during site establishment; and*
> - *project implications (timing) if OOH work is not permitted until the acoustic sheds are constructed.*

Section 5.3.2 of the Noise and Vibration Impact Assessment (NVIA) (RWDI Pty Ltd, June 2021) predicts noise levels of the construction activities associated with shaft sinking out of hours (OOH) for both calm and noise enhancing meteorological conditions. Exceedances of the construction Noise Management Levels (NML) are predicted for shaft sinking during OOH, where no mitigations are in place.

Additional mitigation is required to achieve compliance with the NMLs at all sensitive receivers during OOH shaft sinking. It is noted in the NVIA that OOH shaft sinking would not occur prior to the construction of the acoustic shed(s), unless the relevant construction NMLs are met.

Design of the Project (including the acoustic sheds to manage OOH noise) is being optimised to ensure the relevant construction NMLs are met. IMC is currently consulting with specialised shaft sinking contractors to review their recommended construction methodology and the specific mitigations required to manage potential noise impacts.

Initial feedback from shaft sinking contractors has noted the practicality and effectiveness of sheds and other effective noise attenuation options. Noise mitigation options are presented in Table 28 of the NVIA. The practical considerations which could influence the timing and construction of acoustic sheds, include:

- An acoustic shed must be constructed on a stable concrete pad, so bulk earthworks and pad construction must be completed in the shaft sinking area prior to an acoustic shed.
- The shaft collar, installed to support the temporary headframe and final ventilation ducting, would need to be installed prior to an acoustic shed.
- Piling around the shaft collar, which may be required for management of groundwater and ground stability, would need to occur prior to the construction of an acoustic shed.
- The shaft sinking headframe, winder and stage are likely to be installed first, and acoustic mitigations constructed around them. Given the size and operational

requirements it may be impractical to enclose these structures wholly within a shed. Some equipment or activities supporting the shaft sinking (such as auxiliary ventilation fans and scrubbers) are also impractical to enclose within a shed. Other practical attenuation options are available and will be considered to mitigate each specific noise source in order to achieve the required mitigation such that relevant construction NMLs are met.

As noted in the NVIA, if quieter construction methods are able to be used, the acoustic performance of the sheds/mitigations could be lowered, in recognition of shed practicality and to reduce complexity. Additionally, the required acoustic performance of the sheds/mitigations could be lowered further by entering into negotiated noise agreements with some of the most potentially affected receivers.

The required attenuation measures are proposed to be established during the pre-sink phase of the Project, when shaft sinking operations are restricted to daytime hours. The establishment of mitigations at VS8 would take priority to commence OOH operations at this location first.

Opportunities to install the noise attenuation as early as practicable will be investigated. Establishing mitigations to meet relevant NMLs and transition to a 24/7 shaft sinking cycle will provide significant benefits to mitigate receiver impacts and will provide schedule benefits to the Project. These are discussed further in the Out of Hours Blasting response below.

Detailed noise modelling of each proposed construction methodology is being undertaken, to ensure the noise attenuation options selected will mitigate each specific noise source and achieve the required NMLs. IMC is committed to adopting improvements, efficiencies and innovations where they can be demonstrated to comply with the Mine Approval (as modified) and as such a combination of practical noise mitigation options will continue to be investigated during this phase.

Noise Criteria

> ***Department comment:***
> *As indicted in Table 22 of the NVIA, the proposed duration of construction activities associated with the modification is 2 to 3 years (ie. July 2022 to 2025). This construction period is significantly longer than those contemplated under the ICNG. For longer duration construction projects where receivers are exposed to higher noise levels for extended periods (ie. typically > 6 months), the EPA and the Department require noise criteria derived in accordance with the Noise Policy for Industry (NPfI) (EPA, 2017) to apply and, if necessary, noise mitigation and management to be implemented in accordance with the Voluntary Land Acquisition and Mitigation Policy (VLAMP) (NSW Government, 2014).*
>
> *The Department requests further analysis of predicted noise levels for the modification construction activities proposed over extended periods of time (ie. >6 months) against the project noise trigger levels (PNTLs) derived in accordance with the NPfI, including any implications under the VLAMP.*
>
> *Analysis of the construction noise prediction tables in the NVIA indicates that two residential receivers (R2 and R3) would experience noise levels >5dB(A) and two residential receivers (R13 and R16) would experience noise levels >2 dB(A) above the day-time PNTLs during civil, intersection and shaft sinking (no sheds) activities. The VLAMP may apply to these residences, depending on the duration of these activities. A significant number of additional residences would experience exceedances of the PNTLs prior to the construction of the acoustic sheds.*

Assessment of construction noise levels under the NPFI

As per the Department's request, RWDI have undertaken an analysis of the predicted construction noise levels in consideration of the Noise Policy for Industry (NPfI) in addition to the Interim Construction Noise Guideline (ICGN). Please refer to Attachment B.

Project Noise Trigger Levels (PNTL) for the proposed development were established in Section 3.1.3 of the NVIA for operational noise associated with the site.

The predicted construction noise impacts at the residential receivers during standard hours are presented in Table 25 of the NVIA. Based on these noise predictions, there are four receivers where exceedances of the PNTLs are expected during standard hours (R2, R3, R13 and R16). The construction stages that may result in exceedances of the PNTLs are civil works, intersection works and VS7 and VS8 shaft sinking with no acoustic sheds.

Table 27 of the NVIA indicates that noise emissions from OOH shaft sinking work, as well as deliveries to site are expected to comply with the most stringent night time PNTL at all residential receivers, with appropriate mitigations in place.

The likely construction activities and associated equipment for the site, summarised in Table 24 of the NVIA, are generally representative of typical worst-case construction noise generation for the various construction stages. RWDI have undertaken a detailed review of the construction methodology and based on this additional information have revised construction plant and overall activity sound power levels (SWL) for the VS7 and VS8 shaft sinking stages are presented in Table 5 of Attachment B.

The revised noise predictions indicate that R13 and R16 are expected to experience PNTL exceedances of up to 1dB and 2dB respectively. This corresponds to a negligible impact in accordance with the VLAMP guidelines.

Construction noise impacts at R2 and R3 are predicted to exceed the PNTLs by more than 5dB but are below the recommended amenity noise level of 53 LAeq, 15min and this corresponds to a moderate impact according to the VLAMP guidelines.

For all remaining residential receivers, construction noise impacts during both standard and OOH periods are expected to comply with the PNTLs.

Applicability of the NPFI to construction noise levels

RWDI provide discussion on the applicability of the NPfI and VLAMP on Project construction activities in Attachment B, recommending that construction works for the proposed Site should be conducted in a manner consistent with the ICNG. It is noted in the attached that the NPfI specifically excludes construction activities. It is also noted that the Draft Construction Noise Guideline (DCNG, EPA, 2021), while not yet Government policy, specifically notes construction of ventilation shafts and mine portals as activities that should be assessed against construction noise thresholds.

The assessment approach taken in the NVIA is consistent with the guidance provide to Proponents in the ICNG, NPfI and the DCNG. The Project is distanced from existing surface operations of the Appin Mine, and impacts associated with the construction of the Project are discrete from the operation of the existing Appin Mine. It is IMC's position that construction works for the proposed Project should be conducted in a manner consistent with the ICNG.

IMC is committed to undertaking the proposed Project in a manner that minimizes impacts on the community where practicable. All reasonable and feasible noise mitigation has been considered in the Project proposal. To minimise exceedances of the construction noise criteria R2 and R3 a Construction Noise Management Plan including a variety of mitigation options has been recommended in the NVIA.

In addition to mitigations presented in the Modification Report, in July 2021 IMC proactively engaged with receivers predicted to experience exceedance of NMLs to discuss options for noise treatment at their property, including upgraded façade elements such as windows and doors. The landholders at R3 (30 Finns Road) have elected to undertake research on façade upgrades and share preferred treatment options with IMC. Discussions with R2 are ongoing. While mitigation or acquisition rights under the VLAMP were not anticipated to be required under the relevant guidelines, this proactive approach to engaging with neighboring residents, has already been undertaken as part of our ongoing consultation with these sensitive receivers.

Out of Hours Blasting

Department comment:
The Noise and Vibration Impact Assessment (NVIA) (Wilkinson Murray, June 2021) predicts exceedances of the airblast overpressure guideline levels specified in the Technical basis for guidelines to minimise annoyance due to blasting overpressure and ground vibration (ANZECC Guideline) (ANZECC, 1990) of up to 8 dBL at eight residential receivers.

The Department accepts that airblast overpressure could be controlled to within acceptable levels by blast design and other mitigation measures (blast mats, water curtains and/or acoustic sheds) for daytime blasting activities. However, the Department is concerned that even with controls and mitigation in place, the airblast overpressure levels would remain unacceptably high during night time/ evening periods and may cause annoyance and sleep disturbance for surrounding residences.

The Department notes that approval for evening and night-time blasting activities that lead to blast overpressure at receivers is extremely rare and typically not permitted in NSW. Rather, blasting impacts are managed by restricting this activity to the day time period. This is particularly the case for mining developments.

The Department requests further demonstration of why blasting activities are required outside of standard daytime hours, and the implications of restricting blasting to the daytime period only. If approval for out of hours blasting is still being sought, the Department requires a comprehensive assessment of airblast overpressure levels from blasting against the sleep disturbance criteria established under the Noise Policy for Industry (NPfI) (EPA, 2017).

Approach to Blast Management

The proposed approach to blast management has been developed considering the detailed modeling completed by RWDI in the NVIA, expert advice provided by specialist blasting consultant John Heilig (Heilig and Partners Pty Ltd) and assessment from specialist mine blasting consultant, Prism Mining Pty Ltd.

As outlined in Section 3.7.3.4 of the Modification Report, IMC has proposed a two phased approach to the management of blasting impacts, managed under a Blast Management Strategy. The key element is that OOH blasting is not proposed during the initial stages of shaft sinking, but rather the option would only be explored after monitoring data has been collected to confirm that construction blasting will not impact upon the amenity of adjacent sensitive receivers.

During Phase One of the program (the first 30-50m of shaft sinking), IMC has committed to limiting operations to daytime only. Shaft excavation can be undertaken using mechanical excavation methods, due to the presence of softer Ashfield Shale and the shallower depth. Controlled blasting will also be used and monitored. The excavation rate during the pre-sink is approximately 0.5m per day, due to the reduced construction hours and the excavation methodologies.

During Phase Two, the harder Hawkesbury sandstone layers are encountered, and blasting is required. IMC intends to have acoustic mitigations in place such that NMLs are met for OOH construction activities. By this stage, blasting data will have been reviewed and discussed with key stakeholders, the blast design refined, and measures put in place so that OOH blasting could be undertaken without impact on receiver amenity. Excavation rates would increase to 1.5 - 1.6m per day, due to extended operational hours, use of blasting and the efficiencies gained during 24/7 operations.

The proposed strategy is considered a conservative approach to managing the potential amenity impacts of OOH blasting on the community. The approach is also appropriate for this construction scenario where, as opposed to general construction blasting, there is an increasing benefit of distance between blasting works and sensitive receivers as the shaft sinking depth increases (refer to Attachment C). Further, a significant positive aspect is that the shafts are vertical and the noise and overpressure from the blasting will be preferentially directed away from receivers.

Implications of restricting blasting to the daytime period only

Implications of restricting blasting to the daytime period only include:

- Extension of the shaft construction duration by approximately 30%, resulting in increased duration of impacts on the local community.
- Critical timeframes for ventilation of the underground operations will not be met.
- Additional safety and operational impacts for construction and for the Mine.

Shaft sinking via controlled blasting is a process that relies on a repetitive sequence of activities. Based on cycle time analysis, a restriction to daytime hours during Phase Two of the program would extend each shaft construction period by approximately 30%, or by up to 5 months. The extension of each shaft sinking period by 5 months would increase the overall duration of the construction project, which would result in unnecessary additional duration related impacts to the community and sensitive receivers.

As noted in Section 1.4.2 of the Modification Report, installation of the ventilation shafts (and supporting surface equipment) is critical to ensure a safe and efficient underground working environment. The shafts are required to be operational before 2025. Based on the indicative construction schedule presented in Section 3.5 of the Modification Report, if construction were restricted to daytime only during Phase Two this operational requirement of the Mine would not be met. Lack of adequate ventilation would impact the safety and efficiency of the Mine.

Limiting blasting to standard construction hours has other safety and operational impacts that must be considered:

- Misfires are the complete or partial failure of a blast charge to detonate as planned. To reduce the likelihood of a misfire, once explosives are transported to Site and loaded into the shot holes, other work must cease within the shaft and the charges detonated as soon as safe and reasonably practicable. Interruptions to the blasting cycle would have the potential to increase the likelihood of misfire hazards.
- While blasting is a standard construction practice, it is also an inherently high-risk activity particularly in a confined environment such as within a shaft at depth. Safe

management of a blasting area requires a high level of attention to the ground conditions and water make. Limitations on the blasting cycle would impact the construction team's ability to manage and mitigate such issues as they arise during the shaft sinking cycle.

- As the shaft approaches the Appin Mine workings at ~550 - 590m depth, an increased level of surveillance and control over the blasts is required. At this time, integration of the shaft with the operational Mine requires careful and flexible scheduling of blast times to accommodate the safety of the underground operations, in consultation with the Mine and Regulator.

Blast times are not able to be set at a precise and regular time each day, which would enable a restricted period for blasting. This is because shaft sinking rates vary given the ground conditions encountered during construction. Increased water make, poor ground conditions or hard ground will slow the shaft sinking due to the time taken to employ mitigations or to shorten blasting rounds. It should be noted that because of this variability, blasts will not occur in both shafts every night.

As noted in the Modification Application, consideration will be given to undertaking blasts at times that have the least impact on sensitive receivers, however flexibility in blasting times is required to respond efficiently to changes in conditions.

Based on the above, the opportunity to undertake OOH blasting, with an approved Blast Management Strategy and mitigations in place, is best for both the Project and the local community and is critical to meeting the operational needs of the Mine.

Assessment of Overpressure

In further support of the proposal to undertake blasting OOH, RWDI have undertaken an analysis of overpressure levels from blasting against the sleep disturbance criteria, established under the Noise Policy for Industry (NPfI) (EPA, 2017). Please refer to Attachment C. This report has been peer reviewed by blast design and engineering expert John Heilig (Principal - Heilig & Partners Pty Ltd).

The assessment presents an assessment of blasting with and without mitigations in place against the NPfI (EPA, 2017). As typically only a maximum of 2 blasts could occur per night, external LAmax noise levels associated with night time blasting below 75 dBA are considered unlikely to cause sleep disturbance impacts.

Considering the practical noise mitigation options available (blast design, barrier effects, use of blast mats/ water curtains and acoustic sheds/surface mitigations), a conservative noise reduction of 25 dB is considered against the sleep disturbance criteria.

LAmax noise levels achieved at the closest receivers are presented with a comparison to the nominated criterion in Table 5. As can be seen from Table 5, the predicted LAmax noise levels from blasting are able to achieve the 75dBA LAmax criterion for 1 to 2 night time events.

The assessment concludes it is feasible to conduct night construction blasting as part of this Project. Community consultation and careful blast management will be undertaken to manage the possible night-time noise impacts. It should be noted that night-time blasting is not proposed during the initial stages of the shaft development, but rather the option would only be explored after measurement data has been collected to confirm that it will not impact upon the amenity of adjacent sensitive receivers.

Groundwater Analysis

Department comment:
The Department requests more detailed information on the potential impacts of the modification on local groundwater resources, including:

- *quantification of groundwater 'take' or diversion as a result of the shaft sinking operations;*
- *predicted impact of groundwater 'take' on local groundwater resources, including bores and farm dams;*
- *proposed groundwater mitigation, management and monitoring measures, including the shaft lining and grouting system proposed to minimise ingress of groundwater; and*
- *capacity of the existing groundwater access licences to account for predicted groundwater take.*

It is requested that a hydrogeological specialist be engaged to assist in the preparation of this information.

As per the Departments request, HGEO Pty Ltd has been engaged to prepare a detailed assessment of the potential impacts of the Project on local groundwater resources. Please refer to Attachment D.

Groundwater modelling was undertaken to simulate hydrogeological conditions in the Project area and predict impacts to groundwater resources and sensitive receptors during excavation and ongoing use of the ventilation shafts. The model was calibrated using observed inflows to existing shafts at Appin Mine. The modelled scenario incorporates the proposed mitigation measures for controlling groundwater inflow during excavation and ongoing operation of the shafts as implementation of the mitigation measures is an integral component of the shaft sinking operations.

Maximum predicted inflows during construction of the ventilation shafts are 30.4 ML in 2023 and 59.8 ML in 2024. To ensure shaft sinking efficiency, groundwater inflows will be minimised by targeted grouting of fractured zones and advance pre-grouting of fractured strata. With increased controls, actual inflows may be lower than those predicted. Ongoing seepage into the ventilation shafts of 0.14 ML/year is predicted during ongoing use of the shafts.

There are no registered bores within the Project Site. Predicted drawdown due to the Project is negligible at most registered bores within the modelled area. Minor drawdown is predicted at stock and domestic bore GW105574 (0.85 m), domestic bore GW106574 (0.80 m) and test bore GW108990 (1.47 m). In most cases the incremental drawdown due to shaft construction is negligible or minor compared with the estimated cumulative depressurisation from approved mining and the coal seam gas extraction in the area. Negligible impacts to farm dams are predicted as farm dams in the Project area are shallow and effectively perched within the upper weathered horizons of the Wianamatta Group. Drawdown is not predicted at the Nepean River during construction or operation of the shafts, and therefore there will be no additional induced take of water from the Nepean River as a result of the Project.

The mitigation measures to be implemented during construction include targeted grouting of fractured zones and advance pre-grouting of fractured strata prior to excavation. A concrete lining will be installed closely behind the working area during excavation of the shaft, which will significantly reduce inflows to the shaft by blocking seepage paths.

Management and monitoring of groundwater during the construction phase would be included in the relevant construction environmental management plan prepared for the Project. The Appin Mine Water Management Plan would be updated as required to incorporate the Project.

Taking into account the cumulative take of groundwater for approved and proposed mining at Appin Mine, the share allocation of licences held by IMC is sufficient to account for any incidental groundwater take at the Site during construction and operation of the shafts.

Visual Assessment

> ***Department comment:***
> *The Department requests an overall summary figure which shows the location and direction of the viewpoints depicted in the photomontages (Figures 6-5 – 6-22) of the Modification Report.*

As per the Departments request, provided is a plan depicting the location and direction of the photomontages that were included in the Modification Report. Please refer to Attachment E.

Further to this, updated photomontages and a location plan have also been provided in the Submissions Report. These photomontages consider the specific locations of submissions received regarding visual impact, more phases of the Project and expected vegetation mix growth heights over time.

> ***Department comment:***
> *The Department also requests an additional photomontage and more detailed discussion on how effective tree planting and screening would be to minimise visual impacts associated with the residence at 30 Finns Road (R3, VP7), noting that visual impacts to this property were raised in numerous public submissions on the modification.*

In the initial phases of Project planning, 30 Finns Road (R3) and 310 Menangle Road (R2) were identified as sensitive receivers that may have high to moderate visual impact from the Project. Since September 2020 IMC has been undertaking proactive discussions on screening options with the owners of 30 Finns Road and 310 Menangle Road.

In regard to 30 Finns Road, in consultation with the property owners and an expert landscaper, various options for tree planting on the property were considered. IMC's landscaper recommended *Xylosma senticosa,* an evergreen hedging shrub that grows up to 4m high, and the landholder requested *Prunus Lusitanica,* a similar shrub that grows to a height of 3m. IMC completed vegetation screen planting with the hedge of the resident's choice in May 2021, along with protective fencing, irrigation and mulching.

Please refer to Attachment F which includes updated photomontages from 30 Finns Road and a plan showing the locations of the viewpoints. Table 1 outlines the various phases of the Project and vegetation growth heights considered in the photomontages. The photomontages have conservatively assumed:

- a consistent hedge height of 1.2m at 30 Finns Road (for a comparison a 2.1m hedge is also shown in Figure 11 and Figure 19); and
- realistic growth rates of boundary planting (mix of trees and shrubs) and bunds planting (shrubs only) provided by the landscaper, as per Table 1.

Table 1 – Photomontages at 30 Finns Road

Figure	Location at 30 Finns Road	Phase of Project	Hedge Height	Predicted plant height for boundary/bund
Figure 3	Patio Viewpoint	Construction	No hedge	0.9m/0m
Figure 4	Patio Viewpoint	3 Years	No hedge	3m/4m
Figure 5	Patio Viewpoint	5 Years	No hedge	5m/6m
Figure 6	Patio Viewpoint	Tree Maturity	No hedge	7m/30m
Figure 7	Patio Viewpoint	Construction	1.2m	0.9m/0m
Figure 8	Patio Viewpoint	3 Years	1.2m	3m/4m
Figure 9	Patio Viewpoint	5 Years	1.2m	5m/6m
Figure 10	Patio Viewpoint	Tree Maturity	1.2m	7m/30m
Figure 11	Patio Viewpoint	5 Years	2.1m	5m/6m
Figure 12	Pool Viewpoint	Construction	No hedge	0.9m/0m
Figure 13	Pool Viewpoint	3 Years	No hedge	3m/4m
Figure 14	Pool Viewpoint	5 Years	No hedge	5m/6m
Figure 15	Pool Viewpoint	Tree Maturity	No hedge	7m/30m
Figure 16	Pool Viewpoint	Construction	1.2m	0.9m/0m
Figure 17	Pool Viewpoint	3 Years	1.2m	3m/4m
Figure 18	Pool Viewpoint	5 Years	1.2m	5m/6m
Figure 19	Pool Viewpoint	Tree Maturity	1.2m	7m/30m
Figure 20	Pool Viewpoint	5 years	2.1m	5m/6m

The photomontages indicate that a hedge height of 1.2m will significantly screen the Site from the main viewpoints at the rear of the dwelling. The photomontage indicates that a hedge height of 2.1m would screen the highest operational building (the winder tower) from view at ground level. Given the hedge can grow up to 3m, the hedging along with the Site boundary and bund planting will provide effective screening from 30 Finns Road main outdoor/entertaining areas.

IMC accepts that it will take some time before the full benefit of vegetation screening is realized (both on the Site or at the location chosen by the sensitive receiver). IMC has initiated the screening at the site boundary and at sensitive receiver ahead of Project approval (if granted), in order to minimise this duration as far as possible.

In addition to the screen planting IMC have incorporated numerous design options to minimize visual impact, including sensitive colour and material choices for visible structures, construction of earth bunds around the operational footprint of the Project, screen planting along the Site boundary and on the visual bunds, and lighting design to minimise light spill. The boundary planting location is considerate of existing infrastructure (such as the road and powerlines) and in anticipation of future Site infrastructure.

IMC will continue to consult with the residents at 30 Finns Road and 310 Menangle Road to confirm the suitability of the selected screening material and will consider further design options on Site to further screen the line of site of the facility from the residences.

Attachment B – Memorandum on Noise Criteria (RWDI September 2021)

RWDI Australia Pty Ltd (RWDI)
Level 4, 272 Pacific Highway
Crows Nest, NSW, 2065

Tel: +61.2.9437.4611
E-mail: solutions@rwdi.com
ABN: 86 641 303 871

MEMORANDUM

DATE:	1 October 2021	**RWDI REFERENCE #:** 2101914
TO:	Nicola Curtis	**Email:** Nicola.Curtis@south32.net
FROM:	Justin Leong	**Email:** justin.leong@rwdi.com
	John Wassermann	**Email:** john.wassermann@rwdi.com
RE:	**Response to DPIE Request for Information – Noise Criteria Appin Mine Ventilation and Access Project Menangle, NSW**	

Dear Nicola

This memorandum has been prepared in response to the request for information (RFI) provided by the NSW Department of Planning, Industry and Environment (DPIE) with respect to the Noise and Vibration Impact Assessment (NVIA), RWDI#2101914, dated 24 June, 2021 for the Appin Mine Ventilation and Access Project MP08_0150-Mod-3.

The RFI (dated 12 August 2021) of the DPIE states the following:

*"**Noise Criteria***

As indicated in Table 22 of the NVIA, the proposed duration of construction activities associated with the modification is 2 to 3 years (ie. July 2022 to 2025). This construction period is significantly longer than those contemplated under the ICNG. For longer duration construction projects where receivers are exposed to higher noise levels for extended periods (i.e. typically > 6 months), the EPA and the Department require noise criteria derived in accordance with the Noise Policy for Industry (NPfI) (EPA, 2017) to apply and, if necessary, noise mitigation and management to be implemented in accordance with the Voluntary Land Acquisition and Mitigation Policy (VLAMP) (NSW Government, 2014).

The Department requests further analysis of predicted noise levels for the modification construction activities proposed over extended periods of time (ie. >6 months) against the project noise trigger levels (PNTLs) derived in accordance with the NPfI, including any implications under the VLAMP.

Analysis of the construction noise prediction tables in the NVIA indicates that two residential receivers (R2 and R3) would experience noise levels >5dB(A) and two residential receivers (R13 and R16) would experience noise levels >2 dB(A) above the day-time PNTLs during civil, intersection and shaft sinking (no sheds) activities. The VLAMP may apply to these residences, depending on the duration of these activities. A significant number of additional *residences would experience exceedances of the PNTLs prior to the construction of the acoustic sheds."*

Existing Environment

Sensitive Receivers

A number of rural residential properties are the nearest and most potentially affected receivers near the Site. These sensitive receivers are identified in Table 1 and shown in Figure 1.

The receiver identified as "R1", owned by the Proponent, is located within the construction boundary, is currently unoccupied, and will be demolished as part of the preparatory works or utilised by the Project for the duration of the Project construction and operation phase. R1 is therefore not considered as a sensitive receiver in this assessment.

Table 1: Sensitive Receivers

Receiver ID	Address
R1	345 Menangle Road, Menangle
R2	310 Menangle Road, Menangle
R3	30 Finns Road, Menangle
R4	15 Finns Road, Menangle
R5	3 Finns Road, Menangle
R6	430 Menangle Road, Menangle
R7	436 Menangle Road, Menangle
R8	450 Menangle Road, Menangle
R9	470 Menangle Road, Menangle
R10	475 Menangle Road, Menangle
R11	485 Menangle Road, Menangle
R12	486 Menangle Road, Menangle
R13	775 Moreton Park Road, Menangle
R14	251 Menangle Road, Menangle
R15	235 Menangle Road, Menangle
R16	310 Menangle Road, Menangle
R17	195 Menangle Road, Menangle
R18	110 Finns Road, Menangle
R19	25 Carrolls Road, Menangle
R20	47 Carrolls Road, Menangle
R21	45 Finns Road, Menangle
R22	45 Carrolls Road, Menangle

Receiver ID	Address
R23	35 Finns Road, Menangle
R24	5 Finns Road, Menangle
R25	454 Menangle Road, Menangle
R26	460 Menangle Road, Menangle
R27	474 Menangle Road, Menangle
R28	514 Menangle Road, Menangle
R29	490 Menangle Road, Menangle
R30	510 Menangle Road, Menangle
R31	520 Menangle Road, Menangle
R32	530 Menangle Road Douglas, Park
R33	516 Menangle Road, Menangle
R34	165 Carrolls Road, Menangle
R35	115 Carrolls Road, Menangle

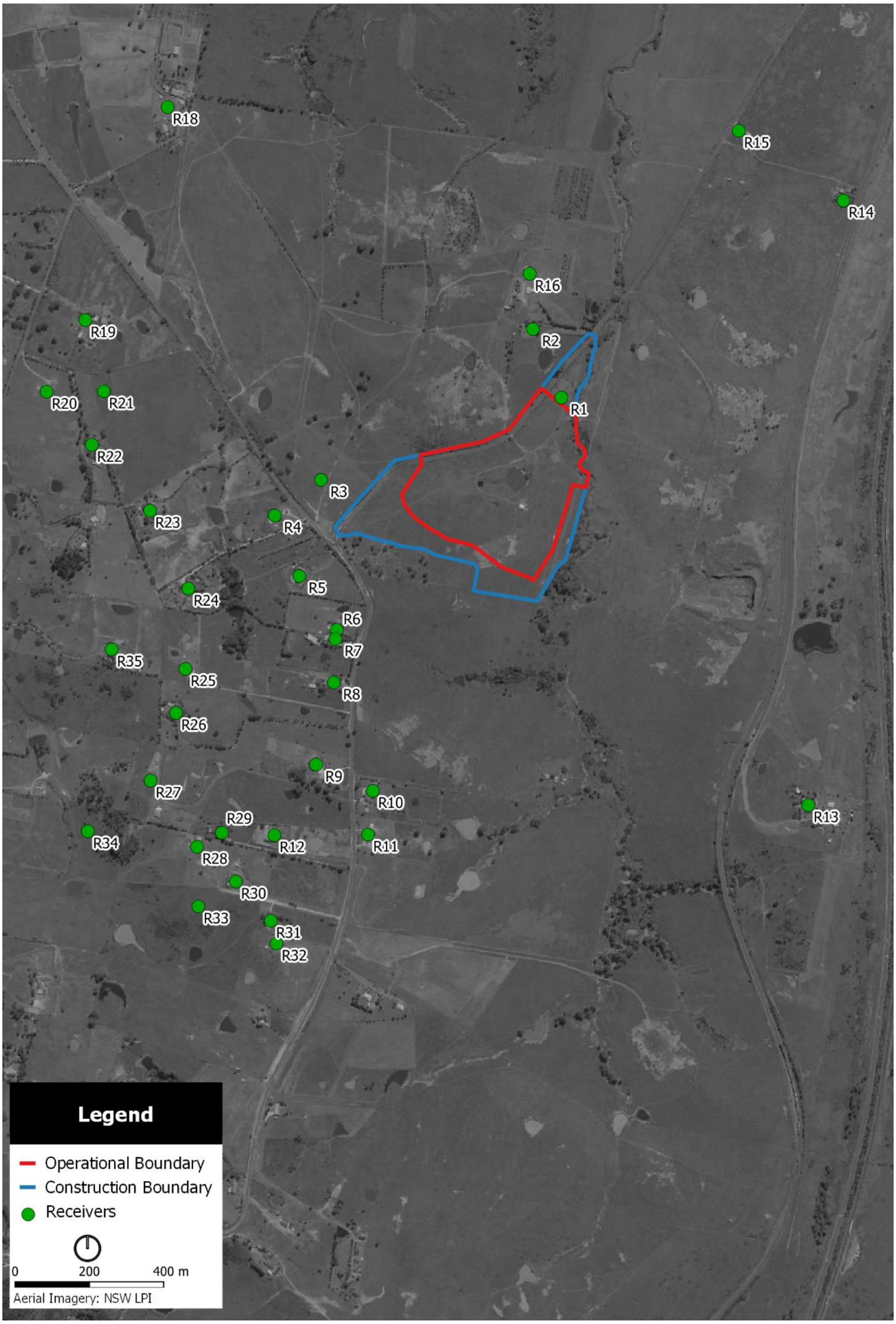

Figure 1: Sensitive Receivers

Acoustic Criteria

NSW EPA NPfI

PNTLs for the proposed development have been established in section 3.1.3 of the NVIA for operational noise associated with the site. These have been based on background noise monitoring conducted on site in October and November 2020. The PNTLs are summarised in Table 2 in bold and will be applied to construction activities as requested by the DPIE (construction activities originally assessed in the NVIA against the EPA's Interim Construction Noise Guideline).

Table 2: Project Noise Trigger Levels

Receiver	Time of Day [a]	Project Intrusiveness Noise Levels ($L_{Aeq,15min}$)	Project Amenity Noise Level ($L_{Aeq,15min}$)
All Nearby Residences	Day	**43**	53
	Evening	**43**	48
	Night	**39**	43

a. Day = 7.00am – 6.00pm; Evening = 6.00pm – 10.00pm; Night = 10.00pm – 7:00am

It is also noted that the recommended amenity noise level for the residential receivers during standard hours is 50 $L_{Aeq,\ period}$ as discussed in section 3.1.2 of the NVIA. This corresponds to a recommended amenity noise level of 53 $L_{Aeq,\ 15min}$ based on the NPfI assumption that the $L_{Aeq,15min}$ equivalent of an $L_{Aeq,period}$ noise level is equal to the $L_{Aeq,15min}$ level plus 3dB.

VLAMP

The NPfI recognises that where all feasible and reasonable noise mitigation measures have been applied to both the source and pathway, a proposed development might give rise to residual noise impacts.

The VLAMP (issued by the DPIE) describes mitigation for residual noise and air quality impacts from State significant mining, petroleum and extractive industry developments through the application of voluntary mitigation and acquisition rights.

Tables 4.1 and 4.2 of the NPfI quantify the significance of potential noise exceedances and provide example measures for addressing residual noise impacts, respectively. These tables are reproduced below in Table 3 and Table 4. The significance categories (i.e. negligible, marginal, moderate and significant) and measures are generally consistent with the significance categories and measures described in Table 1 of the VLAMP.

Table 3: Significance of Residual Noise Impacts

If the predicted noise level minus the PNTL is:	And the total cumulative industrial noise level is:	Then the significance of residual noise level is:
≤2 dBA	Not applicable	Negligible
≥3 but ≤5 dBA	< recommended amenity noise level or > recommended amenity noise level, but the increase in total cumulative industrial noise level resulting from the development is less than or equal to 1 dB	Marginal
≥3 but ≤5 dBA	> recommended amenity noise level and the increase in total cumulative industrial noise level resulting from the development is more than 1 dB	Moderate
>5 dBA	≤ recommended amenity noise level	Moderate
>5 dBA	> recommended amenity noise level	Significant

Table 4: Examples of Potential Receiver-Based Treatment to Mitigate Residual Noise Impacts

Significance of residual noise level	Example of Potential Treatment
Negligible	The exceedance would not be discernible by the average listener and therefore would not warrant receiver-based treatment or controls.
Marginal	Provide mechanical ventilation/comfort condition systems to enable windows to be closed without compromising internal air quality/amenity.
Moderate	As for 'marginal', but also upgraded façade elements, such as windows, doors or roof insulation, to further increase the ability of the building façade to reduce noise levels.
Significant	May include suitable voluntary land acquisition rights where considered feasible and reasonable.

Note in accordance with the *VLAMP*, mitigation rights are afforded to properties with predicted exceedances that are characterised as marginal, moderate or significant and acquisition rights are afforded to properties with predicted exceedances that are characterised as significant.

Assessment of Standard Hours Construction Works

The predicted construction noise impacts at the residential receivers during standard hours are presented in Table 25 of the NVIA. Based on these noise predictions, the receivers where exceedances of the PNTLs are expected are:

- R2
- R3
- R13
- R16

We also note that the construction stages that may result in exceedances of the PNTLs are:

- Civil works
- VS7 and VS8 shaft sinking with no acoustic sheds
- Intersection works

For the sake of brevity in the presentation of results, only these residential receivers and construction stages will be presented in this response. Construction noise impacts at all remaining identified receivers are expected to comply with the PNTLs during standard hours. We highlight that the predicted noise levels from the various construction stages are representative of the typical worst-case level during a given 15-minute, and that the levels are unlikely to be sustained for the duration of each respective stage. As such, construction noise emissions during many 15-minute periods are likely to be lower than those predicted in the NVIA.

Construction Activities, Equipment and Sound Power Levels

The likely construction activities and associated equipment for the site, as advised by IMC, were summarised in Table 24 of the NVIA and are generally representative of typical worst-case construction noise generation for the various construction stages.

A more detailed review of the expected construction methodology reveals that during the VS7 and VS8 shaft sinking stages excavators are unlikely to use rock breaking attachments. We have been advised that the first 20-30m of excavation at both shafts are expected to be of Ashfield Shale, which will be removed using excavators with buckets. After the initial 20-30m of excavation Hawkesbury Sandstone is expected be encountered, which is anticipated to be removed using shaft drilling equipment, controlled blasting and excavators with buckets.

Based on this additional information, the revised construction plant and overall activity sound power levels (SWL) for the VS7 and VS8 shaft sinking stages are presented in Table 5. Construction plant for the civil works and intersection works stages are expected to remain unchanged from those listed in Table 24 of the NVIA.

Table 5: Revised Construction Equipment SWLs for VS& & VS8 Shaft Sinking

Activity	Equipment	Qty	Individual SWL (dBA)	Activity SWL (dBA)	
				Standard	Out of hours
VS7 & VS8 Shaft Construction					
Shaft sinking	50t slewing crane	1	113	121	121
	30t excavator with bucket	3	110		
	Emergency Power Genset and switching (500 kVA typical)	1	103		
	Ventilation Fan and Ducting	1	120		
	Ventilation Scrubber	1	100		
	Shaft Drilling Equipment	2	119		
	Dump truck [a]	1	110		
	Dozer [a]	1	116		
	Water Truck [a]	1	107		
	Shotcrete Delivery Equipment	1	106		
	Concrete Delivery from offsite via Truck	2	110		
	Concrete Delivery System (pumps)	1	102		

a. Activities related to shaft spoil handling, that will occur outside of the acoustic shed are restricted to daytime construction hours only.

Predicted Construction Noise Levels

Based on the revised construction plant and SWLs identified above for the VS7 and VS8 shaft sinking, and the construction plant SWLs presented in Table 24 of the NVIA for civil and intersection works, the predicted construction noise impacts at the potentially most-affected receivers are presented in Table 6.

Table 6: Predicted Construction Noise Levels during Standard Construction Hours – $L_{Aeq,15min}$ dBA

Receiver	Civil Works	VS7 Shaft Sinking No-shed	VS8 Shaft Sinking No-shed	Intersection Works		PNTL	Exceedance
				Pavement	Line marking		
R2	**53**	**51**	**46**	**52**	**45**	43	10 dB
R3	**49**	**44**	**45**	**46**	39	43	6 dB
R13	**44**	40	41	41	34	43	1 dB
R16	**45**	**44**	41	**45**	38	43	2 dB

The revised noise predictions indicate that R13 and R16 are expected to experience PNTL exceedances of up to 1dB and 2dB respectively. This corresponds to a negligible impact in accordance with the VLAMP guidelines.

Construction noise impacts at R2 and R3 are predicted to exceed the PNTLs by more than 5dB but are below the recommended amenity noise level of 53 $L_{Aeq,\ 15min}$ and this corresponds to a moderate impact according to the VLAMP guidelines.

For all remaining residential receivers, construction noise impacts are expected to comply with the PNTLs.

As suggested in the NVIA, RWDI are of the opinion that construction works for the proposed site should be conducted in a manner consistent with the Interim Construction Noise Guideline (ICNG, DECC, 2009).

The ICNG inter alia excludes; *"noise from industrial sources (for example, factories, quarrying, mining, and including construction associated with quarrying and mining) – this is assessed under the NSW Industrial Noise Policy (EPA 2000)"*, however the contemporary Noise Policy for Industry (NPfI, EPA, 2017) inter alia excludes *"Construction activities"* and defines construction activities as *"Activities that are related to the establishment phase of a development and that will occur on a site for only a limited period of time"*.

The purpose of the ICNG in excluding construction activities was to remove the potential for recurring mining type activities (for example progressive clearing and grubbing of land, overburden removal stripping and emplacement, progressive construction of haul roads etc.) as being considered as construction when occurring well into the project's operational life. These are not activities that the community would distinguish from normal operations, and hence should be treated as operational activities. However, the construction of discrete infrastructure on mining sites has been assessed against the ICNG, as has been previously accepted by the DPIE for the Appin Mine Ventilation Shaft No. 6 at Douglas Park, and the rail spur construction for the Vickery Extension Project.

The EPA has recognised the need for additional guidance to better delineate different types of "mining construction" that can and should be assessed against construction noise thresholds and have dedicated an entire case study in the Draft Construction Noise Guideline (DCNG, EPA, 2021) in Appendix A1. This case study specifically notes construction of ventilation shafts and mine portals as activities that should be assessed against construction noise thresholds. While the DCNG is not government policy, it does provide clarity and endorsement to what is essentially current practice.

The rationale equally suggests that it would be inappropriate to apply the government's VLAMP policy to activities that are for all practical purposes construction activities.

When assessing the revised noise predictions against the NMLs of the ICNG only R2 and R3 present an exceedance, with R3 being a nominal 1dB exceedance. All reasonable and feasible noise mitigation has been considered in that visual/ acoustic bunds are proposed around the perimeter of the site (indicatively up to 4-5m high as indicated in green in Figure 2) and acoustic sheds are proposed to be constructed over the ventilation shafts. Additionally, to manage construction noise exceedances at R2 and R3 and minimise exceedances of the construction noise criteria a Construction Noise Management Plan has been recommended in the NVIA.

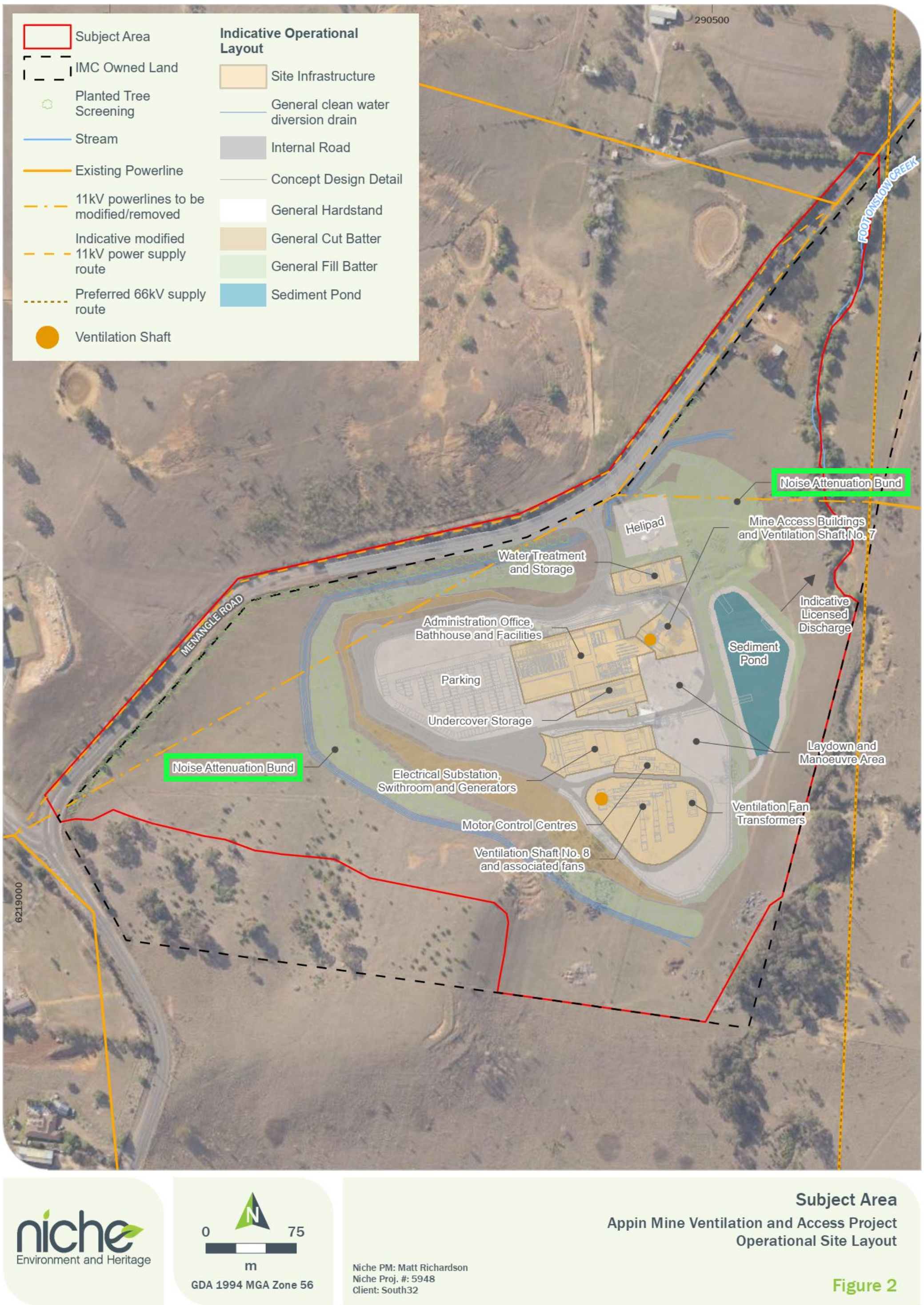

Figure 2: Site Plan Showing Proposed Bund Locations (Indicative)

Assessment of Out of Hours (OOH) Construction Works

The only OOH construction works that are proposed to occur are truck deliveries and shaft sinking works for VS7 and VS8. In Section 5.2.1 of the NVIA, it is confirmed that OOH shaft sinking would not occur prior to the construction of the shed(s) (or other suitable noise mitigation measures/alternative construction methodologies), unless the relevant construction NMLs are met. Noise mitigation options are presented in Table 28 of the NVIA. Construction of the mitigations at VS8 shaft would be prioritised, so that OOH works can commence at this location first.

Based on this, Table 27 of the NVIA indicates that noise emissions from OOH shaft sinking work, as well as deliveries to site are capable of complying with the most stringent night time PNTL (39dBA) at all residential receivers. Given this, no receiver-based acoustic treatments or controls are required for these receivers with respect to OOH works.

Recommendations

As discussed in section 5.3.3 of the NVIA, it is recommended that all reasonable and feasible measures should be applied to manage construction noise emissions from the site. In particular, it is recommended that a detailed Construction Noise Management Plan (CNMP) be prepared and should include, but not be limited to the following:

- Identification of nearby residences and other sensitive land uses;
- Description of approved hours of work;
- Description and identification of construction activities, including work areas, equipment and duration;
- Description of what work practices (generic and specific) will be applied to minimise noise;
- Consider the selection of plant and processes with reduced noise emissions;
- A complaints handling process;
- Noise monitoring procedures;
- Overview of community consultation required for identified high impact works;
- Overview of community consultation process and assessment required for identified additional works outside of standard construction hours;
- Induction and training will be provided to relevant staff and sub- contractors outlining their responsibilities with regard to noise; and
- Development of a “Driver’s Code of Conduct”.

Additional Comments

Sleep Disturbance Criteria

In reviewing the NVIA as part of preparing this response, we note that there was an error in Table 7 of the NVIA in establishing the maximum noise trigger level criteria (in accordance with the NPfI) for the sleep disturbance assessment. In Table 7 of the NVIA the night time Rating Background Level (RBL) was reported as 39dBA, however the night time RBL should be 34dBA. Based on this, the corrected maximum noise trigger level criteria are presented in Table 7 below.

Table 7: Maximum Noise Trigger Levels

Receiver	RBL	RBL + 15 dBA	Maximum Noise Trigger Level (L_{Amax})
All Nearby Residences	34	49	52

Considering this, the maximum noise trigger level criteria presented in Table 13 of the NVIA (operational noise sleep disturbance assessment) will also need to be corrected to 52dBA. We note that noise emissions from the site comply with the corrected maximum noise trigger level criteria at all receivers and so operational noise levels are unlikely to cause sleep disturbance impacts.

We trust this information is sufficient. Please contact us if you have any further queries.

Sincerely,

RWDI

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Acoustical Consultant

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Attachment C – Memorandum on Overpressure (RWDI September 2021)

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30 September 2021

Nicola Curtis
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Re: Appin Mine Ventilation and Access Project MP08_0150-Mod-3 - Request for Additional Information – Out of Hours Blasting

Dear Nicola,

RWDI Australia Pty Ltd (RWDI) conducted a Noise and Vibration Impact Assessment for the Appin Mine Ventilation and Access Project MP08_0150-Mod-3, dated June 24 2021.

RWDI has been requested by South32 Illawarra Metallurgical Coal to provide a response to the Department of Planning, Industry and Environment's (DPIE) request for further information in their letter dated 18 August 2021 requesting an additional "Out of Hours Blasting" assessment for the Bulli Seam Operations (MP08_0150) Mod 3 application. Specifically, DPIE requested:

"a comprehensive assessment of airblast overpressure levels from blasting against the sleep disturbance criteria established under the Noise Policy for Industry (NPfI) (EPA, 2017)."

The sections below present a sleep disturbance assessment for blast overpressure consistent with EPA's NPfI. This sleep disturbance assessment needs to be read in conjunction with the Noise and Vibration Impact Assessment for the Appin Mine Ventilation and Access Project MP08_0150-Mod-3, dated June 24 2021.

Out of Hours (OOH) Construction Blasting

The intent of blasting outside standard hours for the project would be to reduce overall construction impacts, by reducing the duration of the works, without significant additional impacts. In consideration of the construction program, blasting cycle and the need to minimise impacts, a two phased management approach to undertaking blasts is proposed. Initially blasting will be restricted to standard hours, before moving to OOH at greater depths. The approach is considerate of the increase of distance between blasting works and sensitive receivers as the shaft sinking works progress. In the event that shaft sinking activities could not be undertaken 24 hours a day, 7 days a week, it is estimated that the construction schedule for the shaft sinking phase of the Project would increase by approximately 30%.

Shaft sinking using controlled blasting is a cyclical process which relies on a repetitive sequence of activities. Depending on variables such as the ground conditions, size of the round and depth of the working face, the cycle can take between 24 and 32 hours to complete. In order to reduce the overall length of the shaft construction phase, construction blasts should occur regularly in accordance with this sequence (a construction blast in each shaft every 24 to 32 hours) wherever possible.

To support this cycle, activities that support shaft construction may need to occur 24 hours per day, up to seven days per week. Spoil handling and emplacement are anticipated to be conducted primarily during standard construction hours to minimise noise and vibration impact on sensitive receivers.

Generally during construction, exposure to noise and vibration would be greater when works are close to a receiver location and would decrease when the work is further away. Due to the vertical nature of shaft-sinking, as excavation is progressing down the shaft the distance increases and exposure to impacts from each detonation would typically decrease at a receiver. The aim of the sleep disturbance assessment for OOH blast overpressure is to demonstrate that with all mitigations measures in place, the project is unlikely to cause sleep disturbance.

Existing Environment

Sensitive Receivers

A number of rural residential properties are the nearest and most potentially affected receivers near the Site. These sensitive receivers are identified in Table 1 and shown in Figure 1.

The receiver identified as “R1” is within the construction boundary, is owned by the Proponent, is currently unoccupied, and will be demolished as part of the preparatory works or utilised by the Project for the duration of the Project construction and operation phase. R1 is therefore not considered as a sensitive receiver in this assessment.

Table 1: Sensitive Receivers

Receiver ID	Address
R1	345 Menangle Road, Menangle
R2	310 Menangle Road, Menangle
R3	30 Finns Road, Menangle
R4	15 Finns Road, Menangle
R5	3 Finns Road, Menangle
R6	430 Menangle Road, Menangle
R7	436 Menangle Road, Menangle
R8	450 Menangle Road, Menangle
R9	470 Menangle Road, Menangle

Receiver ID	Address
R10	475 Menangle Road, Menangle
R11	485 Menangle Road, Menangle
R12	486 Menangle Road, Menangle
R13	775 Moreton Park Road, Menangle
R14	251 Menangle Road, Menangle
R15	235 Menangle Road, Menangle
R16	310 Menangle Road, Menangle
R17	195 Menangle Road, Menangle
R18	110 Finns Road, Menangle
R19	25 Carrolls Road, Menangle
R20	47 Carrolls Road, Menangle
R21	45 Finns Road, Menangle
R22	45 Carrolls Road, Menangle
R23	35 Finns Road, Menangle
R24	5 Finns Road, Menangle
R25	454 Menangle Road, Menangle
R26	460 Menangle Road, Menangle
R27	474 Menangle Road, Menangle
R28	514 Menangle Road, Menangle
R29	490 Menangle Road, Menangle
R30	510 Menangle Road, Menangle
R31	520 Menangle Road, Menangle
R32	530 Menangle Road Douglas, Park
R33	516 Menangle Road, Menangle
R34	165 Carrolls Road, Menangle
R35	115 Carrolls Road, Menangle

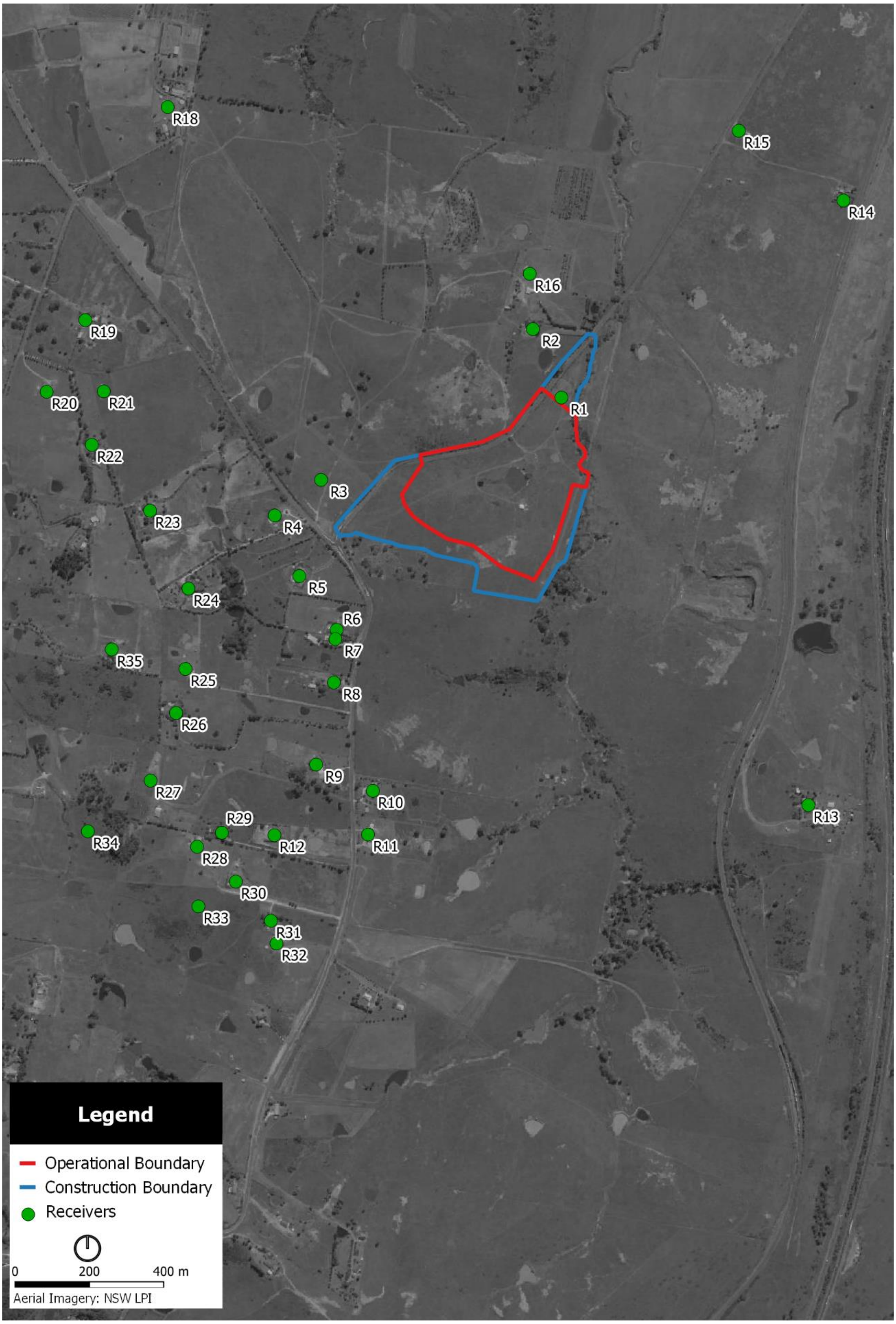


Figure 1: Sensitive Receivers

Existing Noise Levels

Unattended noise monitoring was conducted in October and November 2020 to quantify the existing ambient noise levels at sensitive receivers.

The existing ambient noise levels were presented in the noise assessment for the modification and are presented in Table 2.

Table 2: Rating Background Levels used for the Project

Receiver	Time of Day [a]	RBL (dBA)
All nearby residences	Day	38
	Evening	39
	Night	34

a. Day = 7.00am – 6.00pm; Evening = 6.00pm – 10.00pm; Night = 10.00pm – 7:00am

Maximum noise level event assessment Criteria

Unlike noise from mechanical activities, or general construction works, overpressure from blasting is typically assessed with a linear weighting (dBL). The requirement is commonly linked with the ability of the overpressure pulse to cause building damage, or potentially cause rattling of windows or loose-fitting elements of the dwelling which are subsequently perceived as secondary vibration. The potential for damage from overpressure is extremely unlikely unless the blasting occurs very near the property (i.e. within 50 metres). The potential for secondary vibration is possible, but at the distances the properties are from the shafts, no more so than would occur during moderate winds. In this regard, the approach to assess overpressure in terms of a perceptible response measured in the dBA metric is considered acceptable.

The disruption of a person's normal sleep patterns, or sleep disturbance, due to night time noise, has been the subject of numerous research studies conducted over the last 30 years. Despite intensive research, the triggers for and effects of sleep disturbance have not yet been conclusively determined. Sleep disturbance occurs through changes in sleep state and awakenings. Awakenings are better correlated to subjective assessments of sleep quality than are changes in sleep state.

The EPA recommend a screening maximum noise level assessment to consider sleep disturbance considering the following criteria:

- $L_{Aeq,15min}$ 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.

Where the screening maximum noise trigger levels are complied with, no additional assessment is required. Where exceeded a detailed maximum noise level event assessment should be undertaken.

As this assessment considers blast overpressure and the event would be short in duration, the $L_{eq,15\ minute}$ criterion is not considered any further in this assessment.

The screening maximum noise trigger levels have been developed consistent with NPfI and are presented in Table 3.

Table 3: Maximum Noise Trigger Levels

Receiver	RBL	RBL + 15 dBA	Maximum Noise Trigger Level (L_{Amax})
All nearby residences	34	49	**52**

Impact Assessment (without mitigation)

The predicted L_{Amax} levels from overpressure levels were calculated **without mitigation** for blasting in Ventilation Shaft 7 (VS7) and 8 (VS8) close to the surface and are presented in Table 4. A 3.0 kg MIC blast has been assumed to be required consistent with preliminary blasting designs from Prism Mining Pty Ltd.

Table 4: Predicted Blast Maximum Noise Levels at Sensitive Receivers, MIC = 3.0 kg

Receiver	Predicted Blasting L_{Amax} [1]	
	VS7	VS8
R2	97	93
R3	94	94
R4	91	92
R5	91	93
R6	91	94
R7	91	93
R8	90	92
R9	87	88
R10	87	89
R11	85	87
R12	84	86
R13	84	85
R14	84	83
R15	84	83
R16	93	90

Receiver	Predicted Blasting L_{Amax} [1]	
	VS7	VS8
R17	80	79
R18	81	81
R19	83	83
R20	82	82
R21	84	84
R22	84	84
R23	86	86
R24	87	88
R25	85	87
R26	84	86
R27	83	84
R28	82	84
R29	83	85
R30	82	84
R31	82	83
R32	81	83
R33	81	82
R34	81	82
R35	84	84

Note 1 – Conversion of -26dB was assumed between dBLin and LAmax. (Richards A, 2008, Prediction and Control of Air Overpressure from Blasting In Hong Kong). It should be noted that the conversion of -26dB is most likely attributable to a dominant frequency of around 65Hz. It is possible that the frequency would be lower which would lead to an increased reduction, possibly by -30 to -40dB. The assumptions used in determining the potential impact on residents may therefore be conservative.

As can be seen in Table 4 the maximum noise level from unmitigated blasting close to the surface exceed the screening maximum noise trigger level at all receivers. Therefore, in accordance with the NPfI procedures, a more detailed assessment is required, considering all feasible and reasonable mitigation.

The detailed assessment includes:

- the maximum noise level;
- the extent to which the maximum noise level exceeds the rating background noise level; and
- the number of times this happens during the night-time period.

Some guidance on possible impact is contained in the review of research results in the NSW Road Noise Policy.

The NSW Road Noise Policy states that from the research on sleep disturbance to date it can be concluded that:

- maximum internal noise levels below 50–55 dB(A) are unlikely to awaken people from sleep;
- one or two noise events per night, with maximum internal noise levels of 65–70 dB(A), are not likely to affect health and wellbeing significantly.

It is noted that L_{Amax} noise levels associated with blasts, inside (internal to) the sensitive receivers dwellings, would be somewhat lower than external noise levels during these events due to noise reduction across the façade of the dwelling. The noise reduction across the façade is expected to be in the range of 5-10 dBA. Therefore, since typically only 2 blasts could occur per night, external L_{Amax} noise levels associated with night time blasting below 75 dBA are considered unlikely to cause sleep disturbance impacts.

Mitigation and Management Options

Important parameters that can be adjusted to control L_{Amax} noise levels from surface blasting include:

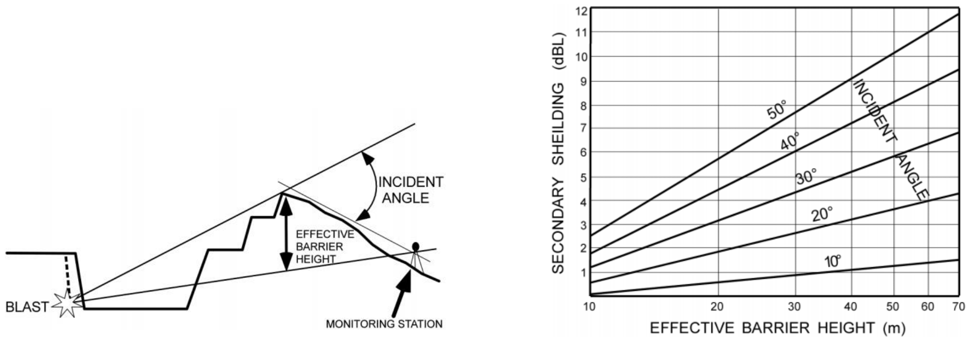
- Charge mass and distance from blast.
- Face height and orientation.
- Stemming height and type.
- Blast hole diameter to burden ratio.
- Burden, spacing, and sequential initiation timing.
- Topographic shielding.

Due to the vertical orientation of the ventilation shafts, which isn't accounted for in the predictions, overpressure levels at sensitive receivers are anticipated to be significantly lower due to a number of factors as discussed below .

The dispersion of the overpressure pulse from a vertical shaft, unlike surface blasting where it occurs in a hemispherical arrangement from the point of blasting, relies on the overpressure propagating to the shaft collar at which point it is preferentially dispersed upwards. The amplitude at the point at the shaft collar determines the overpressure levels that are measured at different areas around the shaft. Mitigation measures such as water sprays and mats are reasonable controls. Other factors such as the smoothness of the shaft wall will also influence the overpressure level measured at the collar. The subsequent overpressure level at the sensitive receivers would be dependent upon the topography and the resulting weather conditions, including wind and wind direction, as well as inversion and cloud cover layers. Blasting will not be conducted in meteorological conditions that would likely enhance overpressure levels.

A significant positive aspect is that the shafts are vertical and the overpressure pulse from the blasting will be preferentially directed upwards. If the blasting had occurred in a decline, measurements taken at other sites show properties that are located in front of the portal can experience elevated levels of overpressure even when blasting is more than 500 metres from their property. Providing there are no unfavourable weather conditions, the level of overpressure from the shaft blasting at this same distance will be less.

The relationship between shielding, the effective barrier height and the incident angle, has been investigated (Richards A, 2008, Prediction and Control of Air Overpressure from Blasting in Hong Kong). These terms are illustrated in Figure 2a. Analysis of measurements taken for various shielding situations when blasting indifferent rock types has permitted a relationship to be developed. The relationship between secondary shielding measured in decibels-linear (dBL), barrier height, and incident angle is shown in Figure 2b.



(a) **(b)**

Figure 2: Shielding Effects

For the proposed project, where construction blasting is not expected to occur until a shaft excavation depth of approximately 20-30m, the incident angle will be in the vicinity of 30-40 degrees with an effective barrier height close to 20-30m. This would correspond to a shielding loss of between 3-6dB.

The barrier height would continue to increase with depth. Its anticipated that construction blasting would begin to occur OOH after the shaft has reached at least 30-50m depth. This would correspond to a shielding loss of between **5-8dB**.

The maximum shielding loss would likely plateau at around 12dB.

There are a range of mitigation measures available to reduce blast overpressure, including:

- Blast design, considering options such as limiting diameter and length of rounds, splitting the round into two benches and/or adjusting blast hole firing sequence, can provide up to **5dB** reduction in overpressure levels (Richards A, 2008, Prediction and Control of Air Overpressure from Blasting in Hong Kong).

- The use of "blast mats" and "water curtains" which typically provide **5-10dB** reduction in overpressure levels.
- As noted in the NVIA, OOH shaft sinking would not occur unless the relevant construction NMLs are met. To meet these NMLs, acoustic sheds or other noise mitigations (to be determined during detailed design) will be installed for much of the shaft construction and are likely to reduce overpressure levels by **10dB** or more. A conservative 10dB has been assumed for blasting overpressure as it is typically low frequency in nature.

The final selection of mitigation measures would be conducted following trial blasts, the development of a site law and detailed blast design(s). A 'trial blast' involves firing a number of small explosive charges in the ground to be blasted and monitoring the resultant vibrations at key monitoring locations around the site. The purpose of a trial blast is to:

- Confirm the site law (the site-specific relationship between explosive charge weight, distance to sensitive receivers and magnitude of vibration);
- Confirm blast design parameters on a smaller scale prior to full scale construction blasting;
- Confirm monitoring results are in-line with predictions;
- Confirm the effectiveness of any mitigation strategies (e.g. blast mats, acoustic sheds); and
- Optimise the site blasting procedures.

A number of blasts would be monitored at varying locations, during standard working hours and therefore evening or night-time blasting would only occur after a sound understanding of the possible outcomes are known.

Impact Assessment (with mitigation)

Considering the noise mitigation strategies discussed above (blast design, barrier effects, use of blast mats/ water curtains and acoustic sheds/surface mitigations) noise reductions of up to 37dB would appear to be possible when compared to an unmitigated scenario. Assuming a conservative reduction of 25 dB for a depth of 30m, the L_{Amax} noise levels achieved at the closest receivers are presented with a comparison to the nominated criterion in Table 5.

Table 5: Predicted Blast Maximum Noise Levels (L_{Amax}) at Sensitive Receivers Assuming a MIC of 3.0 kg (depth of approximately 30 metres).

Receiver	Predicted Blasting L_{AMax}		Criterion L_{AMax}	Complies (Yes/No)
	VS7	VS8		
R2	72	68	75	Yes
R3	69	69	75	Yes
R4	66	67	75	Yes

Receiver	Predicted Blasting L_{AMax}		Criterion L_{AMax}	Complies (Yes/No)
	VS7	VS8		
R5	66	68	75	Yes
R6	66	69	75	Yes
R7	66	68	75	Yes
R8	65	67	75	Yes
R9	62	63	75	Yes
R10	62	64	75	Yes
R11	60	62	75	Yes
R12	59	61	75	Yes
R13	59	60	75	Yes
R14	59	58	75	Yes
R15	59	58	75	Yes
R16	68	65	75	Yes
R17	55	54	75	Yes
R18	56	56	75	Yes
R19	58	58	75	Yes
R20	57	57	75	Yes
R21	59	59	75	Yes
R22	59	59	75	Yes
R23	61	61	75	Yes
R24	62	63	75	Yes
R25	60	62	75	Yes
R26	59	61	75	Yes
R27	58	59	75	Yes
R28	57	59	75	Yes
R29	58	60	75	Yes
R30	57	59	75	Yes
R31	57	58	75	Yes
R32	56	58	75	Yes
R33	56	57	75	Yes

Receiver	Predicted Blasting L_{AMax}		Criterion L_{AMax}	Complies (Yes/No)
	VS7	VS8		
R34	56	57	75	Yes
R35	59	59	75	Yes

As can be seen from Table 5, the predicted L_{Amax} noise levels from blasting are able to achieve the 75dBA L_{Amax} criterion for 1 to 2 night time events. It should be noted that these calculations are based on a conservative 25dB mitigation loss and that it is likely that another 12 dB could be achieved.

There are procedures that specifically consider the relation between the indoor maximum levels L_{Amax} and the number of tolerable noise events. Bullen developed a methodology for the direct assessment of the impact of environmental noise on sleep (Bullen, et al, 1996, "Sleep Disturbance due to Environmental Noise: A Proposed Assessment Index", Acoustics Australia).

The procedure calculates a Sleep Disturbance Impact (SDI). The SDI is numerically equal to the estimated average number of awakenings per night which would be caused by the noise in question. Typically, research indicates values of SDI less than 0.2 represents a relatively insignificant level of sleep disturbance. SDI's greater than 5 represent a very high level of sleep disturbance. The SDI is calculated as presented below:

$SDI = N \cdot W(L_{Amax}) / 100$

Where N = events per night;

L_{Amax} = maximum internal noise level, dBA

$W(L) = 0.142(L-45)+0.00473(L-45)^2$ if $L>45$ or $W(L)=0$ if $L<=45$

Table 6 presents SDI levels for two blasts per night, one blast from VS7 and one from VS8 using the L_{Amax} levels presented in Table 5.

Table 6: Predicted Blast SDI at Sensitive Receivers Assuming a MIC of 3.0 kg (depth of approximately 30 metres).

Receiver	Partial SDI from VS7	Partial SDI from VS8	Total SDI
R2	0.05	0.04	0.10
R3	0.04	0.04	0.09
R4	0.03	0.04	0.07
R5	0.03	0.04	0.08
R6	0.03	0.04	0.08
R7	0.03	0.04	0.08
R8	0.03	0.04	0.07
R9	0.02	0.03	0.05
R10	0.02	0.03	0.05
R11	0.02	0.02	0.04
R12	0.02	0.02	0.04
R13	0.02	0.02	0.04
R14	0.02	0.01	0.03
R15	0.02	0.01	0.03
R16	0.04	0.03	0.07
R17	0.01	0.01	0.01
R18	0.01	0.01	0.02
R19	0.01	0.01	0.03
R20	0.01	0.01	0.02
R21	0.02	0.02	0.03
R22	0.02	0.02	0.03
R23	0.02	0.02	0.04
R24	0.02	0.03	0.05
R25	0.02	0.02	0.04
R26	0.02	0.02	0.04
R27	0.01	0.02	0.03

Receiver	Partial SDI from VS7	Partial SDI from VS8	Total SDI
R28	0.01	0.02	0.03
R29	0.01	0.02	0.03
R30	0.01	0.02	0.03
R31	0.01	0.01	0.03
R32	0.01	0.01	0.02
R33	0.01	0.01	0.02
R34	0.01	0.01	0.02
R35	0.02	0.02	0.03

As can be seen from Table 6, the predicted Total SDI levels from the two blasts at night are below 0.1 indicating an insignificant level of sleep disturbance.

Other sleep research includes (Spreng 2002 "Corticol excitation, cortisol excretion, and estimation of tolerable nightly overflights" Noise and health. (4) 39-46.). Spreng (2002) developed a model that allowed the calculation of noise and number combinations that cause the same predefined risk with respect to intermittent noise. The focus of the model was more to identify the lowest observable threshold (L_{Amax}) at which to avoid sleep effects (referred to as tolerable nocturnal noise events). The model proposed by Spreng is presented in Figure 3.

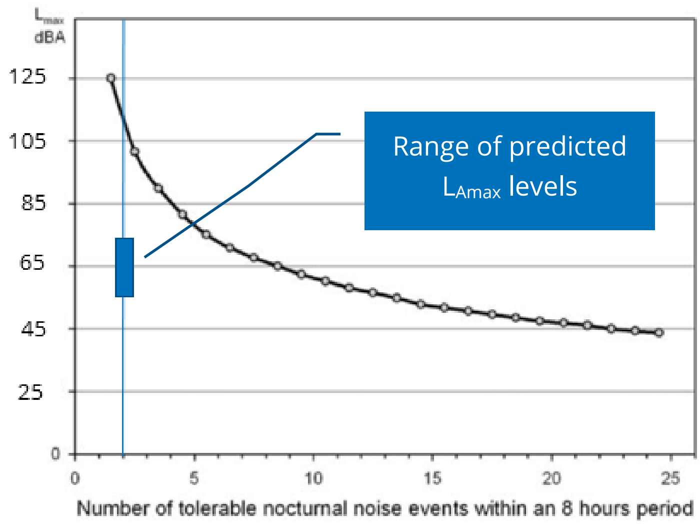


Figure 3: The relation between the outdoor maximum levels L_{Amax} and the number of tolerable noise events within an 8-hour period during the

night. (Spreng 2002) modified by RWDI to reflect outdoor levels (5dB difference between inside and outside)

The range of predicted noise levels calculated for the two blasts for a MIC of 3.0 kg and at a depth of approximately 30 metres has been plotted on the Spreng curve in Figure 3. It can be concluded that the predicted L_{Amax} levels from the two blasts are substantially below the curve indicating that 2 blast events are unlikely to cause substantial sleep awaking reactions.

From the more detailed review of sleep disturbance it is demonstrated that the two blasts in the predicted L_{Amax} range is unlikely to result in significant sleep disturbance in the neighbouring community. It is however, acknowledged that this approach will need to be carefully managed. Therefore, it is proposed that a Blast Management Strategy will be prepared in consultation with relevant stakeholders and reviewed by a suitably qualified and experienced person before blasting begins.

Blast Management Strategy

In consideration of the construction program, blasting cycle and the need to minimise impacts, a two phased management approach to undertaking blasts is proposed, as outlined below. In both phases, typically up to one construction blast per shaft, per day is anticipated.

Construction Blasting Phase One

During Phase One of the blasting program, construction blasting would be restricted to standard construction hours only. This phase would generally align to the pre-sink phase of shaft sinking when the acoustic shed(s) and/or other noise mitigations are under construction. During this phase, a monitoring program would closely monitor for impacts generated by the construction blasts and seek feedback from potentially affected receivers.

The data and feedback collected during Phase One would be used review and revise the Blast Management Strategy, prior to commencement of Phase Two.

Construction Blasting Phase Two

During Phase Two of the blasting program, construction blasting would occur 24 hours a day, 7 days a week. This phase would generally align with the main-sink phase of shaft sinking, when the acoustic shed(s) and/or other noise mitigations are in place and the working area of the shaft has reached a depth of approximately 20-50 metres.

Due to the length of the shaft sinking cycle, during Phase Two, the construction blasts will not occur every night and will not be the same time each day. Where possible construction blasts would be carried out during periods anticipated to have the least impact on receivers.

Construction blasting in both phases will be undertaken as per the Project Blast Management Strategy to be developed during detailed project design. A detailed blast design will also be completed during the detailed project design.

The Blast Management strategy will include:

- details of blasting to be performed, the program and method;
- identification of all potentially affected receivers;
- establishment of appropriate criteria for blast overpressure and ground vibration levels at each receiver;
- management of misfires, where additional detonations may be required to complete the construction blast;
- establishment of appropriate criteria to transition from Phase One to Phase Two construction blasting (see below);
- details of the storage and handling arrangements for explosive materials and the proposed transport of those materials to the construction site;
- identification of hazardous situations that may arise from the storage and handling of explosives,
- the blasting process and recovery of the blast site after detonation of the explosives;
- determination of potential noise and vibration and risk impacts from blasting and appropriate best management practices;
- details of the proposed blasting monitoring program; and
- consultation, impact mitigation and notification procedures for all potentially affected receivers.

The Blast Management Strategy would be developed in consultation with relevant stakeholders and reviewed by a suitably qualified and experienced person. Consultation with receivers identified as potentially affected would occur throughout all phases of the blasting program.

Blast monitoring would be carried out in accordance with the guidelines provided in Australian Standard AS 2187.2-2006 and be undertaken by a specialist consultant. It is proposed to implement an automated monitoring system, at the site, whereby monitor data is automatically uploaded to a central server.

The proposed approach to blast management has been developed considering the expert advice provided by Heilig and Partners Pty Ltd, and a preliminary blasting impact assessment for the Project, prepared by Prism Mining Pty Ltd. Predictions from the preliminary impact assessment identified that assessment criteria for sensitive receivers were able to be achieved. The assessment recommended further refinement and development of the site law during the detailed design, as is standard industry practice.

Conclusion

It is considered feasible to conduct night construction blasting as part of this project. Community consultation and careful blast management will need to be undertaken to manage the possible night-time noise impacts. It should be noted that night-time blasting is not proposed during the initial stages of the shaft development, but rather the option would only be explored after measurement data has been collected to confirm that it will not impact upon the amenity of adjacent sensitive receivers.

An acceptable interim outcome may be that blasting outside of normal hours only proceed after the initial trial blast and subsequent monitoring has been completed and the results reviewed by the relevant regulatory authority, as proposed as part of the Blast Management Strategy.

This letter has been peer reviewed by John Heilig (Heilig and Partners), an expert in blasting (http://www.heiligandpartners.com.au/).

I trust this information is sufficient. Please contact us if you have any further queries.

Yours faithfully,

RWDI

John Wassermann
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Attachment D – Groundwater analysis (HGEO September 2021)

South32 Illawarra Metallurgical Coal

Appin Mine Ventilation and Access Project

Groundwater assessment

HGEO Pty Ltd

Date: October 2021

Project number: J21520

Report: D21147

DOCUMENT REGISTER

Revision	Description	Date	Comments
A	1st Draft	19/9/2021	MS Word for review
B	Final	1/10/2021	pdf

FILE

Https://hgeocomau.sharepoint.com/sites/HGEO/Shared Documents/Shared/Client_Site/Appin/Projects/J21526_Appin_BSO_M3_Shafts/D21147_Appin_VS7_VS8_GroundwaterAssessment_V8.docx

QUALITY CONTROL

Process	Staff	Signature	Date
Authors	Stuart Brown, Louisa Rochford		
Approved	Stuart Brown		1/10/2021

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ABBREVIATIONS

Abbreviation/Term	Meaning
DPIE	Department of Planning, Infrastructure and Environment
GWMP	Groundwater monitoring plan
IMC	South32 Illawarra Metallurgical Coal
ML	Megalitres
OM	Order of magnitude (i.e. factor of 10)
VS7	Ventilation shaft 7
VS8	Ventilation shaft 8
VWP	Vibrating wire piezometer

EXECUTIVE SUMMARY

Project description

South32 Illawarra Metallurgical Coal (IMC) hold approval for underground longwall mining operations at Appin Mine in the Southern Coalfield of NSW approximately 35 km north-west of Wollongong. IMC is seeking to modify the existing approval to include the construction and operation of two additional ventilation shafts and associated surface infrastructure.

Shaft excavations will be undertaken from surface to seam using a conventional shaft sinking method, which employs a combination of mechanical excavation and controlled blasting. The method has a number of benefits for managing groundwater inflows as it allows for targeted grouting of fracture zones and progressive installation of the shaft lining to minimise inflows.

A Modification Report was submitted to the Department of Planning, Infrastructure and Environment (DPIE) for assessment in July 2021. DPIE has requested more detailed information on the potential impacts of the Project on local groundwater resources, in particular quantification of groundwater take during shaft sinking operations, predicted impact of groundwater take on local groundwater resources, including bores and farm dams and proposed groundwater mitigation, management and monitoring measures.

Hydrogeological setting

The hydrogeological setting of the Project area is as follows:

- Perched groundwater systems associated with the upper Wianamatta Group. These perched water tables are hydraulically disconnected from the deeper groundwater systems.
- Shallow groundwater systems comprising layered water-bearing zones within the saturated Hawkesbury Sandstone. The highest yielding groundwater bores are typically associated with coarse sandstone units and/or fractured sandstone
- Deeper groundwater systems within the Narrabeen Group and the Illawarra Coal Measures. These units typically are of much lower permeability than the Hawkesbury Sandstone and produce low bore yields and poorer water quality. Groundwater pressures in these units are affected by underground mining at Appin Mine and coal seam depressurisation resulting from the Camden Gas Project.

Most private water supply bores in the Project area extract groundwater from the Hawkesbury Sandstone or Bulgo Sandstone for stock and domestic purposes. Farm dams in the Project area are shallow, perched within upper weathered horizons of the Ashfield Shale and disconnected from the underlying aquifers of the Hawkesbury Sandstone. There are no upland swamps in the Project area.

Impact assessment

Numerical groundwater modelling was undertaken to simulate hydrogeological conditions in the Project area and predict impacts to groundwater resources and sensitive receptors during excavation and ongoing use of the ventilation shafts.

The modelled scenario incorporates the proposed mitigation measures for controlling groundwater inflow during excavation and ongoing operation of the shafts as implementation of the mitigation measures is an integral component of the shaft sinking operations.

Estimated total groundwater inflow to the two shafts is 30.4 ML in 2023 and 59.8 ML in 2024. To ensure shaft sinking efficiency, groundwater inflows will be minimised by targeted grouting of fractured zones and advance pre-grouting of fractured strata. With increased controls, actual inflows may be lower than those predicted. Shaft inflow will decline significantly following construction because the shafts are fully lined and geological units will be depressurised due to mining. Observed seepage at operational shafts at Appin Mine indicate that the combined long-term water take for VS7 and VS8 will be no greater than 0.14 ML/year. Accounting for the predicted cumulative take of groundwater for approved and proposed mining at Appin Mine the share allocation of licences held by IMC (877 ML) is sufficient to account for any incidental groundwater take at the Site during construction and use of the shafts.

Predicted drawdown due to the Project is negligible at most registered bores within the modelled area. Minor drawdown is predicted at stock and domestic bore GW105574 (0.85 m), domestic bore GW106574 (0.80 m) and test bore GW108990 (1.47 m). Negligible impacts to farm dams are predicted as farm dams in the Project area are shallow and effectively perched within the upper weathered horizons of the Wianamatta Group. Drawdown is not predicted at the Nepean River during construction or operation of the shafts, and therefore there will be no additional induced take of water from the Nepean River as a result of the Project.

Mitigation and management

From an operational perspective, groundwater inflows across the full depth of the shaft should be kept below 3 L/s during the shaft sinking. Groundwater inflows will be controlled by targeted grouting of fractured zones and advance pre-grouting of fractured strata prior to excavation.

A non-hydrostatic concrete lining will be installed closely behind the working area during excavation of the shaft such that a maximum of 15 m of unlined wall is exposed at any time through the depth of the shaft. The numerical groundwater modelling included the proposed construction schedule and mitigation measures for controlling groundwater inflow during excavation.

Monitoring

IMC currently conducts groundwater monitoring in Area 7 at Appin Mine in accordance with the Area 7 Water Management Plan (WMP), which was developed in accordance with the BSO Approval Condition 5 (h), Schedule 3. The Area 7 WMP details the requirements for surface water and groundwater monitoring and assessment of data against performance criteria in the Trigger Action Response Plan (TARP). This includes monitoring of landholder groundwater bores in the vicinity of the Project.

Management and monitoring of groundwater during the construction phase would be included in the relevant construction environmental management plan prepared for the Project. The Appin Mine Water Management Plan describes the requirements for ongoing groundwater management at Appin Mine, and would be updated as required to incorporate the Project.

Groundwater monitoring should include the multi-piezometer array installed at bore S2524, located between VS7 and VS8 (Figure 3). Monitoring results should be compared against expected depressurisation from numerical modelling.

1. Introduction

South32 Illawarra Metallurgical Coal (IMC) currently operate Appin Mine in the Southern Coalfield of New South Wales (NSW) approximately 35 kilometres (km) north-west of Wollongong (Figure 1). IMC hold approval for underground longwall mining operations to extract primarily hard coking (metallurgical) coal from the Bulli Seam. Longwall mining is currently being undertaken in Area 7 and Area 9 (Figure 1).

IMC is seeking to modify the existing project approval to include the construction and operation of two additional ventilation shafts and associated surface infrastructure, referred to as the Appin Mine Ventilation and Access Project (the Project). The additional ventilation shafts, Ventilation Shaft 7 (VS7) and Ventilation Shaft 8 (VS8), are critical to maintain a safe and efficient working environment within the underground mine.

A Modification Report, which considers the environmental and community impacts associated with development of the shafts and associated surface infrastructure, was submitted to the Department of Planning, Infrastructure and Environment (DPIE) for assessment in June 2021. Following submissions, DPIE has requested more detailed information on the potential impacts of the Project on local groundwater resources, in particular:

- Quantification of groundwater 'take' or diversion during shaft sinking operations
- Predicted impact of groundwater 'take' on local groundwater resources, including bores and farm dams
- Proposed groundwater mitigation, management and monitoring measures, including the shaft lining and grouting system proposed to minimise ingress of groundwater
- Capacity of the existing groundwater access licences to account for predicted groundwater take.

This report has been prepared by HGEO Pty Ltd to present the findings of the groundwater assessment undertaken in response to DPIE's request. The report provides details of the numerical groundwater flow modelling undertaken for the Project area, the assessment of potential impacts of the shaft sinking operations on groundwater resources and sensitive receptors, and the proposed mitigation, management and monitoring measures that will be implemented.

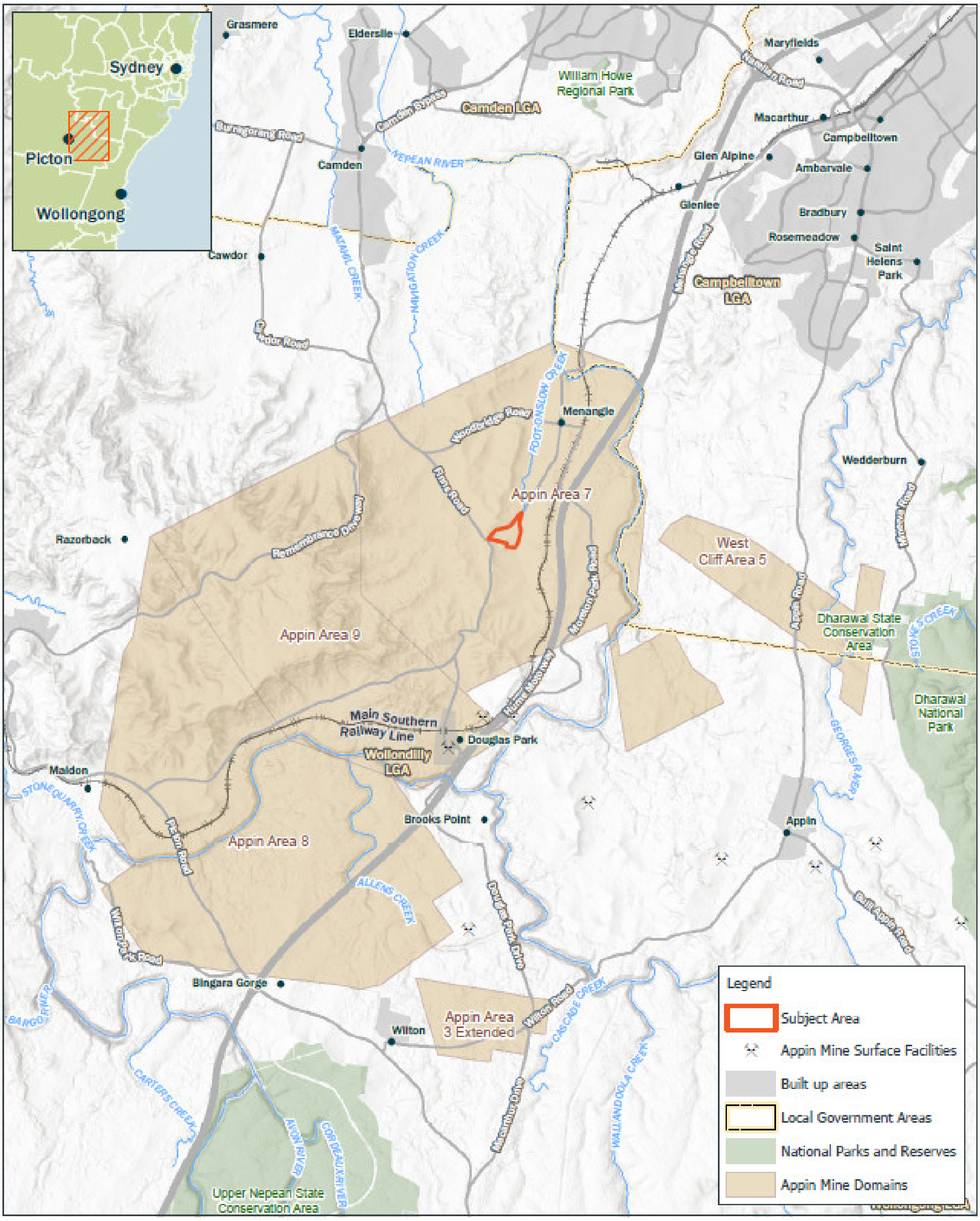


Figure 1 Site location

1.1 Project description

Ventilation infrastructure and mine access facilities are an integral requirement of underground mining to ensure a safe and efficient underground working environment. The Project involves the construction of a downcast ventilation shaft (VS7), an upcast ventilation shaft (VS8) and the installation of associated extraction fans and ancillary surface infrastructure to ensure a reliable and adequate supply of air to personnel working underground in Appin Mine. The Project also involves the development of mine access infrastructure (head frame and winder) within VS7 and the construction of mine access associated facilities at the Site. The Project will have the potential to impact on groundwater resources during construction of the ventilation shafts, which will be constructed from the surface to below the Bulli Seam.

Ventilation Shaft 7 is proposed to be constructed to an approximate depth of 591 m with an approximate diameter of ~8.1 m (finished and lined internal diameter of ~7.5 m). Ventilation Shaft 8 is proposed to be constructed to an approximate depth of 560 m with an approximate diameter of ~6.1 m (finished and lined internal diameter of ~5.5 m). Various methods of shaft sinking were considered for the Project. The conventional shaft sinking method, which employs a combination of mechanical excavation and controlled blasting, was selected as the most suitable method based on geotechnical conditions and community impacts (as discussed in the Modification Report). The method has a number of benefits for managing groundwater inflows as it allows for targeted grouting of fracture zones and progressive installation of the shaft lining to reduce inflows.

The shaft sinking process will take approximately 17 months and is scheduled to commence in February 2023. Initially the pre-sink stage will involve the construction of a temporary headframe and winder, establishment of a shaft collar and intake evase, and excavation of the shaft to the required depth for installation of the sinking stage in preparation for the main shaft construction. The pre-sink will involve both mechanical excavation and controlled blasting to excavate through the weathered overburden until hard rock is reached at approximately 30 to 50 m. Broken rock will be removed from the shaft via standard civil excavation methods. The shaft collar will be installed and will be constructed of heavily reinforced concrete and designed to prevent ingress of surface water and shallow interflow into the shaft. Prior to the commencement of works for the main shaft, the shaft sinking headframe, winder, kibble and stage will be installed.

The main shaft excavations will be undertaken using small, controlled blasts to break rock incrementally from the pre-sink depth to the final depth. The established headframe, winding equipment, kibble and stage will provide access to the shaft for personnel, equipment and removal of broken rock. Buckets will be lowered into the shaft and loaded with waste rock, then hoisted to the surface and emptied. The buckets will also be used to remove water that has seeped from the surrounding geology into the working area. The rate of excavation is expected to range from approximately 1 to 3 m/day depending on rock strata properties and stability.

From an operational perspective, groundwater inflows will ideally be kept below 3 L/s during the shaft sinking. The shaft sinking contractors will be limited in their capacity for pumping water and higher inflow rates will cause nuisance within the working area and slow the rate of waste rock removal and shaft progression. If areas of significant groundwater inflow such as fracture zones are encountered, the shaft sinking contractors will conduct in-shaft grouting to keep total inflows within the capacity of the pumping system. This will involve drilling holes into the walls of the shaft at the permeable zone and injecting fine grout under pressure to fill the fracture system and create a grout curtain. Using this approach, inflows to the shaft can quickly be managed so that construction of the shaft can progress.

In addition to targeted grouting of zones of higher inflows, the shafts will be lined with an in-situ lining system, nominally of 300 mm thick reinforced concrete. The lining will be poured progressively during excavation of the shafts. In the upper shaft the lining will be advanced relatively close to the sinking face such that only about 9 m of unlined wall might be exposed, with a maximum of 15 m of unlined wall exposed at any time through the depth of the shaft. The non-hydrostatic concrete lining proposed will significantly reduce inflows to the shaft by blocking seepage paths, with minor seepage occurring at the construction joints between the lining pours. In general, when grouting with cement, a reduction of the conductivity by approximately a factor 10 is expected.

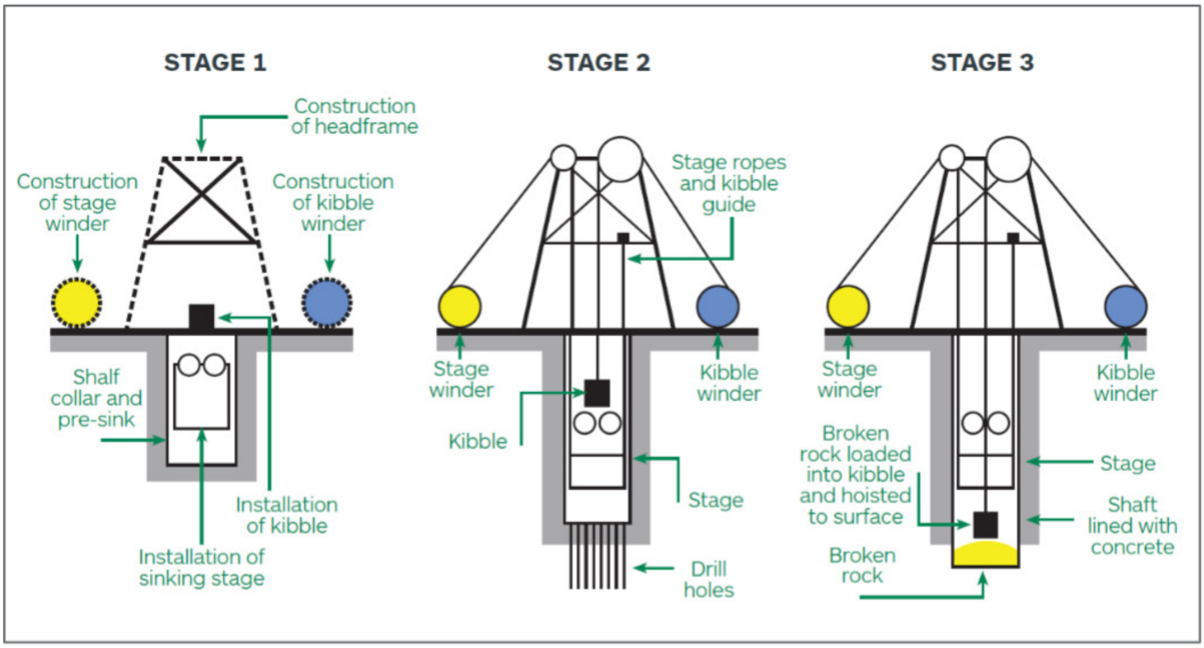


Figure 2 Staged schematic of conventional shaft sinking method using controlled blasting

1.2 Expected inflows

Pitt&Sherry (2021b) estimated that total groundwater inflows to the VS7 and VS8 were likely to be in the order of 1.6 L/sec and 2.5 L/sec respectively, with higher inflows possible if excavations encounter significant fracture networks. These estimates are supported by observations during sinking of No. 1 shaft at Tahmoor Colliery, peak inflows of 21 L/s were experienced from a zone at 37 m depth which required in-shaft grouting. The inflow was from a distinct underground void in the sandstone and was not representative of the general rock mass. Residual inflows after grouting gradually increased as the shaft sinking progressed from 0.8 L/s to 3.8 L/s. After 112 m depth no further water was encountered.

A high permeability zone was encountered in VS1 at Dendrobium Mine at 48 m depth, which required in-shaft grouting to be performed to allow a fibrecrete lining to be applied. In the same geological sequence, Golder estimated there could be inflows of up to 4 L/sec into VS2 and VS3 for Dendrobium Mine, although these estimates were based on a SEEPW model and influenced by potential recharge from the nearby reservoir. As these shafts were blind bored, there was no record of inflows as the groundwater pressure was likely balanced by the drilling fluids.

1.3 Site location

The proposed ventilation shafts and associated surface infrastructure are located on rural land at 345 Menangle Road, Menangle, NSW (the Site) within Area 7 of Appin Mine. The western extent of the Site is bounded by Menangle Road and the eastern side by Foot Onslow Creek. The layout of the Site is shown in Figure 1.

2. Hydrogeological setting and conceptual model

The hydrogeological setting of Appin Mine and the Project area is detailed in SLR (2021), the Modification Report for the Project and the geotechnical reports for VS7 (Pitt and Sherry, 2021) and VS8 (Calibre, 2021) and is summarised below.

2.1 Topography

The Site is on the southern margins of the Cumberland Plain, which is characterised by low lying, gently undulating plains and hills. The Site is also on the peripheries of the Woronora Plateau, as defined by the gorges and sandstone plateaus found to the east and the incised Nepean Gorge.

The Site is situated on undulating land with the hill slope falling from the west at Menangle Road to the east with the lowest point at Foot Onslow Creek. The general Site arrangement has been designed such that the majority of the operational footprint will be located on relatively flat ground between the break of slope and Foot Onslow Creek.

2.2 Climate

The Camden Airport Automatic Weather Station is the nearest weather station to the Site with publicly available long term climate statistics. It is approximately 13 km north-west of the Site.

The area experiences moderate rainfall, with an average annual rainfall of approximately 789.8 mm. Rainfall is generally evenly distributed throughout the year, with the highest mean rainfall in autumn and summer and the lowest in late winter/early spring.

Temperatures range throughout the year from a mean maximum of 29.8°C in January to a mean minimum of 3°C in July. Long-term average potential evaporation at Appin is approximately 1576 mm/year and actual evapotranspiration is approximately 922 mm/year.

2.3 Drainage

The Site is located within the Hawkesbury-Nepean catchment. The primary water body near the Site is Foot Onslow Creek, which reports to the Nepean River approximately 3 km to the north of the Site. The Nepean River generally flows in a northerly direction and has perennial flows influenced by dam releases and baseflow contributions from the incised Hawkesbury Sandstone.

Foot Onslow Creek is a degraded, ephemeral rural waterway and meanders in and out of the eastern boundary, flowing in a northerly direction (Figure 1). It is a 3rd order (Strahler) stream. Foot Onslow Creek contained stagnant pools of water during ecology surveys in August 2020 and January 2021 and was not flowing.

There are two unnamed ephemeral drainage lines on the Site which flow into Foot Onslow Creek. One follows the contour of the Site from the south-western corner through a series of dams before meeting Foot Onslow Creek, while the other flows under Menangle Road in the west and flows into Foot Onslow Creek in the north of the Site. Both drainage lines are 1st order (Strahler) streams. Neither contained any water when ecologists inspected the site.

The Site is not located within WaterNSW 'Special Areas' drinking water catchments. Foot Onslow Creek and the Nepean River do not supply drinking water to the local or broader community within the Sydney Basin.

2.4 Geology

Appin Mine is located within the Southern Coalfield of the Sydney Basin (Figure 3). Site geology was characterised during an investigation program involving the drilling of investigation boreholes for each of the planned shafts. S2524 is the investigation borehole for VS8 and S2525 is the investigation borehole for VS7. S2524 is located 15 m to the north of the planned position for downcast ventilation shaft 8 and was drilled to a total depth of 617.17 m. S2525 is located 15 m to the south of the planned shaft position for VS7 and was drilled to a total depth of 613.31 m.

The Triassic Wianamatta Group is present at surface at the proposed shaft locations and is approximately 34 m thick. The Hawkesbury Sandstone (HBSS) underlies the Wianamatta Group and comprises bedded sandstone units approximately 155 m thick. The HBSS is underlain by the Triassic sandstones, siltstones and claystones of the Narrabeen Group. This includes the Bulgo Sandstone, Scarborough Sandstone and Coal Cliff Sandstone, as well as the Bald Hill Claystone, Stanwell Park Claystone and Wombarra Claystone. The Permian aged Illawarra Coal Measures underlie the Narrabeen Group. The Illawarra Coal Measures consist of interbedded sandstone, shale and coal seams, with a thickness of approximately 200 m to 300 m. The Bulli Seam is the primary economic sequence of interest at Appin Mine. At the location of the shafts the Bulli Seam is around 3.2 m thick and approximately 558 m below surface. The stratigraphic sequence at the Site is shown in Figure 3.

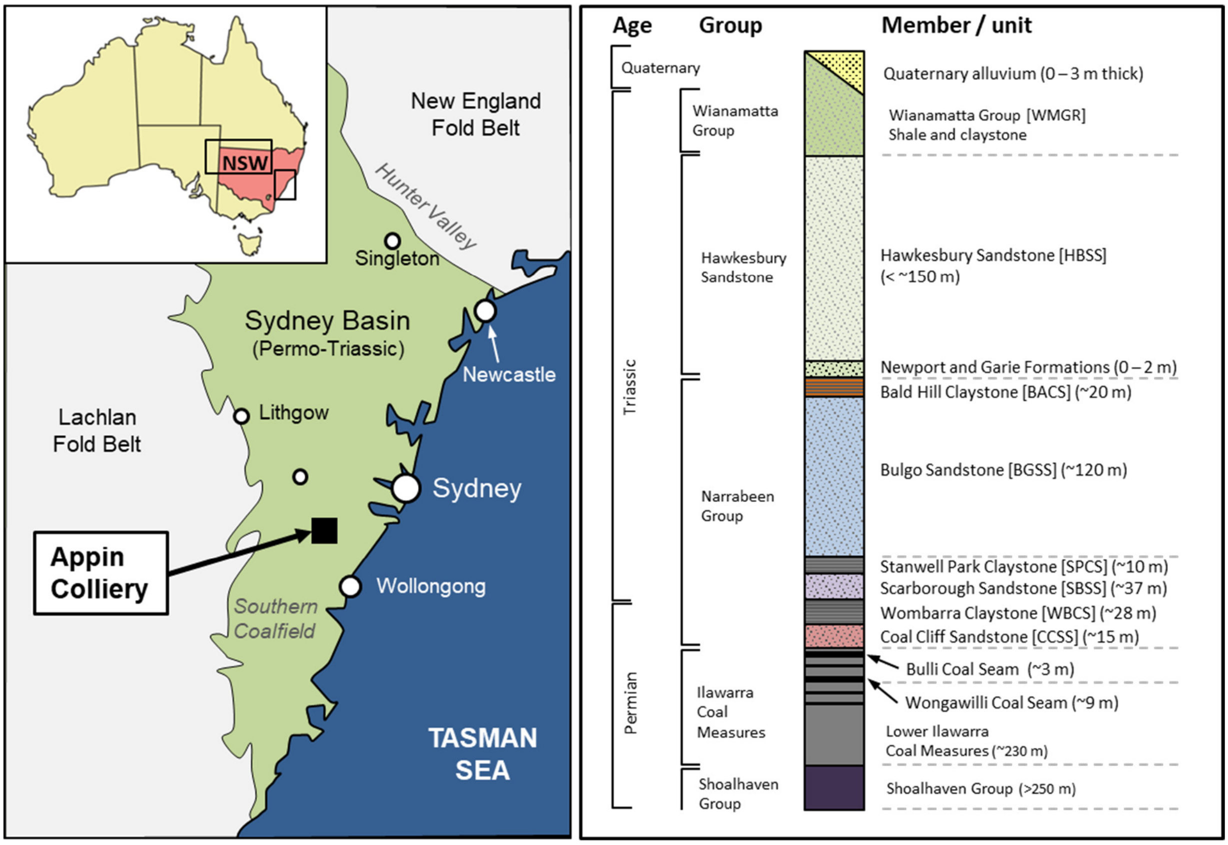


Figure 3 Stratigraphy

Structural geology

The Permian coal measures dip approximately 2 % in a north-westerly direction, towards the Douglas Park syncline. The major geological structures (faults) in the region include the Nepean Fault Zone, O'Hares Fault and J-Line Fault. Within Area 7 there is a series of NNW-SSE orientated dykes and minor faults with displacement of less than 3 m.

The Wandinong Fault is the major structure in the vicinity of the proposed shafts which was first identified in 2003 from an AGL borehole. Subsequent geophysics and in seam drilling investigations by IMC have proven this fault to have a maximum displacement of 30 m and to consist of a steeply dipping fault zone rather than a single plane. The current interpretation of the Wandinong Fault places it approximately 70 m away from the proposed VS8 location and approximately 140 m away from the proposed VS7 location at the surface and it is not expected to intersect the proposed shafts at any point. No evidence of the Wandinong Fault was seen in the S2524 and S2525 core.

2.5 Hydrogeology

Appin Mine has an extensive groundwater monitoring network that monitors shallow groundwater levels and deep groundwater pressures using vibrating wire piezometers (VWPs), shallow screened bores and open standpipes. The groundwater monitoring program includes daily readings of pressure head at the VWPs, manual measurement of water levels at the monitoring bores, and groundwater quality sampling and analysis. The locations of groundwater monitoring installations in the vicinity of the Site are shown in Figure 4.

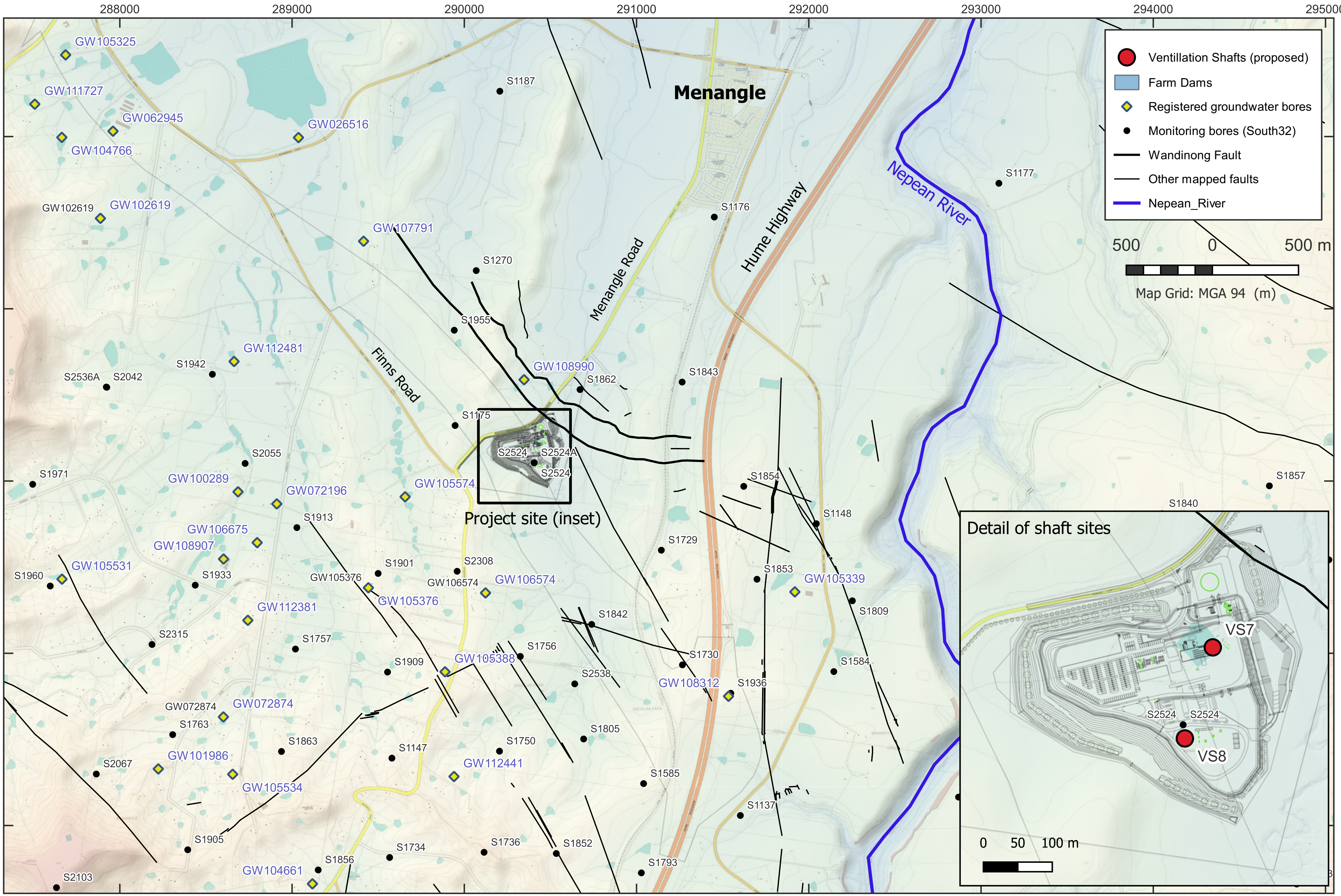
The nearest groundwater monitoring location to the proposed ventilation shafts is S2524. Nine VWP sensors were installed in this borehole and monitoring has been ongoing since March 2021. Four sensors are in the Hawkesbury Sandstone, one sensor is in the Bald Hill Claystone and four sensors are in the Bulgo Sandstone. The construction details of S2524 are provided in Appendix A.

Hydrogeological units

Quaternary alluvium has been mapped within the Project area but was not identified during investigation drilling for the ventilation shafts at S2524 and S2525. Mapping indicates alluvium is localised along Foot Onslow Creek and the Nepean River over 3 km north of the Project. Groundwater in the alluvium is likely unconfined and recharged from rainfall and surface water with discharge to surface water (baseflow contributions) possible where gradients allow. Groundwater flow is expected to follow topography and streamflow in a general northerly direction.

The Wianamatta Group outcrops across the Project area. Groundwater in the Wianamatta Group is associated with perched water table zones with limited vertical flow. Groundwater monitoring at VWP S1954 indicates a perched water table separated by a difference of 100 m groundwater head from the regional water table present in the Hawkesbury Sandstone. Groundwater in the Wianamatta Group is moderately saline (median electrical conductivity 4,750 µS/cm) and suitable for short term irrigation and water for some stock (i.e. sheep and dairy cattle). Due to low yields the Wianamatta Group is not considered a productive groundwater source.

The Hawkesbury Sandstone underlies the Wianamatta Group and is the main groundwater source in the Project area due to its regional extent and exposure at the surface outside the Project area that enables rainfall recharge and easy access for private water supply bores. It is a thick aquifer (approximately 155 m) with numerous high and low permeability horizons and provides baseflow contributions where incised along major rivers including the Nepean River. Due to the stratification of the sandstone sequences, groundwater flow is primarily horizontal. Groundwater monitoring in the Project area, including at S2524, indicates there is a general downward gradient within the Hawkesbury Sandstone. Groundwater flow is generally in a northerly direction, and locally influenced where intersected by rivers and private abstraction bores. The quality of groundwater in the



Appin Mine Ventilation and Access Project: Groundwater assessment

Location of proposed ventillation shafts and sensitive receptors

Figure 4

file: Appin_Vent_Shafts.qgz

hgeo.com.au

Hawkesbury Sandstone is variable but in general brackish (median electrical conductivity 2,060 μS/cm) with a neutral pH (median pH of 7.5) and suitable for short term irrigation (due to elevated iron concentrations) and stock water.

The Narrabeen Group underlies the Hawkesbury Sandstone and is a sequence of interbedded sandstone, claystone, and siltstone. The main water bearing unit is the confined Bulgo Sandstone. Groundwater flow in the Bulgo Sandstone is in a north-westerly direction through bedding planes, joints and fractures. Groundwater quality is moderately saline (median electrical conductivity 4,950 μS/cm), neutral (median pH 7.2) and suitable for short term irrigation and water for some stock (i.e. sheep and dairy cattle). The Narrabeen Group also comprises three low permeability aquitards which impede vertical flow within the unit. The Bald Hill Claystone, which is approximately 30 m thick in the Project area, overlies the Bulgo Sandstone and interrupts the vertical groundwater flow from the Hawkesbury Sandstone. The Stanwell Park Claystone, which is approximately 7 m thick, underlies the Bulgo Sandstone and limits the interaction of groundwater between the Bulgo Sandstone and the Scarborough Sandstone. The Wombarra Claystone, which forms the base of the Narrabeen Group, is approximately 32 m thick in the Project area and impedes vertical flow to the Illawarra Coal Measures. Groundwater monitoring within the Project area at S2524 indicates that groundwater heads at depth within the Narrabeen Group tend to be higher than those observed in the HBSS.

Groundwater monitoring at VWP 1941 since 2010 has shown gradual depressurisation within the Bulgo Sandstone and Scarborough Sandstone with the progression of mining and depressurisation of the Bulli Seam at Appin Mine. Depressurisation of the Narrabeen Group is also visible in response to the Camden Gas Project that is active to the north of the Project area and is influencing current groundwater conditions. A 40 m decline in potentiometric levels in the Scarborough Sandstone have been observed from commencement of monitoring.

The Illawarra Coal Measures underlie the Narrabeen Group and comprise interbedded sandstones, shale and coal seams with a thickness of approximately 200 m to 300 m. Groundwater occurrence within the Illawarra Coal Measures is associated with the more permeable coal seams. Groundwater is confined and flow is generally in a northerly direction. The coal seams outcrop to the east of Appin Mine, where coal seams are truncated along the Illawarra Escarpment. Prior to mining, groundwater heads in Wongawilli Seam were around 1 to 5 m higher than the heads in Bulli Seam. On a regional scale, groundwater in the Bulli and Wongawilli seams flowed towards the north. Groundwater in the coal seams has been locally depressurised due to current and historical mining at Appin Mine and coal seam gas extraction at the Camden Gas Project.

Piezometric head

The standing water level recorded in the geophysical logs was 11 m for S2524 and 10 m for S2525 where the well had been standing overnight. Groundwater monitoring at VWP S2524 since March 2021 has indicated that piezometric head has remained relatively stable, with some decline in head observed in the Hawkesbury Sandstone sensor at 134.8 m depth. Monitoring at VWP S2524 will be ongoing prior to construction of the shafts to establish a baseline of piezometric head data. Monitoring will continue during and after construction of the shafts to detect impacts to groundwater pressures. Further details of the proposed monitoring program are provided in Section 5.2.

Aquifer properties and parameters

Packer permeability testing was conducted in boreholes S2524 and S2525 by SCT. A total of 101 straddle packer tests were conducted over the entire length of the borehole at each location. Intervals for testing were set at a nominal distance of 6 m.

The measured conductivity with depth in boreholes S2524 and S2525 is presented in Figure 5. There appears to be no strong trend of decreasing hydraulic conductivity with depth, however the results indicated higher conductivity are in the upper 70 m within the Ashfield Shale and the upper part of the Hawkesbury Sandstone. The geotechnical assessment did not identify any obvious correlation between hydraulic conductivity and fracture frequency (Calibre, 2021).

In borehole S2524, a maximum hydraulic conductivity of 1.35E-05 m/s was measured for the 31.5 to 37.5 m interval in the Hawkesbury Sandstone. Another zone of similar hydraulic conductivity, 1.1E-05 m/s was measured between 49.5 to 55.5 m. In borehole S2525, a maximum hydraulic conductivity of 1.9E-05 m/s was recorded between 33.0 – 39 m in the Hawkesbury Sandstone. The sandstone units (coloured in yellow in Figure 5) present a good indication of the prevalence of sandstone in the boreholes.

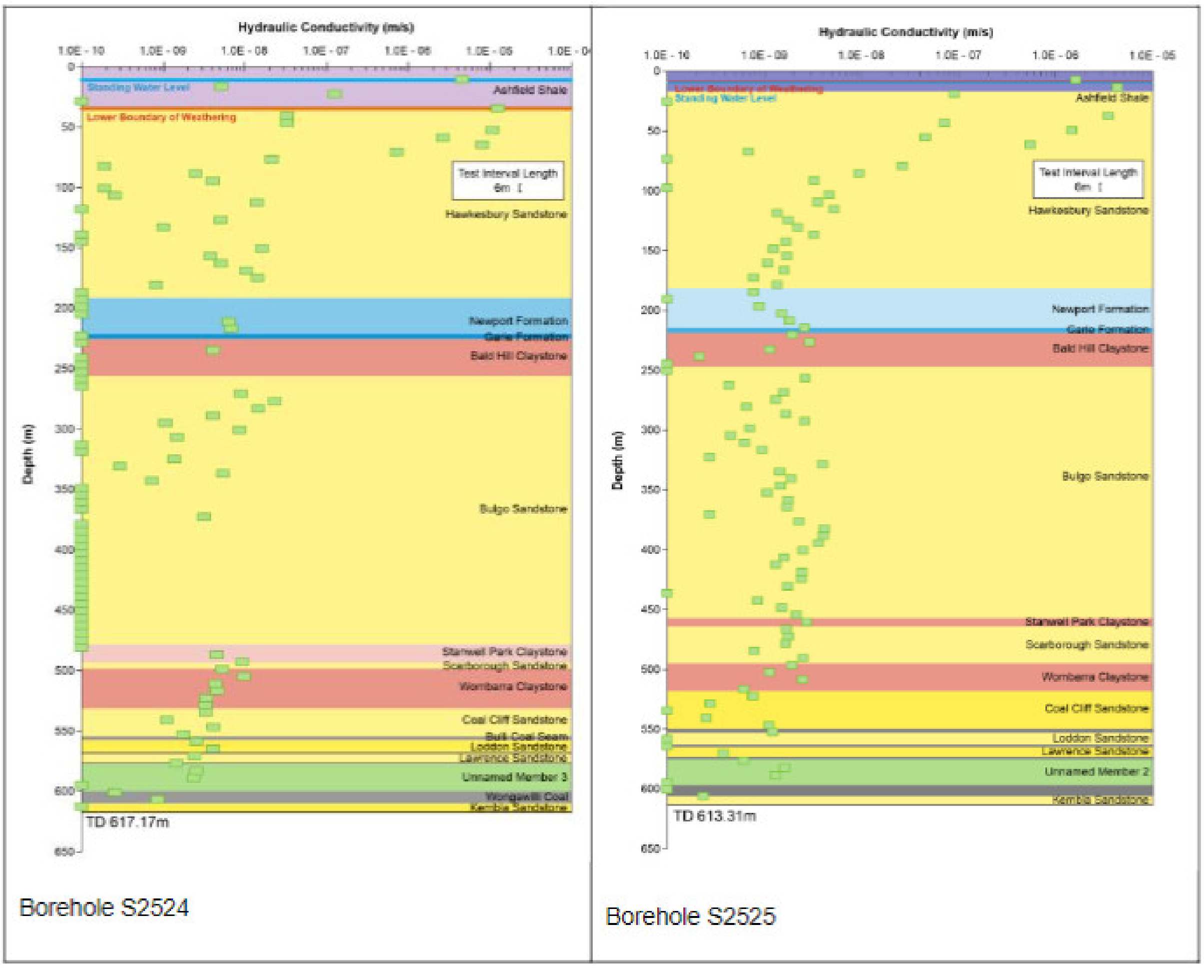


Figure 5 Hydraulic conductivity vs depth (SCT, 2021)

2.6 Sensitive receptors

Swamps

Upland headwater swamps have been mapped in the region; however, the closest swamps are approximately 9 km from the Project area and are therefore not considered potential receptors for this Project.

Private water supply bores

Registered bore data from the Bureau of Meteorology's National Groundwater Information System (NGIS) indicates there are 25 registered bores within the Project area (model extent). The purpose of these bores, target lithology and depth is provided in Table 1. The location of the bores is shown on Figure 3.

Most private water supply bores in the Project area extract groundwater from the Hawkesbury Sandstone or Bulgo Sandstone. Water supply bores in the Project area are predominantly used for stock and domestic purposes, with some bores also used for irrigation or recreation. There are two test bores in the Project area and one bore used for industrial purposes. Maximum yield of private bores within the Project area is generally less than 1.9 L/s.

Table 1 Private water supply bores

Bore ID	Bore purpose	Geology	Depth (m)
GW026516	Water Supply, Stock, Irrigation	Unconsolidated Clay/Silt	-
GW062945	Stock, Domestic	Sandstone	150
GW072196	Domestic	Likely Hawkesbury Sandstone	-
GW072874	Stock, Domestic	Sandstone, Siltstone and Shale	189
GW100289	Stock, Domestic	Gravel	30
GW101986	Stock, Domestic	Sandstone	210
GW102619	Stock, Domestic, Irrigation	Sandstone	224
GW104766	Stock, Domestic	Sandstone and Shale	192
GW105325	Stock, Domestic, Recreation	Sandstone and Shale	159
GW105339	Stock, Domestic, Irrigation	Sandstone and Shale	238
GW105376	Stock, Domestic	Sandstone	219
GW105388	Stock, Domestic	-	230
GW105531	Stock, Domestic	Sandstone and Shale	210
GW105534	Stock, Domestic	Sandstone and Slate	201
GW105574	Stock, Domestic	Sandstone, Clay and Shale	210
GW106574	Domestic	-	238
GW106675	Stock, Domestic	Sandstone and Shale	183
GW107791	Stock, Domestic	Sandstone	231
GW108312	Test Bore	Sandstone	175
GW108907	Stock, Domestic	Sandstone and Shale	210
GW108990	Test Bore	-	-
GW111727	Stock, Domestic	-	261

Bore ID	Bore purpose	Geology	Depth (m)
GW112381	Stock, Domestic	Sandstone	152
GW112441	Stock, Domestic	-	294
GW112481	Industrial	Bulli Coal Seam	633

Dams

The location of dams in the Project area are shown on Figure 3. The dams are understood to be farm dams used for stock and domestic purposes. Farm dams are relatively shallow features and typically located in gullies, small streams or overland flow paths. Within the Project area, farm dams are perched within weathered horizons of the Ashfield Shale and disconnected from the underlying aquifers of the Hawkesbury Sandstone.

2.7 Nearby projects

Bulli Seam Operations

The Site is located within Area 7 of Appin Mine. Appin Mine extracts coal from the Bulli Coal Seam within the Illawarra Coal Measures via the longwall mining method. Appin Mine includes Area 1, Area 2, Area 3, Area 4, Area 5, Area 7, Area 9 and North Cliff, as well as previous mine areas Tower Colliery and West Cliff Mine (Figure 1). The current active mine areas are in Area 7 and Area 9.

The existing mining operations are undertaken in accordance with Project Approval 08_0150 for the Bulli Seam Operations (BSO), granted in December 2011 and modified in October 2016 to incorporate the Appin Ventilation Shaft No. 6 Approval. Heritage Computing (2009) conducted the groundwater impact assessment for the BSO, which included numerical groundwater modelling to predict impacts. The key findings of the assessment included:

- Negligible reduction in groundwater contribution to total stream flows;
- Drawdown (due to depressurisation) in Hawkesbury Sandstone with predicted 1 m drawdown contour extending up to 5 km from the mine footprint. The extent of drawdown was most significant north to north-east of Area 8 and Area 9;
- Extensive depressurisation predicted for aquifers beneath the Bald Hill Claystone (i.e. Bulgo Sandstone, Scarborough Sandstone and Bulli Seam), with the 10 m drawdown contour extending over 6 km north of the mine footprint;
- Reduction in water level of up to 23 m at some private production bores intersecting the Hawkesbury Sandstone and up to 85 m for bores within the Bulgo Sandstone, with main impacts around Area 9;
- Mine inflows of around 4 ML/day across the entire BSO operations at the end of mining, averaging 2 ML/day each year over 30 years; and
- At the end of the 100-year recovery period, water levels in the main hydrogeological units had recovered to at least, and often higher than, the levels recorded at the start of mining (Year 1). The higher water levels observed after the recovery period are due to the starting heads including some residual impacts of historical dewatering at other mines.

IMC are currently undertaking groundwater monitoring and reporting in accordance with the BSO approval to assess impacts to groundwater resources and sensitive receptors against what was predicted. Current groundwater levels indicate depressurisation within the Bulli Seam extends approximately 1 to 2 km from active mine areas, consistent with the groundwater modelling undertaken for the BSO (Heritage Computing, 2009). Current monitoring data also shows depressurisation within the Scarborough Sandstone and Bulgo Sandstone due to mining and within the Scarborough Sandstone due to CSG activities (Camden Gas Project) as was previously predicted for BSO (Heritage Computing, 2009). Overall, no adverse impacts beyond those previously predicted have been observed due to existing operations at Appin Mine.

Appin Mine Extraction Plan

The development consent conditions for the BSO require that an Extraction Plan (EP) is approved prior to commencement of secondary extraction. IMC seeking EP approval for Longwalls 709, 710A, 710B, 711 and 905. SLR Consulting Australia Pty Ltd (SLR) completed a groundwater impact assessment for the proposed EP, which included numerical groundwater modelling to predict impacts (SLR, 2021a). The results of the assessment were reported as incremental impacts to the approved BSO impacts and as cumulative impacts of the BSO and EP. The key findings of the assessment included:

- No change in peak mine inflows when compared to the approved BSO;
- Depressurisation of aquifers beneath the Bald Hill Claystone, including the Bulgo Sandstone and Scarborough Sandstone, up to 1.7 km from the proposed longwall panels;
- Negligible predicted impacts on surface water bodies including stream inflows due to depressurisation of the coal measures; and
- Predicted drawdown at registered bores ranging from negligible drawdown within shallow strata to up to 122 m in a bore within the Bulgo Sandstone, with depressurisation of registered bores within the Hawkesbury Sandstone ranging between 4 and 24 m depending on the distance from the longwall panels.

Appin Mine Full Development

Future mining at Appin Mine is additionally proposed to include longwall mining in Areas 8 and 10. The SLR groundwater model was updated to quantify the groundwater take associated with future operations at Appin Mine (SLR, 2021b). The modelling indicated that up to 360 and 401 ML/year of groundwater inflows could be intercepted in the underground workings under the Sydney Basin Nepean Groundwater Source (Management Zone 2) due to approved (mining within the BSO approval boundary) and full development mining (extending to Areas 8 and 10) at Appin, respectively.

Camden Gas Project

The AGL Camden Gas Project is located at the northern end of Appin Mine. The Camden Gas Project has been in operation since 2001, with production to cease by 2023. The Camden Gas Project comprises 137 wells (86 currently active) targeting the Bulli and Balgownie seams north of the Project. The CSG activities involve abstraction of water to induce gas flow, resulting in a reduction in water pressure in the target seam. IMC groundwater monitoring indicates potential localised depressurisation within the Scarborough Sandstone of the Narrabeen Group associated with depressurisation around the CSG wells.

2.8 Conceptual hydrogeological model

The geology of the Site comprises Wianamatta shales underlain by Hawkesbury Sandstones. Vertical groundwater flow continuity in the Wianamatta Group is retarded by the Ashfield Shale. Whilst of low permeability, the Hawkesbury Sandstone has a relatively higher permeability compared to other units and is capable of higher groundwater yields. The general groundwater regime for the Project area comprises:

- Perched groundwater systems associated with the Wianamatta Group. These perched water tables are hydraulically disconnected from the deeper groundwater systems;
- Shallow groundwater systems comprising layered water-bearing zones within the saturated Hawkesbury Sandstone. The highest yielding groundwater bores are typically associated with coarse sandstone units and/or fractured sandstone; and
- Deeper groundwater systems within the Narrabeen Group and the Illawarra Coal Measures. These units typically are of much lower permeability than the Hawkesbury Sandstone and produce low bore yields and poorer water quality.

The main aquifer in the Project area is the Hawkesbury Sandstone. Recharge to this system is from rainfall and lateral groundwater flow and discharge is to incised streams and loss by evapotranspiration in outcrop areas. Groundwater pressures in the underlying Narrabeen Group sandstones and coal seams of the Illawarra Coal Measures are affected by underground mining at Appin Mine and coal seam depressurisation for the Camden Gas Project.

Most private water supply bores in the Project area extract groundwater from the Hawkesbury Sandstone or Bulgo Sandstone for stock and domestic purposes. Farm dams in the Project area are shallow, perched within upper weathered horizons of the Ashfield Shale and disconnected from the underlying aquifers of the Hawkesbury Sandstone. There are no upland swamps in the Project area.

3. Numerical groundwater model

3.1 Assessment approach

Numerical groundwater modelling has been undertaken to simulate hydrogeological conditions in the Project area and predict impacts to groundwater resources and sensitive receptors during excavation and ongoing use of the ventilation shafts. The modelled scenario incorporates the proposed mitigation measures for controlling groundwater inflow during excavation and ongoing operation of the shafts as implementation of the mitigation measures is an integral component of the shaft sinking operations. The mitigation measures included in the model are:

- Targeted grouting of fracture zones and high permeability horizons to control inflows exceeding 3 L/s, which is the preferred maximum pumping capacity during shaft operations; and
- Progressive pouring of a non-hydrostatic concrete lining closely behind the working area during excavation of the shaft such that a maximum of 15 m of unlined wall is exposed at any time through the depth of the shaft.

The numerical groundwater modelling undertaken simulates construction and operation of the ventilation shafts but does not simulate the underground coal mining and coal seam gas operations occurring in the Project area. To assess cumulative impacts of the Project and other activities occurring in the area, the impacts to groundwater predicted for the ventilation shafts have been added to the impacts to groundwater predicted for the mining and coal seam gas operations reported in SLR (2021a) and SLR (2021b). The results of the modelling are presented in Chapter 4.

3.2 Model code and design

A site-scale model was developed using MODFLOW6, the latest version of the control-volume finite difference groundwater modelling code developed by the United States geological Survey (USGS). The model employs an unstructured (Voronoi polygon) mesh, constructed using Algomesh software. The model was constructed and run through the Groundwater Vistas (Version 8) graphical user interface. The model boundary was set at between 2.3 and 2.9 km from the vent shafts, well outside the expected groundwater drawdown influence. The extent includes the Nepean River to verify that drawdown is unlikely to extent to the river (Figure 6).

The mesh polygons are typically near-hexagonal, ranging in size from approximately 150 m diameter over most of the model domain to approximately 12 m diameter within 100 m of the vent shafts. The polygons hosting the shafts themselves were set such that the diameters exactly match the design shaft diameters.

The geology was represented using 39 flat layers of 15 m thickness. The permeability of each layer was defined using the weighted average of packer tests across each layer depth interval from hole S2524. The 15 m layer thickness reflects the expected length of unlined shaft at any time during excavation.

A total of 79 stress periods were used to simulate the shaft construction process. The stress periods were uneven in length, with the start and end dates being selected to coincide with the expected dates on which each shaft will reach the elevation of each layer bottom. The first stress period is steady state to establish equilibrium conditions, while the final (79th) stress period was added to estimate the ongoing seepage rate after shaft completion.

Boundary conditions

A General Head Boundary (GHB) condition was placed at the model margins in all layers to simulate an extensive aquifer system. A GHB was used in case the modelled drawdown impinged on the model margins. The model drawdown was found to be well-contained by the model domain and so the conductance distance component was left at 1 m (similar to a constant head condition). The initial head was set at 10 m below the surface across the model domain, reflecting the observed heads in investigation bores at the site (S2524 and S2525). The same head was applied to the GHB for all stress periods. No recharge or evapotranspiration was applied to the model and therefore drawdown calculations will be conservative.

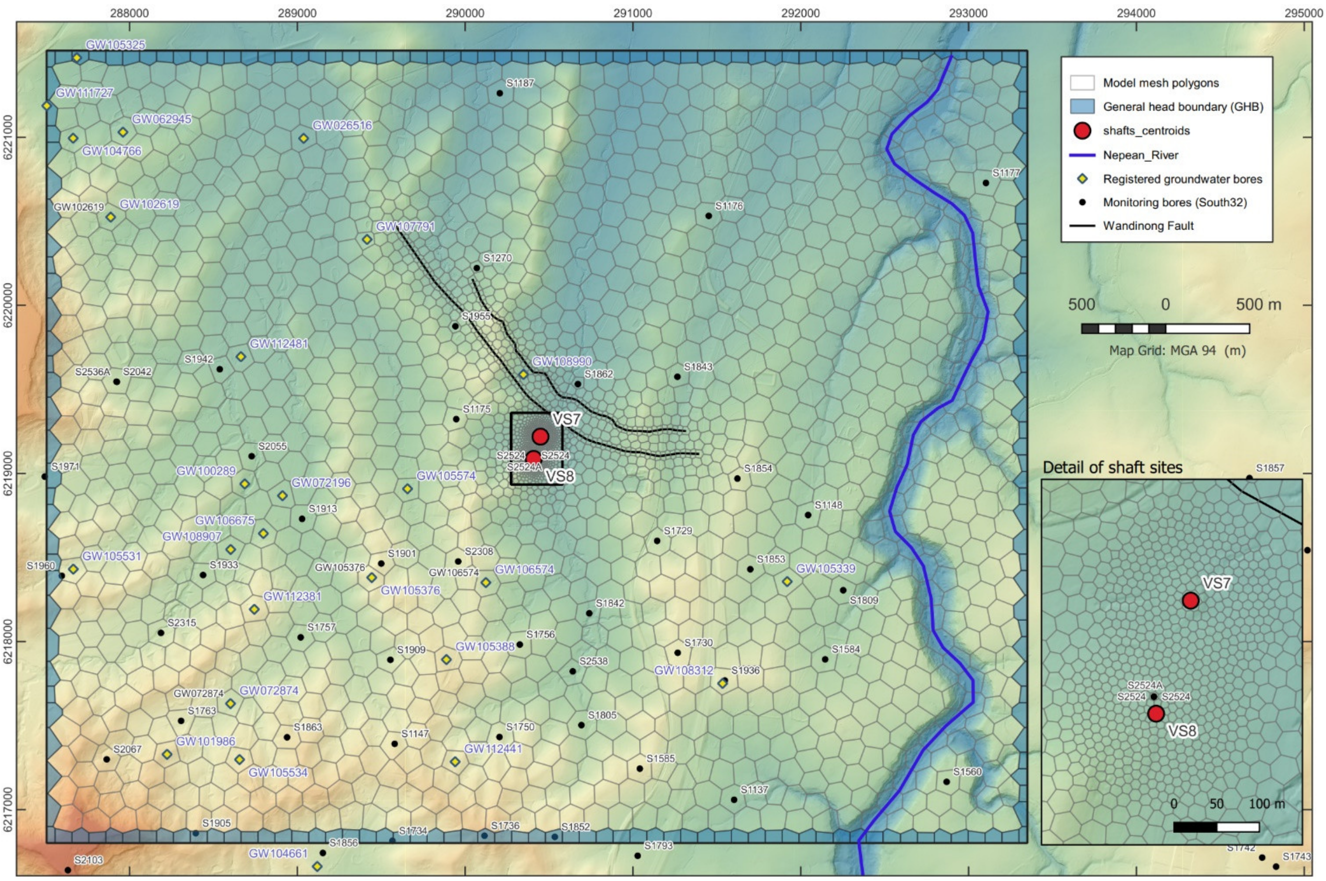


Figure 6 Model domain and model grid

Representation of shaft excavation

Groundwater inflow to the shaft was simulated using the Drain (DRN) package. The drain conditions were set according to the expected construction schedule as follows:

- For each shaft, the drain boundary is activated in progressively deeper layers according to the construction schedule.
- The conductance of the drain in the active 15 m excavation layer was set using the expected excavation (unlined) shaft circumference and the hydraulic conductivity of the host formation for that layer (i.e. inflow is not impeded within the active 15 m working section). Note that in the upper 75 m, the host formation is assumed to be pre-grouted (see below).

- To simulate the lined shaft above the active excavation layer, the conductance of the drains above the active layer was reduced using the lined shaft circumference and the hydraulic conductivity of the lining (conservatively set 1 order of magnitude [OM] lower than the host formation).
- At the end of the construction period, it was assumed that the entire shaft lengths were lined.

An initial run of the model showed that the shaft groundwater inflow would likely exceed 3 L/sec in the upper 4 model layers (to 75 m depth). Therefore, the hydraulic conductivity of the cells immediately surrounding the shaft in those layers were reduced to reflect pre-excavation grouting of the upper layers, as per the proposed construction method. The hydraulic conductivity of the pre-excavation grouted material was assumed to be 10-2 m/day (2.3 x 10-7 m/sec), similar to unfractured Hawkesbury Sandstone.

Faults

The Wandinong Fault zones were represented in the mesh as a curvilinear zone approximately 50 m wide (Figure 6). Following the baseline model run, two further model runs were carried out to assess the effect of the fault zones being less transmissive (a barrier) and more transmissive (a conduit) than the host formation. For those runs the hydraulic conductivity of the faults zones was set 1 OM lower and 1 OM higher (respectively) than the host formation in each layer. The fault zones were assumed to be vertical and to fully penetrate all layers in the model.

Model predictions

Inflow to the shafts was exported from the model as a timeseries for each drain node and aggregated to provide a timeseries of inflow rate for each shaft (see Figure 7 and Table 2).

The model calculates the groundwater level (head) in each model node (polygon) in each model layer. A groundwater drawdown timeseries was calculated for each registered groundwater user bore. A timeseries was generated for the expected drawdown at the water table (layer 1) and the average drawdown across all layers intersected by the bore, according to the recorded bore depth. The latter drawdown is reported in Section 4 (Table 4). Drawdown contours for the water table are presented in Section 4 for the baseline model run, and in Appendix 2 for the fault zone scenarios.

4. Model results

The numerical groundwater modelling undertaken simulates the groundwater impacts during construction and operation of the ventilation shafts To assess cumulative impacts of the Project and other activities occurring in the area, the (incremental) impacts to groundwater predicted for the ventilation shafts have been added to the impacts to groundwater predicted for the mining and coal seam gas operations reported in SLR (2021a) and SLR (2021b). The results presented in the following sections include the predicted shaft inflows, and maximum aquifer depressurisation and drawdown at landholder bores during construction. Long-term water take is based on estimates of observed inflow at existing shafts within operational mining areas.

4.1 Estimated shaft inflows

Estimated inflows during construction

Groundwater modelling has indicated that during construction and ongoing use of the ventilation shafts, the Project may involve the incidental 'take' or diversion of groundwater. The groundwater take was estimated based on the drain package (DRN) flux in MODFLOW for each shaft from the commencement of construction in 2023 to ongoing operations in 2025. The modelled scenario includes the proposed mitigation measures for controlling groundwater inflow, which include targeted grouting of fracture zones and high permeability horizons, and progressive pouring of a non-hydrostatic concrete lining closely behind the working area during excavation of the shaft.

Figure 6 presents the predicted inflow rates during and after construction of the ventilation shafts with the mitigation measures in place. The short-term increases in flow rate observed reflect excavation of the shaft through a fracture zone or high permeability horizon, followed by targeted grouting and pouring of the lining to reduce inflows. As expected, the total inflow rate to the shafts increases with depth of shaft excavation and inflows during the operational phase will remain stable.

To ensure shaft sinking efficiency, groundwater inflows will be minimised by targeted grouting of fractured zones and advance pre-grouting of fractured strata. With increased controls, actual inflows may be lower than those predicted.

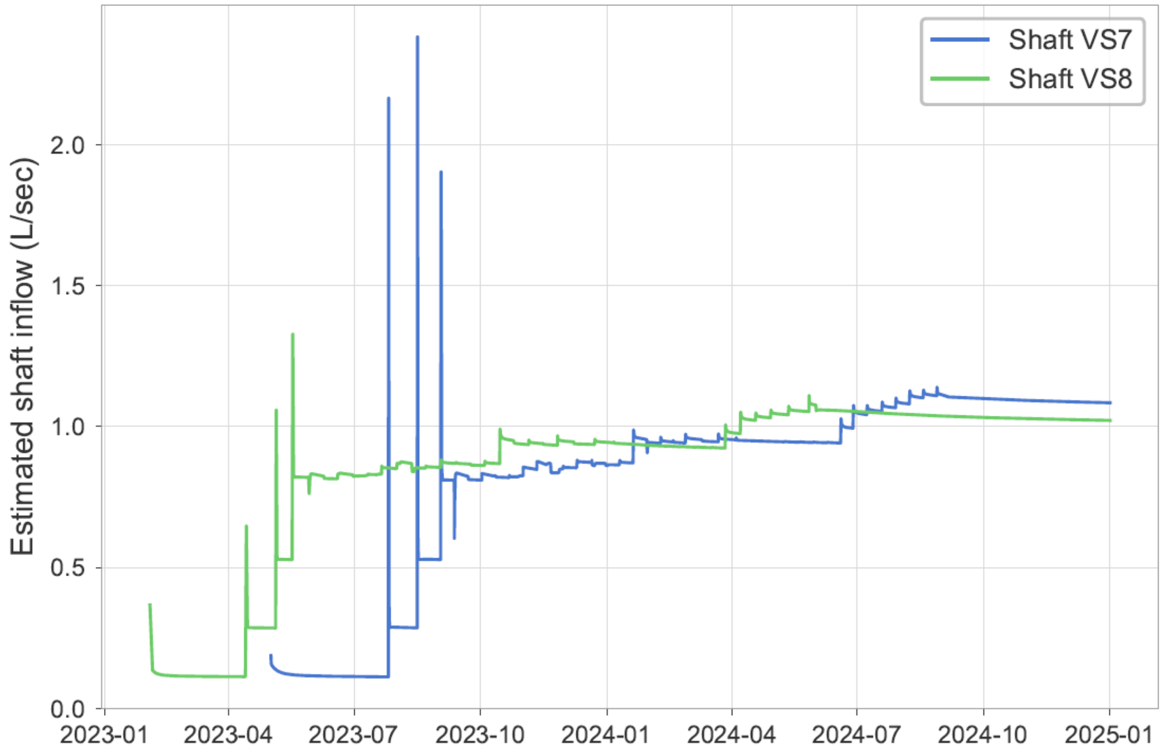


Figure 7 Estimated shaft inflow rates during construction

Estimated inflows during operations

Shaft inflow will decline significantly following construction because the shafts are fully lined and geological units will be depressurised due to mining. Therefore, long-term water take is based on estimates of observed inflow at existing shafts within operational mining areas.

Recent observations of seepage into ventilation shafts within operational areas at Appin are as follows:

- Appin West Winder Shaft: A conservative estimate of 200 L/day pumped from the shaft sump. Likely an overestimated value because the sump also collects wastewater from regular hosing down of surfaces.
- Appin Mine Ventilation Shaft No. 6: Little or no water accumulation at shaft base and no regular pumping required.

Based on the above observations, it is estimated that the combined long-term water take for VS7 and VS8 will be no greater than 400 L/day or 0.14 ML/year.

Predicted shaft inflows during construction in 2023 and 2024 and during operation of the shafts are presented in Table 2.

Table 2 Total inflows during construction and operation of the shafts

Year	Phase	VS7 inflows (ML/year)	VS8 inflows (ML/year)	Total predicted inflows (ML/year)
2023	Construction	19.3	11.1	30.4
2024	Construction	29.9	29.9	59.8
Long-term	Operation	0.07	0.07	0.14

Water Access Licences

The Water Act 1912 and Water Management Act 2000 (WM Act) provide the framework for the allocation and management of water in NSW and require a licence or approval for taking water. The main tool in the WM Act for managing the state's water resources are Water Sharing Plans, which set out the rules for sharing and trading water within a water source.

The Site is in ‘Nepean Management Zone 2’ (MZ2) of the Water Sharing Plan for the Greater Metropolitan Region Groundwater Sources 2011. IMC hold three Water Access Licences (WAL) in MZ2 for the Mine. The WALs are summarised in Table 3.

Table 3 Water Access Licences held by IMC in Nepean Management Zone 2

WAL number	Category	Tenure type	Extraction times or rates	Share component (units or ML)
36477	Aquifer	Continuing	Subject to conditions water may be taken at any time or rate	303.00
36481	Aquifer	Continuing	Subject to conditions water may be taken at any time or rate	274.00
37464	Aquifer	Continuing	Subject to conditions water may be taken at any time or rate	300.00
			TOTAL	877.00

The Appin Mine Annual Review reports that the water take due to groundwater ingress at Appin Mine was 778 ML in the FY2021 reporting period and 710 ML for the FY2020 reporting period. Modelling indicates that the Project may result in an incidental ‘take’ or diversion of up to 59.8 ML/year of groundwater in 2024, with ongoing operational seepage of less than 0.14 ML/year. The share allocations of Water Access Licences held by IMC (totalling 877 ML/ year) is sufficient to account for any incidental groundwater take at the Site.

4.2 Depressurisation

Depressurisation in all formations from surface to seam is predicted to occur due to construction and operation of the ventilation shafts. The results show a sharp decline in groundwater pressures in the immediate vicinity of the ventilation shafts but subtle water table drawdown.

Figure 5 presents predicted water table drawdown associated with the proposed ventilation shafts. The results presented are the maximum drawdown in Layer 1 at the completion of construction of the ventilation shafts, after which time groundwater levels will recover. Drawdown of 2 m or more is expected to be restricted to within 30 to 40 m of the shafts, and in the area between the shafts. The 1 m drawdown contour extends up to approximately 200 m from the shafts. Less than 0.5 m drawdown of the water table is expected beyond 400 m from the shafts. The observed drawdown is likely to be less than predicted due to rainfall recharge of the aquifers which is not included in the model.

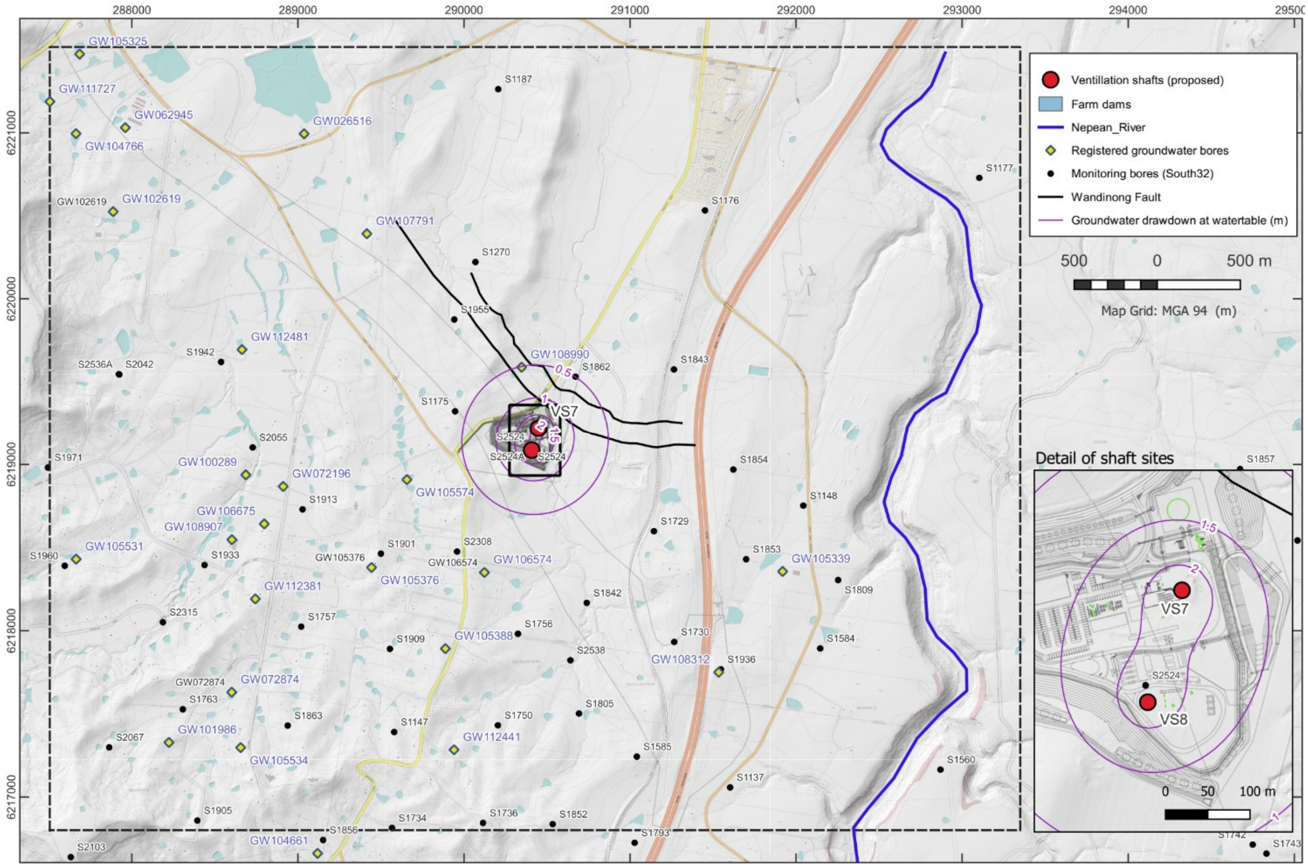


Figure 8 Water table drawdown

The non-hydrostatic concrete lining proposed for the ventilation shafts will significantly reduce inflows to the shaft by blocking seepage paths, however some seepage pressure relief will occur at the construction joints between the lining pours on an ongoing basis and drainage of the shafts will be required. Recovery of groundwater pressures will occur during operation of the ventilation shafts, however there will continue to be some minor depressurisation in the immediate vicinity of the shafts.

4.3 Drawdown

Maximum predicted drawdown at groundwater receptors, including registered bores, farm dams and the Nepean River, is presented below.

Landholder bores

As discussed in Section 2.6, there are 25 registered bores within the Project area (within 2.3 km north-south and 2.9 km east-west of the shafts). Table 4 presents predicted maximum cumulative drawdown in registered bores, including due to construction and operation of the ventilation shafts. The results presented are maximum drawdown averaged across all layers intersected by the bore.

Predicted drawdown is negligible at most registered bores. Minor drawdown was predicted at stock and domestic bore GW105574 (0.85 m), domestic bore GW106574 (0.80 m) and test bore GW108990 (1.47 m). SLR (2021a) reported cumulative drawdown at 45 registered bores for the BSO and EP projects and other nearby mining and coal seam gas operations. The predicted cumulative drawdown for registered bores in the Project area is summarised in Table 4. In most cases the additional incremental drawdown due to shaft construction is negligible or minor compared with the estimated cumulative depressurisation from approved mining projects.

Table 4 Predicted maximum drawdown at private water supply bores

Bore ID	Bore purpose	Predicted cumulative drawdown due to BSO and EP projects (SLR, 2021a) (m)	Predicted maximum drawdown due to shafts (m)
GW026516	Water Supply, Stock, Irrigation	10	0.00
GW062945	Stock, Domestic	150	0.00
GW072196	Domestic	0	0.03
GW072874	Stock, Domestic	149	0.00
GW100289	Stock, Domestic	30	0.01
GW101986	Stock, Domestic	189	0.00
GW102619	Stock, Domestic, Irrigation	70	0.00
GW104766	Stock, Domestic	192	0.00
GW105325	Stock, Domestic, Recreation	159	0.00
GW105339	Stock, Domestic, Irrigation	1	0.02
GW105376	Stock, Domestic	219	0.13
GW105388	Stock, Domestic	N/A	0.08
GW105531	Stock, Domestic	141	0.00
GW105534	Stock, Domestic	151	0.00
GW105574	Stock, Domestic	185	0.85
GW106574	Domestic	N/A	0.80
GW106675	Stock, Domestic	132	0.02
GW107791	Stock, Domestic	231	0.03
GW108312	Test Bore	156	0.01
GW108907	Stock, Domestic	173	0.01
GW108990	Test Bore	2	1.47
GW111727	Stock, Domestic	261	0.01
GW112381	Stock, Domestic	152	0.01

Bore ID	Bore purpose	Predicted cumulative drawdown due to BSO and EP projects (SLR, 2021a) (m)	Predicted maximum drawdown due to shafts (m)
GW112441	Stock, Domestic	N/A	0.01
GW112481	Industrial	633	0.01

Dams

There are negligible predicted impacts on farm dams due to construction and operation of the ventilation shafts. The farm dams in the project area are shallow and effectively perched above the water table, estimated to be 10 m or more below the ground surface. Farm dams are therefore disconnected from the regional water table such that fluctuations in the water table will not affect the dam water level, nor affect the rate of seepage losses from the dams if this condition already exists.

Nepean River

The numerical groundwater model included a monitoring target at the Nepean River at the closest point to the proposed ventilation shafts to assess potential impacts to baseflow (should it be occurring). Drawdown was calculated for Layer 1 at the surface, and as an average across all layers in the model. The results confirm that measurable drawdown from the Project will not extend to the Nepean River during construction or operation of the shafts. Therefore there will be no additional induced take of water from the Nepean River as a result of the Project.

The effects of faulting

Following the baseline model run, two further model runs were carried out to assess the effect of the Wandinong Fault zones being less transmissive (a barrier) and more transmissive (a conduit) than the host formation. Plans showing predicted maximum drawdown of the water table at the end of shaft construction are shown in Appendix 2 (Figure 9 and Figure 10). The plans show minor deviations in the drawdown contours where the cone of drawdown impinges on the fault zone. In general, if the fault zones are non-transmissive (a barrier) then drawdown on the Project-side of the fault will be slightly greater. The opposite is true if the fault zone is transmissive. The radial distance to the 1.0 m drawdown contour differs by 40 m to 100 m. The difference in drawdown at landholder bores is negligible.

5. Mitigation, management and monitoring

5.1 Mitigation and management

From an operational perspective, groundwater inflows across the full depth of the shaft should be kept below 3 L/s during the shaft sinking. Groundwater inflows will be controlled by grouting and lining of the affected areas as follows.

Horizontal holes are drilled into the walls of the shaft in areas where fracture zones and high permeability horizons are encountered. Fine grout is injected into the drill holes under pressure to fill the fracture system and rock mass and create a grout curtain. Using this approach, inflows to the shaft can quickly be managed so that construction of the shaft can progress. Where high inflow conditions are ongoing or anticipated, grout may be injected into holes fanning outward (and downward) from the shaft base such that excavation continues through a pre-grouted curtain.

In addition to targeted grouting of high inflow zones, the shafts will be fully lined with a reinforced concrete lining system. The liner will be approximately 300 m thick and will be poured progressively during excavation of the shafts. In the upper shaft, where the more permeable Hawkesbury Sandstone occurs, the lining will be advanced relatively close to the sinking face such that only about 9 m of unlined wall might be exposed, with a maximum of 15 m of unlined wall exposed at any time through the depth of the shaft. The non-hydrostatic concrete lining proposed will significantly reduce inflows to the shaft by blocking seepage paths, with some seepage pressure relief occurring at the construction joints between the lining pours and requiring ongoing drainage during operation of the shafts. In general, when grouting with cement, a reduction in the conductivity by approximately a factor 10 is expected.

The numerical groundwater modelling undertaken for the Project has included the proposed mitigation measures for controlling groundwater inflow during excavation. The modelling has been conservative in its assumptions, assuming that targeted grouting will be undertaken where inflows exceed 3 L/s and that 15 m of unlined wall will be exposed at any one time. In reality, targeted grouting of permeable zones will likely be undertaken at lower inflow rates and typically less than 15 m of unlined wall will be exposed during much of the shaft progression. The predicted impacts are therefore considered conservative, with impacts expected to be less than reported.

5.2 Monitoring

IMC currently conducts groundwater monitoring in Area 7 at Appin Mine in accordance with the Area 7 Water Management Plan (WMP), which was developed in accordance with the BSO Approval Condition 5 (h), Schedule 3. The Area 7 WMP details the requirements for surface water and groundwater monitoring and assessment of data against performance criteria in the Trigger Action Response Plan (TARP). This includes monitoring of landholder groundwater bores in the vicinity of the Project.

Management and monitoring of groundwater during the construction phase would be included in the relevant construction environmental management plan prepared for the Project. The Appin Mine Water Management Plan, developed in accordance with the BSO Approval Condition 16, Schedule 4, describes the requirements for ongoing groundwater management at Appin Mine, and would be updated as required to incorporate the Project.

Groundwater monitoring during construction should include the multi-piezometer array installed at bore S2524, located between VS7 and VS8 (Figure 3). Monitoring results should be compared against expected depressurisation from numerical modelling. Monitoring at S2524 commenced in March 2021 and will provide a baseline of groundwater pressures prior to the proposed commencement of construction of the ventilation shafts in 2023. S2524 has nine VWP sensors: four in the Hawkesbury Sandstone, one in the Bald Hill Claystone and four in the Bulgo Sandstone. Each sensor monitors water pressure on an hourly interval and transmits data automatically via FTP. The construction details of S2524 are provided in Appendix A.

6. Conclusions

IMC is seeking to modify the existing approval to include the construction and operation of two additional ventilation shafts and associated surface infrastructure.

Numerical groundwater modelling was undertaken to assess the potential impacts of the Project on groundwater resources. The numerical model incorporates proposed groundwater ingress mitigation strategies. Estimated total groundwater inflow to the two shafts is 30.4 ML in 2023 and 59.8 ML in 2024. To ensure shaft sinking efficiency, groundwater inflows will be minimised by targeted grouting of fractured zones and advance pre-grouting of fractured strata. With increased controls, actual inflows may be lower than those predicted. Shaft inflow will decline significantly following construction because the shafts are fully lined and geological units will be depressurised due to mining. Observed seepage at operational shafts at Appin Mine indicate that the combined long-term water take for VS7 and VS8 will be no greater than 0.14 ML/year. Accounting for the predicted cumulative take of groundwater for approved and proposed mining at Appin Mine (SLR, 2021b), the share allocation of licences held by IMC is sufficient to account for any incidental groundwater take at the Site during construction and use of the shafts.

Predicted drawdown at most registered bores in the Project area is negligible. Minor drawdown is predicted at stock and domestic bore GW105574 (0.85 m), domestic bore GW106574 (0.80 m) and test bore GW108990 (1.47 m). Negligible impacts to farm dams are predicted as farm dams in the Project area are shallow and effectively perched within the upper weathered horizons of the Wianamatta Group. Drawdown is not predicted at the Nepean River during construction or use of the shafts. Therefore, there will be no additional induced take of water from the Nepean River as a result of the Project.

7. REFERENCES

Calibre Professional Services One Pty Ltd (Calibre) (2021) Geotechnical Investigation for Ventilation Shaft 8 (VS8), COPP20023-C000000-REF-G-0116, Revision 0, 12 July 2021

Heritage Computing (2009), Bulli Seam Operations Groundwater Assessment, A Hydrogeological Assessment in support of the Bulli Seam Operations Environmental Assessment for Illawarra Coal Holdings Pty Ltd, HC2009/5, July 2009

Pitt & Sherry (2021a) Geotechnical Investigation for Ventilation Shaft 7 (VS7), Rev 00, 8 July 2021

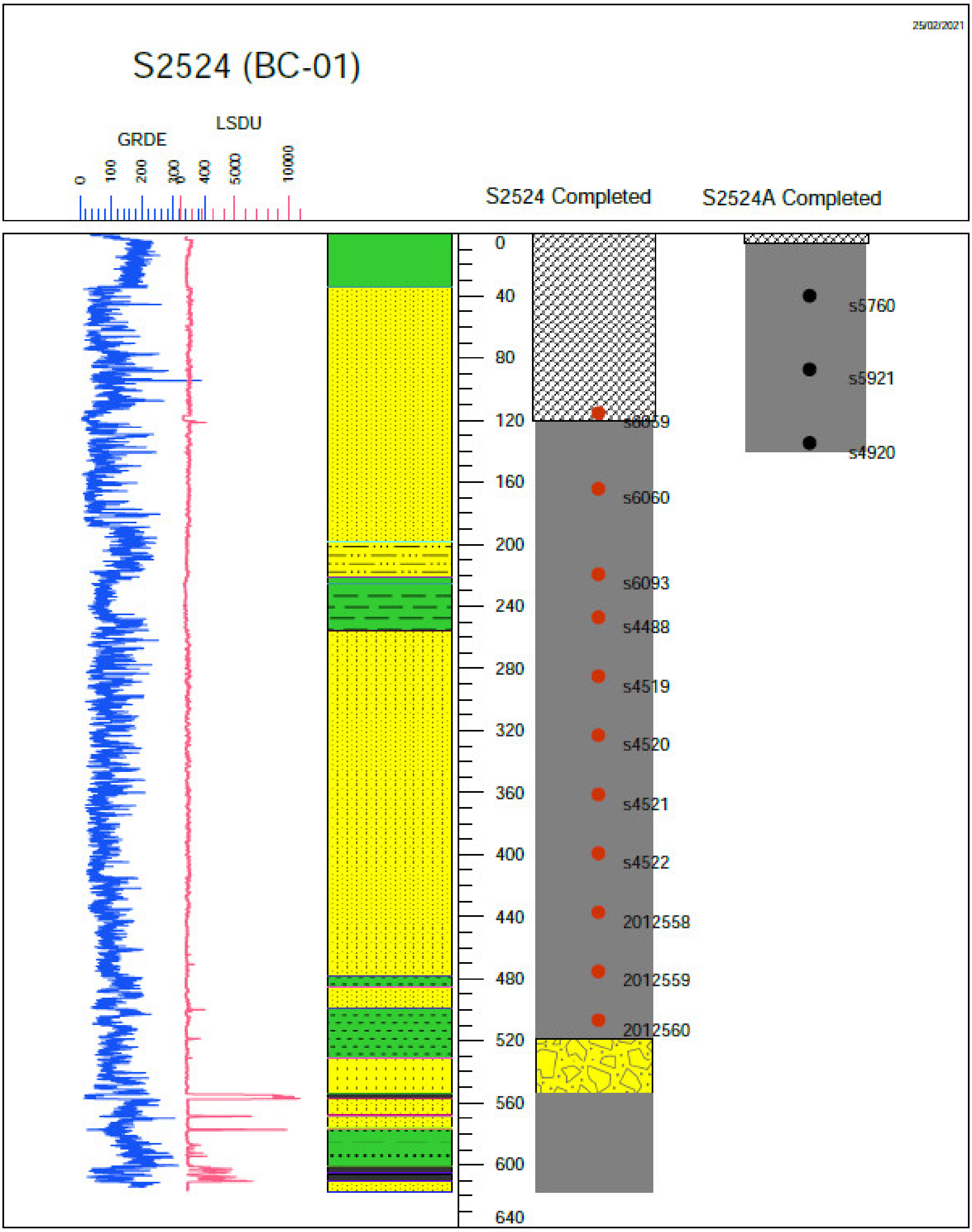
Pitt&Sherry, (2021b). Review of VS7 & VS8 shaft water inflow estimates (Memo No. T-SY19011-GEO-MEM-042), Report by Pitt&Sherry Pty Ltd for Illawarra Metallurgical Coal.

SCT (2021) In Situ Overcore Measurements in Exploration Borehole S2525.SCT Operations Pty Ltd - STH325212AC–15April2021Strata2(2020) Report No:STH-003-Rev3: Subsidence Effects on Proposed Shaft Sites, internal report to IMC, 11 September 2020

SLR Consulting Australia Pty Ltd (SLR) (2021a) Appin Mine Extraction Plan Groundwater Impact Assessment, SLR Ref: 665.10015-R01, Version No: -v5.0, April 2021

SLR Consulting Australia Pty Ltd (SLR) (2021b) Appin Closure Water Take Estimate, 665.10015_M01_v2.0.doc, 7 January 2021

APPENDIX I – Construction log for S2524



Procedure
Set piezometers at 40,87.4,134.8,164.2,219.4,247.1,285.1,323.1,361.2,399.2.437.2,475.2 and 506.7m
Fill hole with S32 Grout

All piezometers in S2524 set 19.5m higher than design at the values cited above due to hole conditions
Grout below Bulli Coal placed by drill rig prior to piezometer install
S2524A deepened to 140m and additional piezometer added to compensate for piezometer elevated to inside casing
Piezometer s6059 not connected to logger, - inside casing

APPENDIX 2 – Results of fault scenario modelling

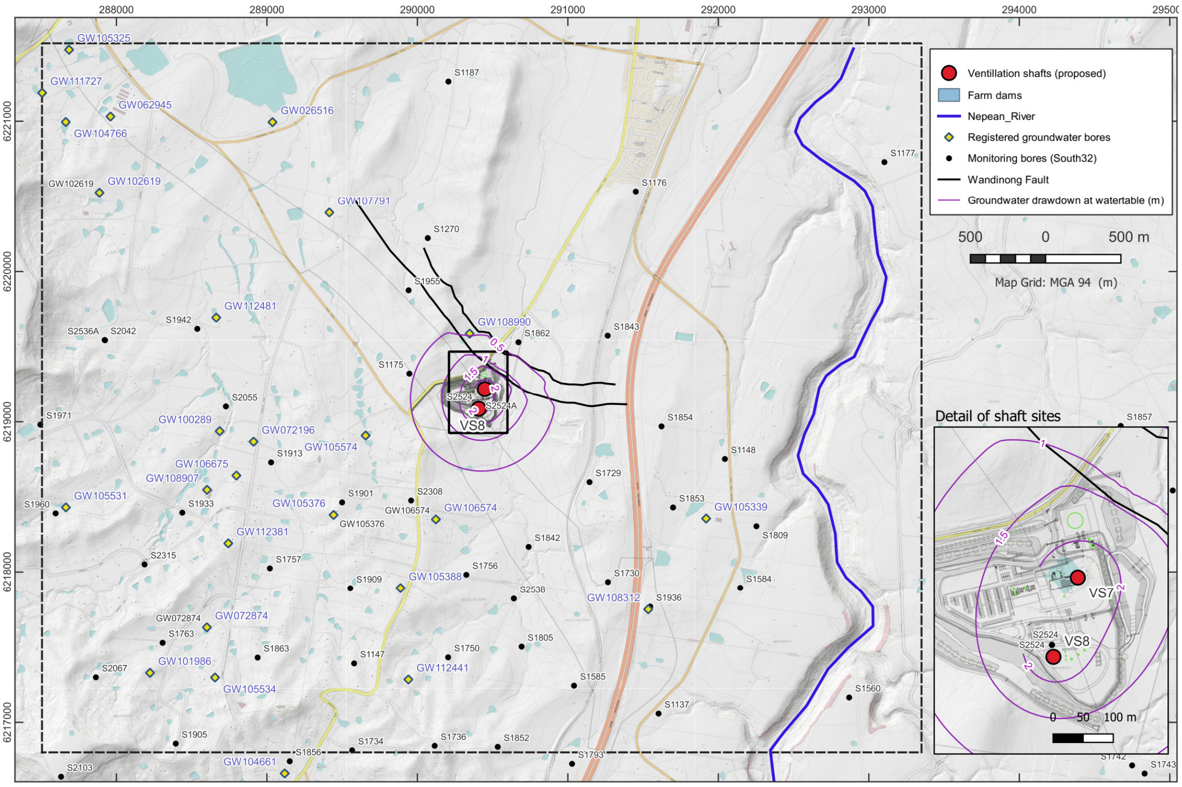


Figure 9. Modelled drawdown at the water table assuming Wandinong Fault is a barrier

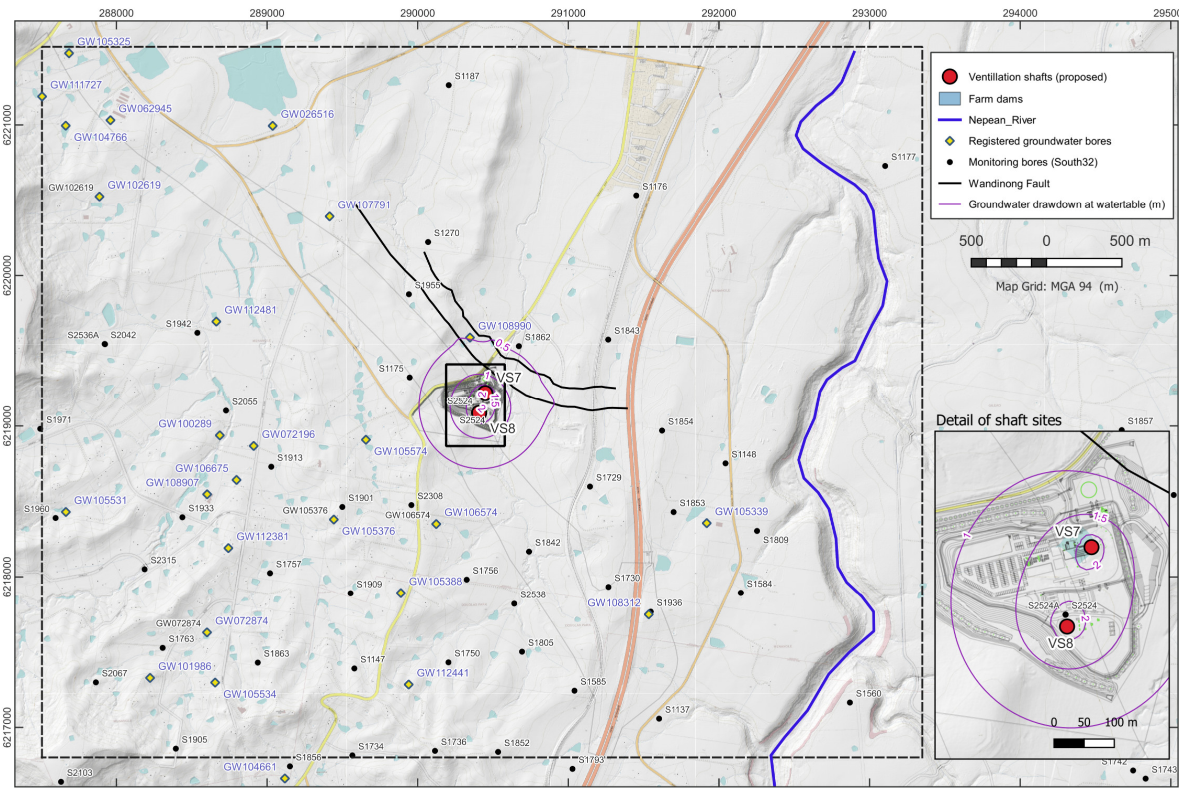


Figure 10. Modelled drawdown at the water table assuming Wandinong Fault is a conduit

Attachment E – Modification Report photomontage location plan

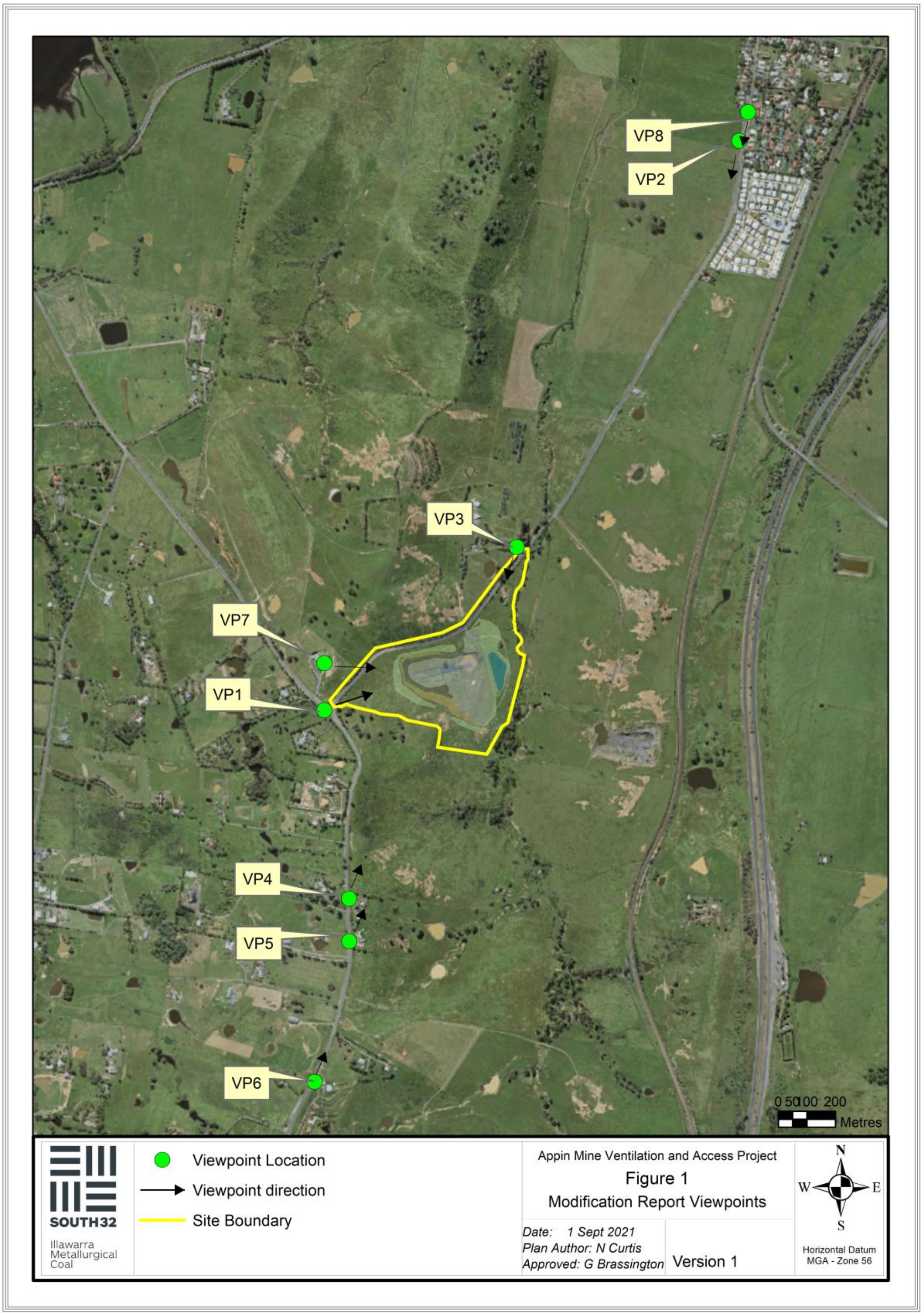


Figure 1 – Location Plan of Modification Report Photomontages

Attachment F – 30 Finns Road Photomontages

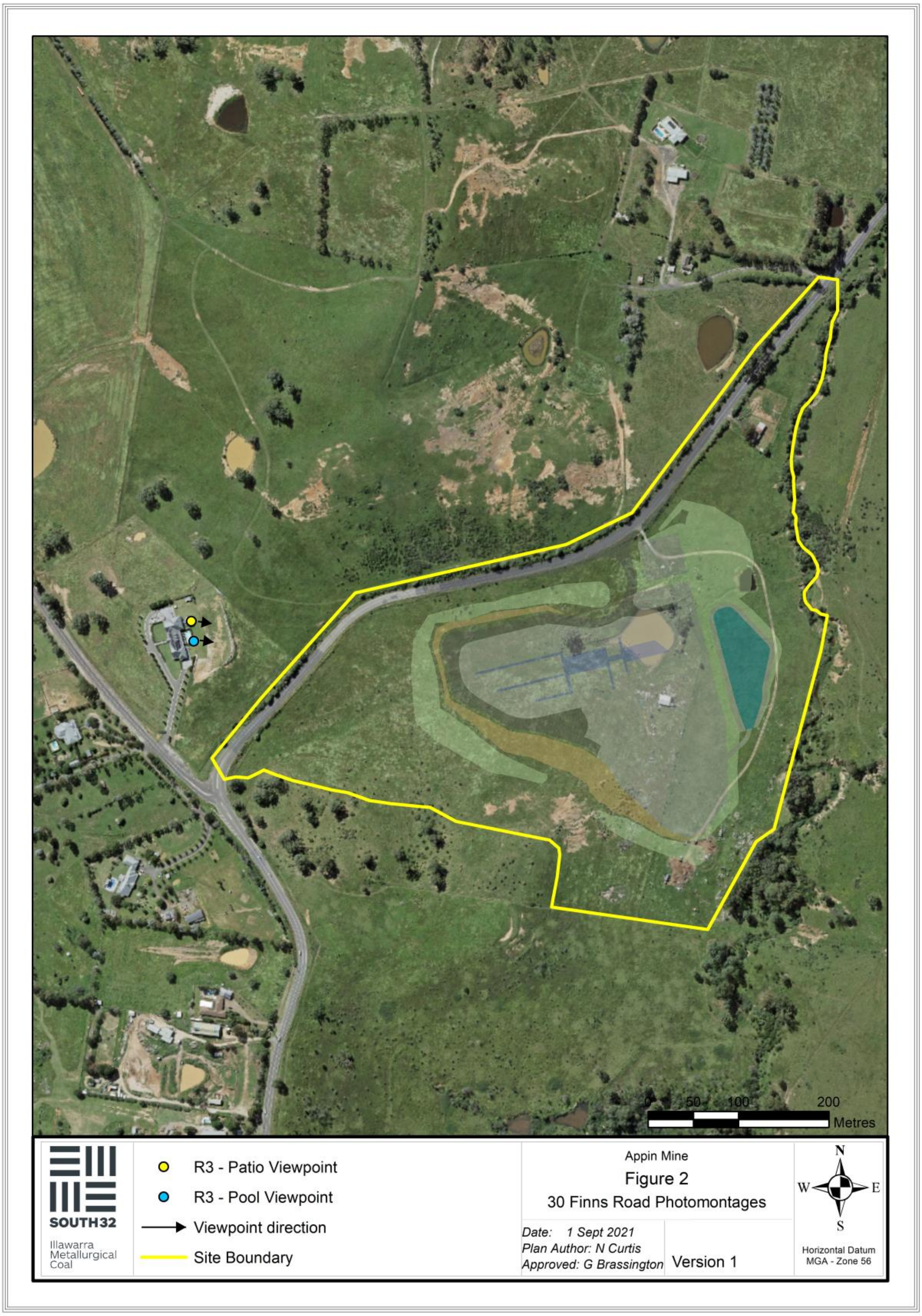


Figure 2 – 30 Finns Road Photomontage locations

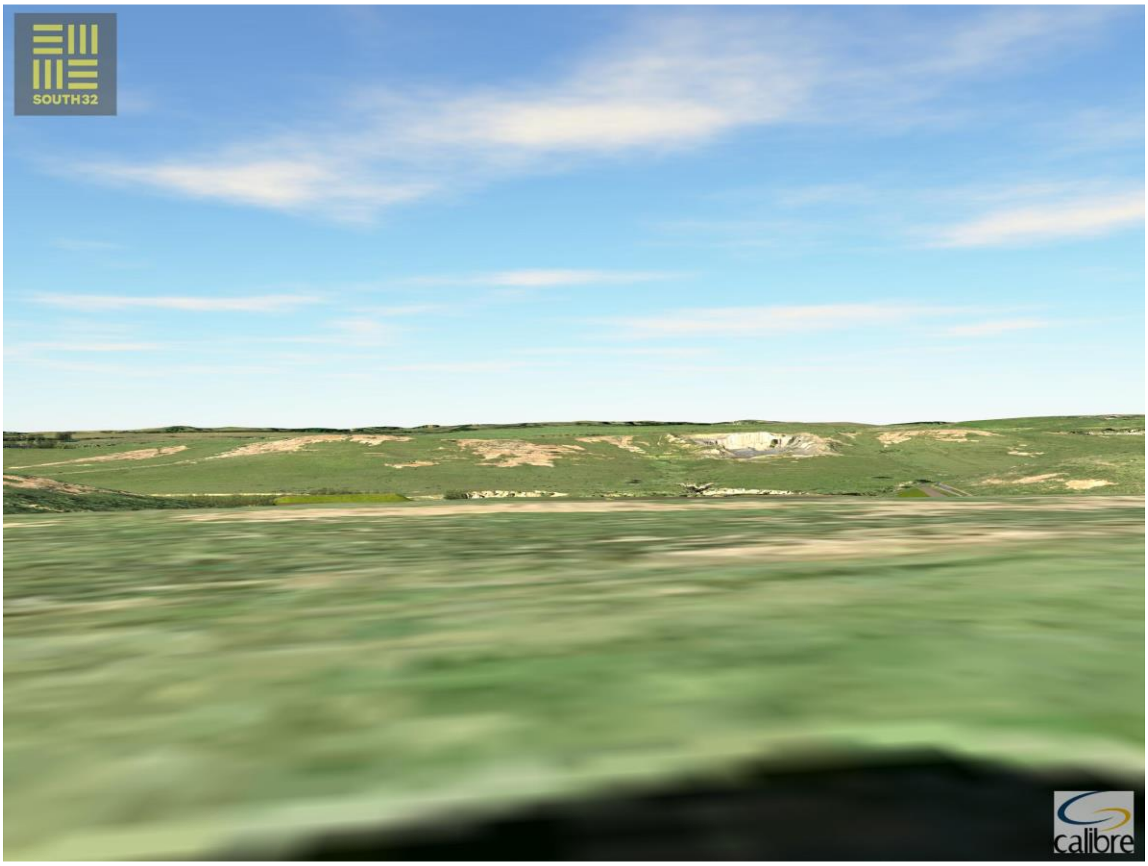


Figure 3 - 30 Finns Road Patio Viewpoint – Construction (no hedge)

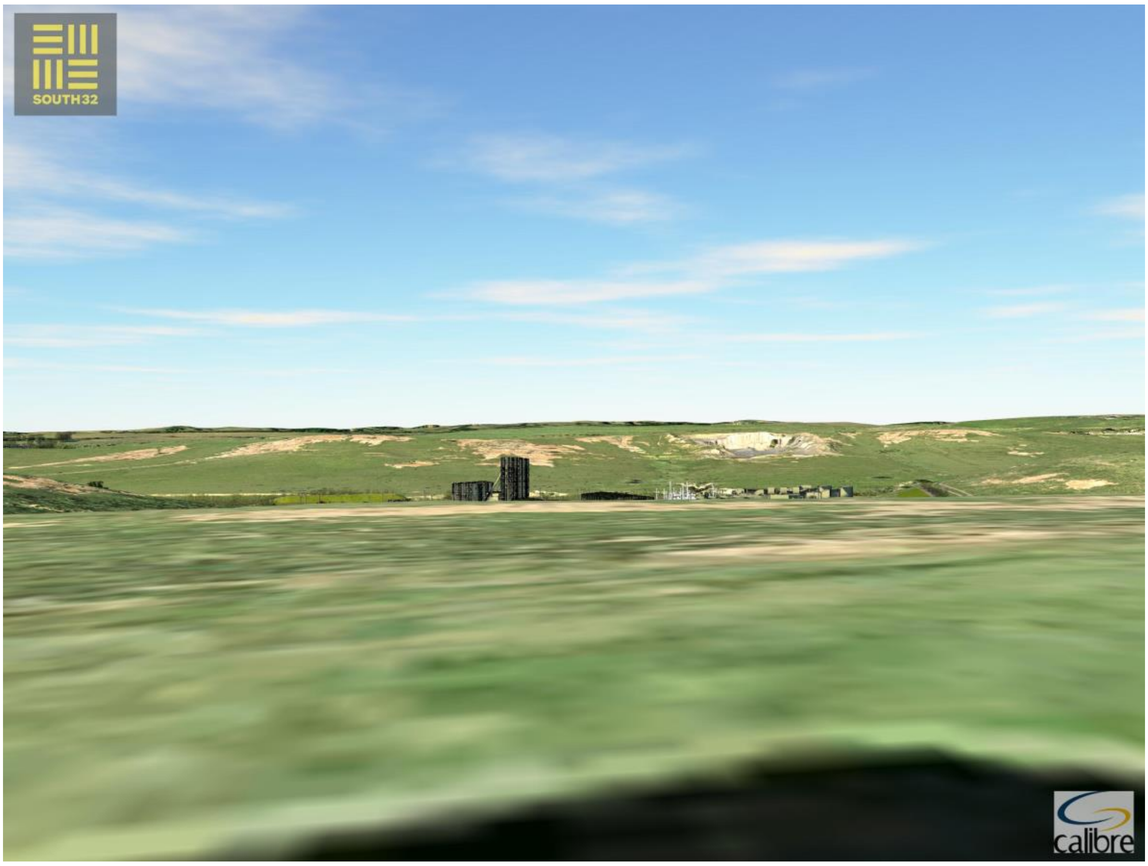


Figure 4 - 30 Finns Road Patio Viewpoint - Boundary Trees 3 Years (no hedge)

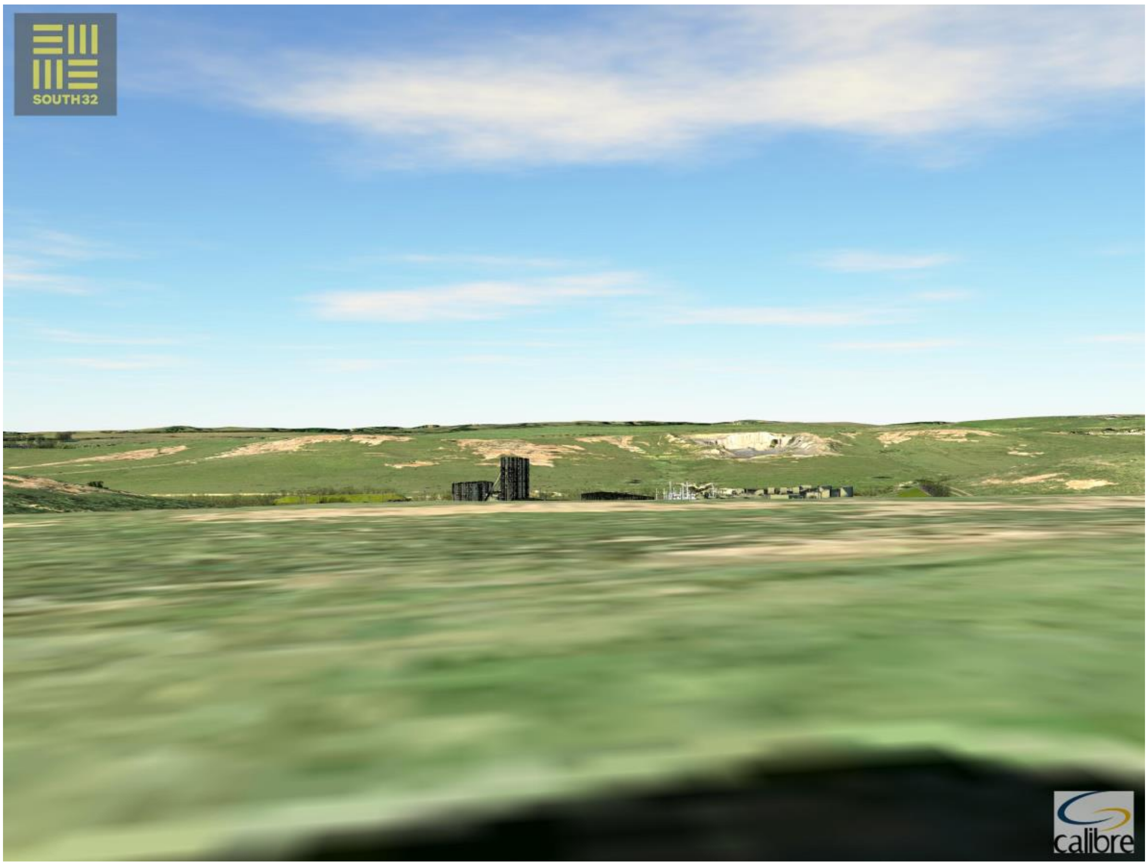


Figure 5 - 30 Finns Road Patio Viewpoint – Boundary Trees 5 Years (no hedge)

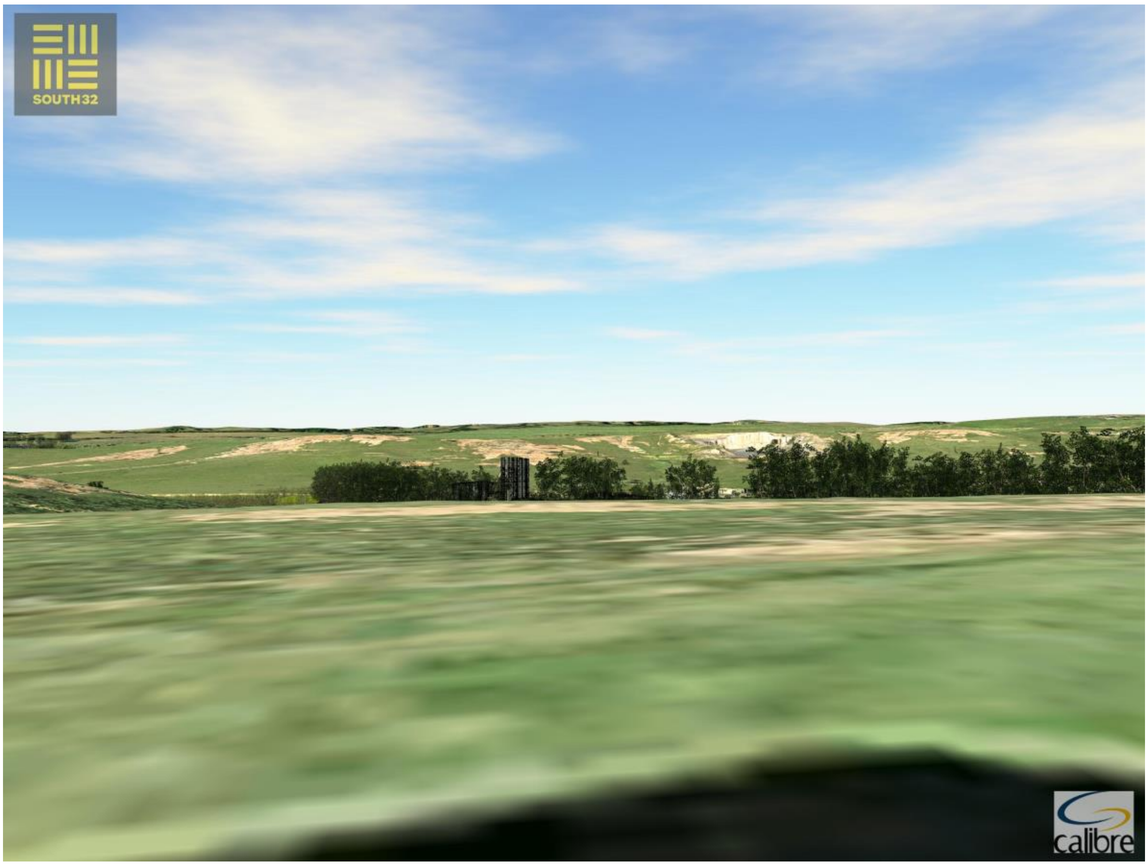


Figure 6 - 30 Finns Road Patio Viewpoint – Boundary Tree Maturity (no hedge)

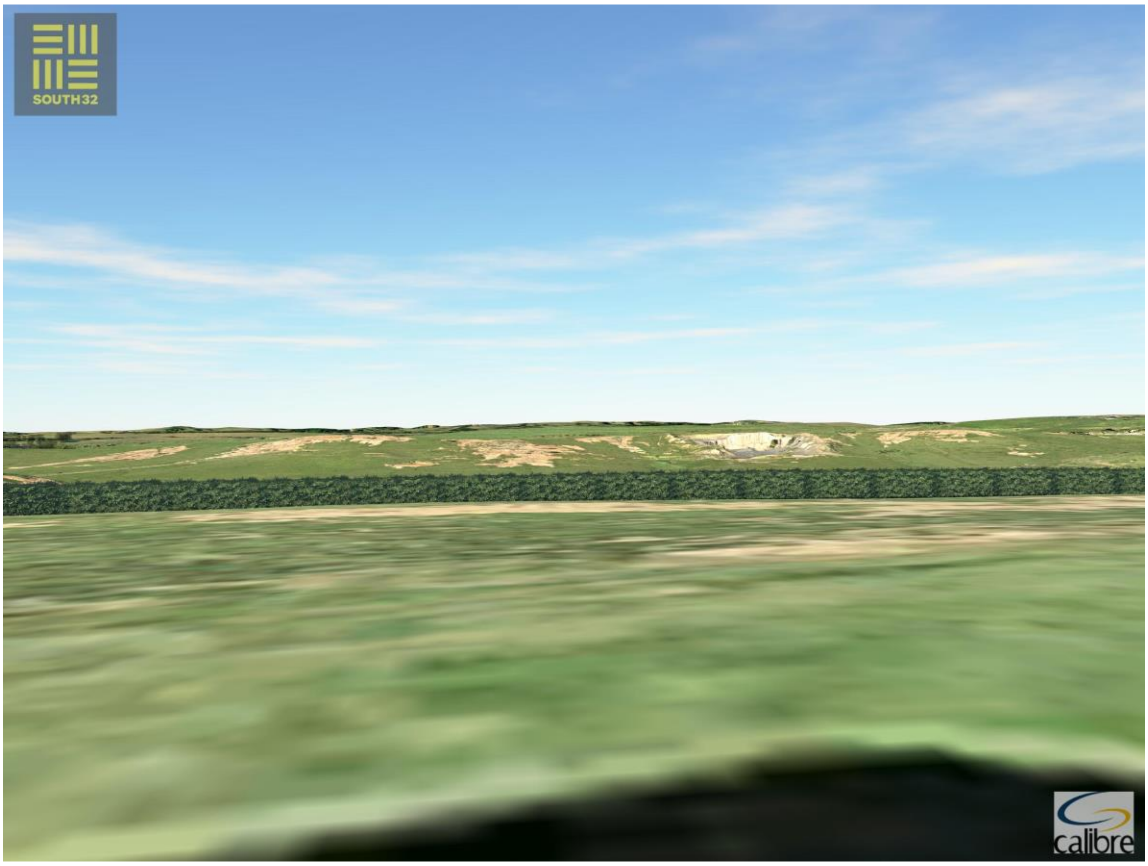


Figure 7 - 30 Finns Road Patio Viewpoint - 1.2m Hedge and Boundary Trees – Construction

Figure 8 - 30 Finns Road Patio Viewpoint - 1.2m Hedge and Boundary Trees - 3 Years

Figure 9 - 30 Finns Road Patio Viewpoint - 1.2m Hedge and Boundary Trees - 5 Years

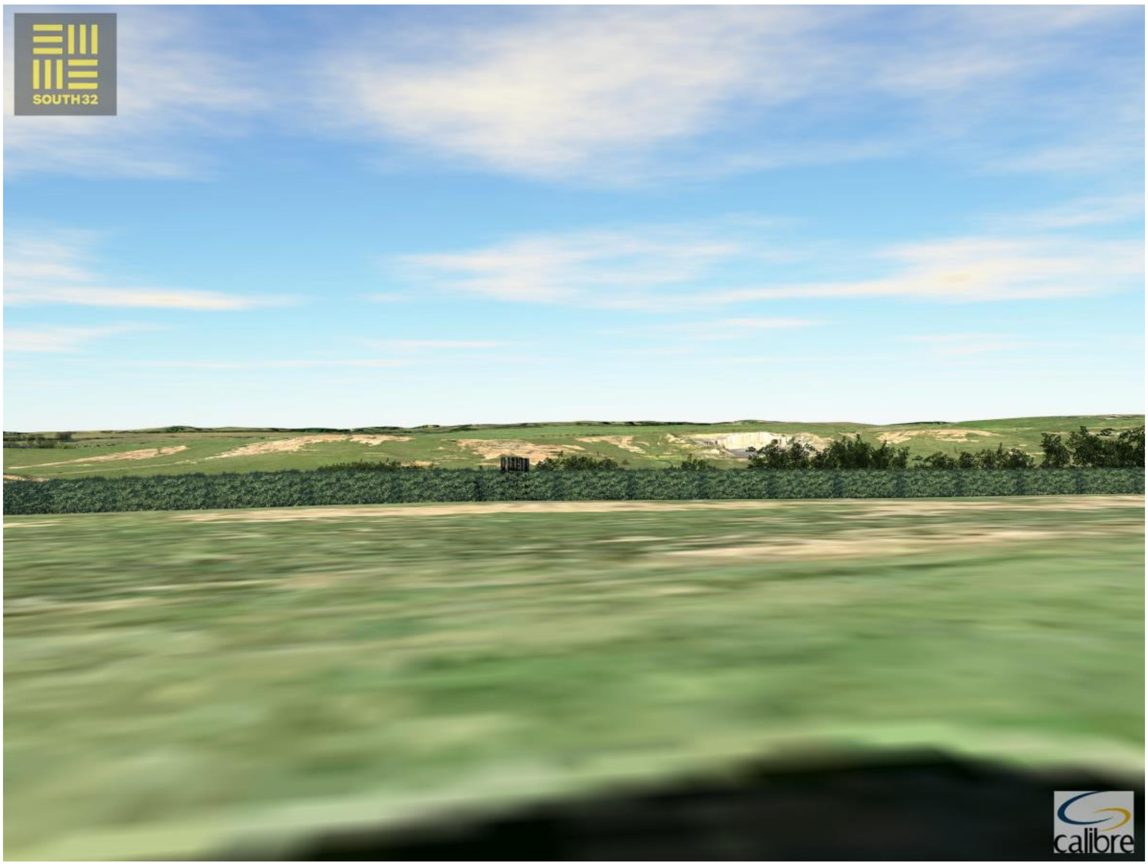


Figure 10 - 30 Finns Road Patio Viewpoint - 1.2m Hedge and Boundary Trees - Tree Maturity

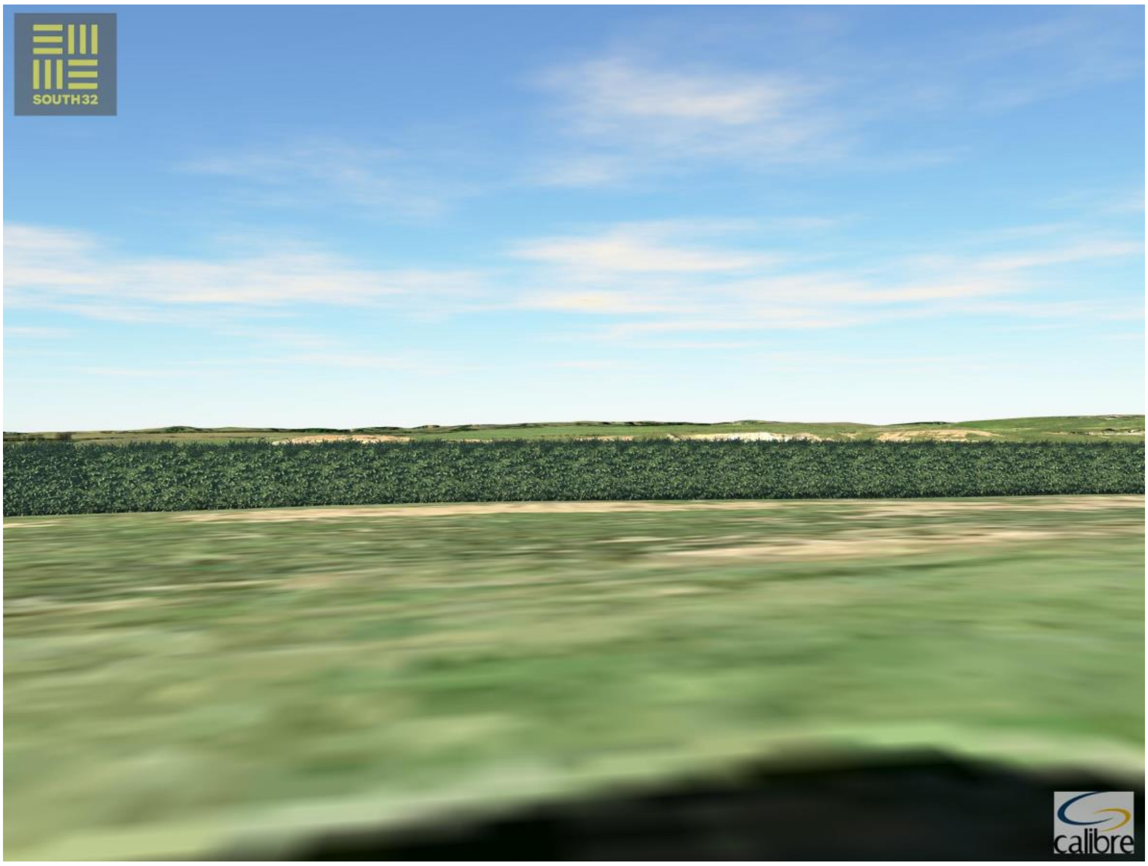


Figure 11 - 30 Finns Road Patio Viewpoint - 2.1m Hedge and Boundary Trees - 5 Years

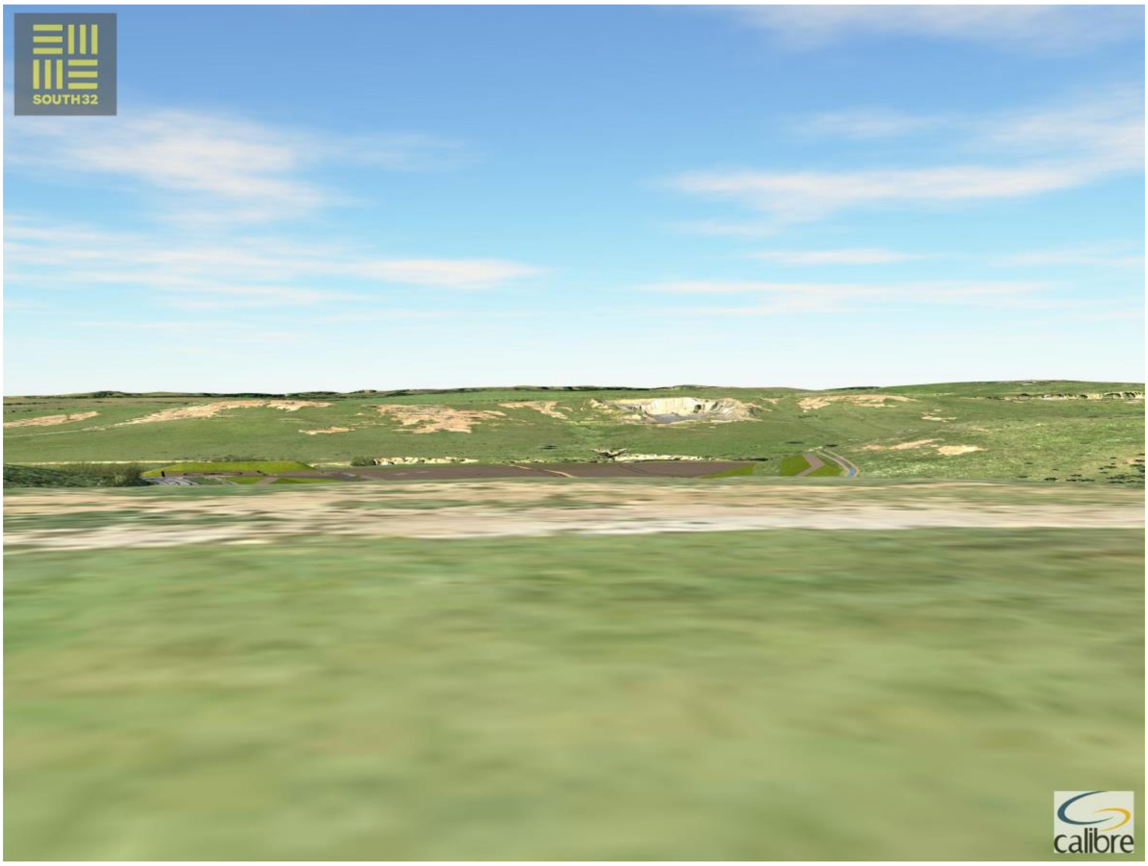


Figure 12 - 30 Finns Road Pool Viewpoint – Construction (no hedge)

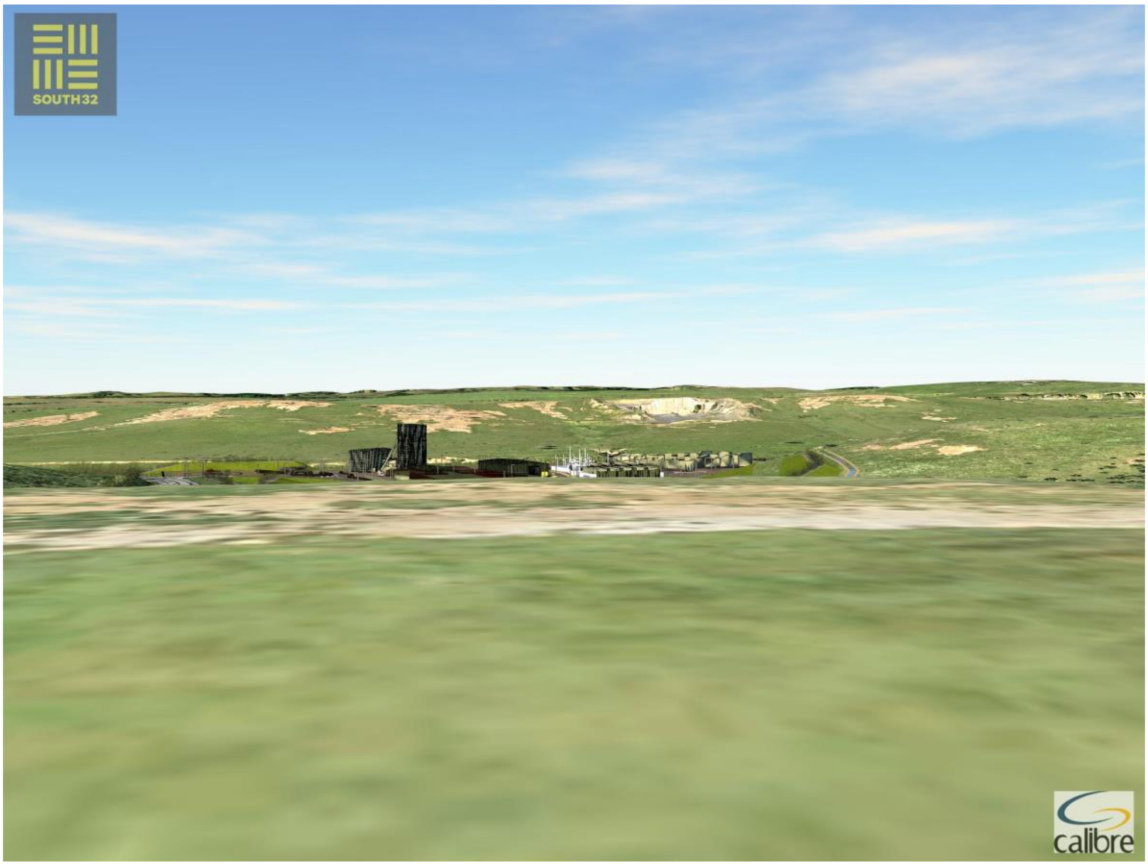


Figure 13 - 30 Finns Road Pool Viewpoint – Boundary Tree 3 Years (no hedge)

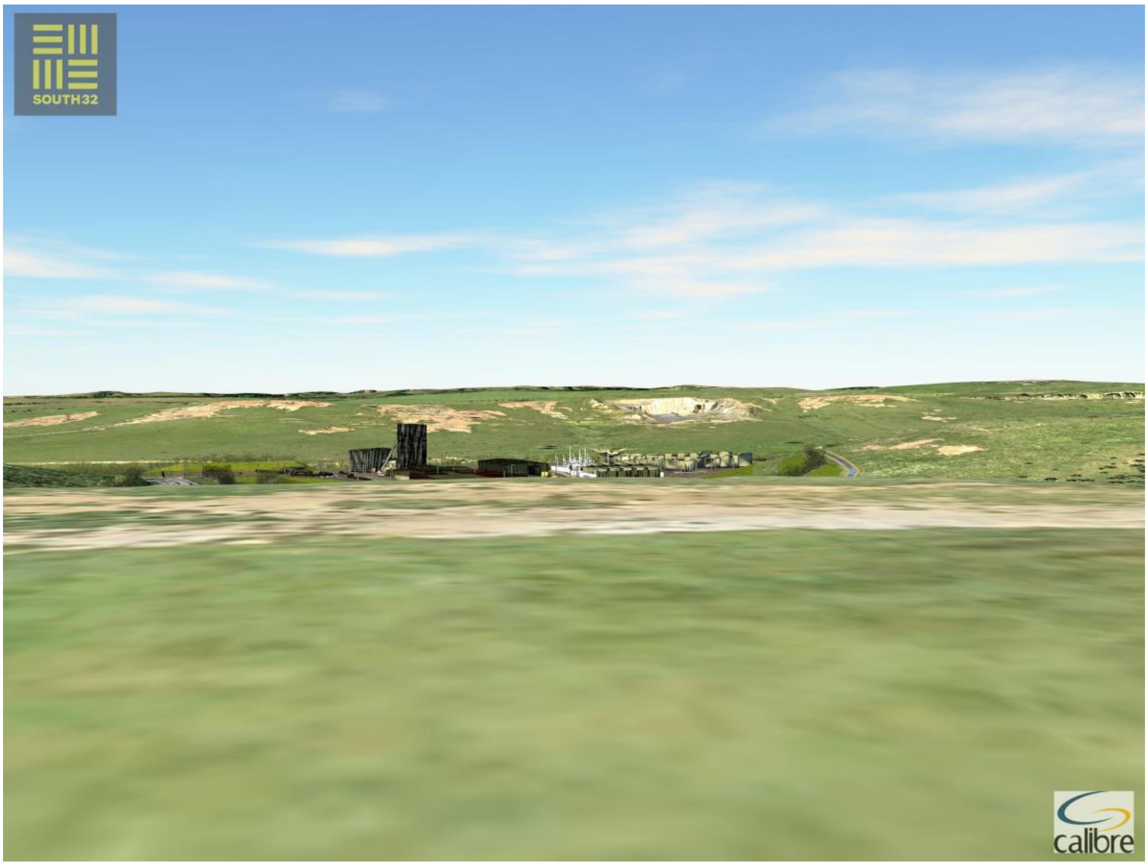


Figure 14 - 30 Finns Road Pool Viewpoint – Boundary Tree 5 Years (no hedge)

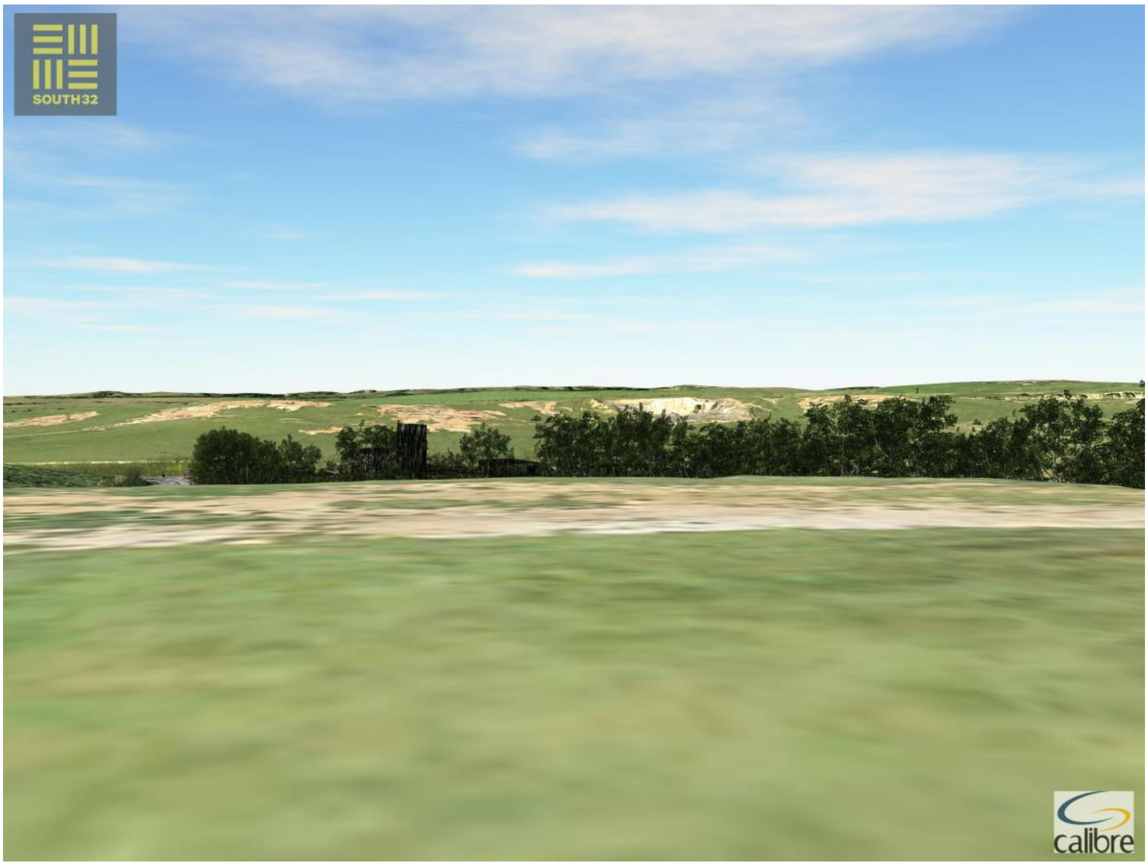


Figure 15 - 30 Finns Road Pool Viewpoint – Boundary Tree Maturity (no hedge)

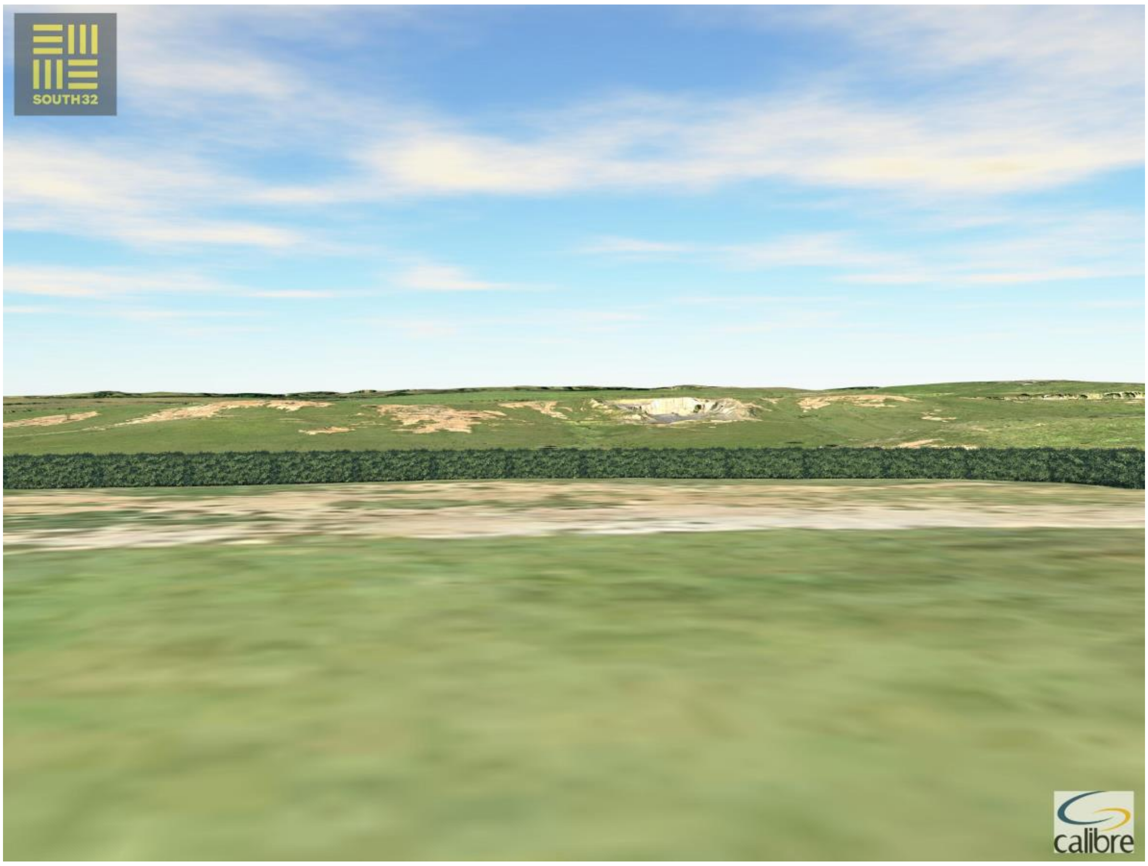


Figure 16 - 30 Finns Road Pool Viewpoint - 1.2m Hedge and Boundary Tree - Construction

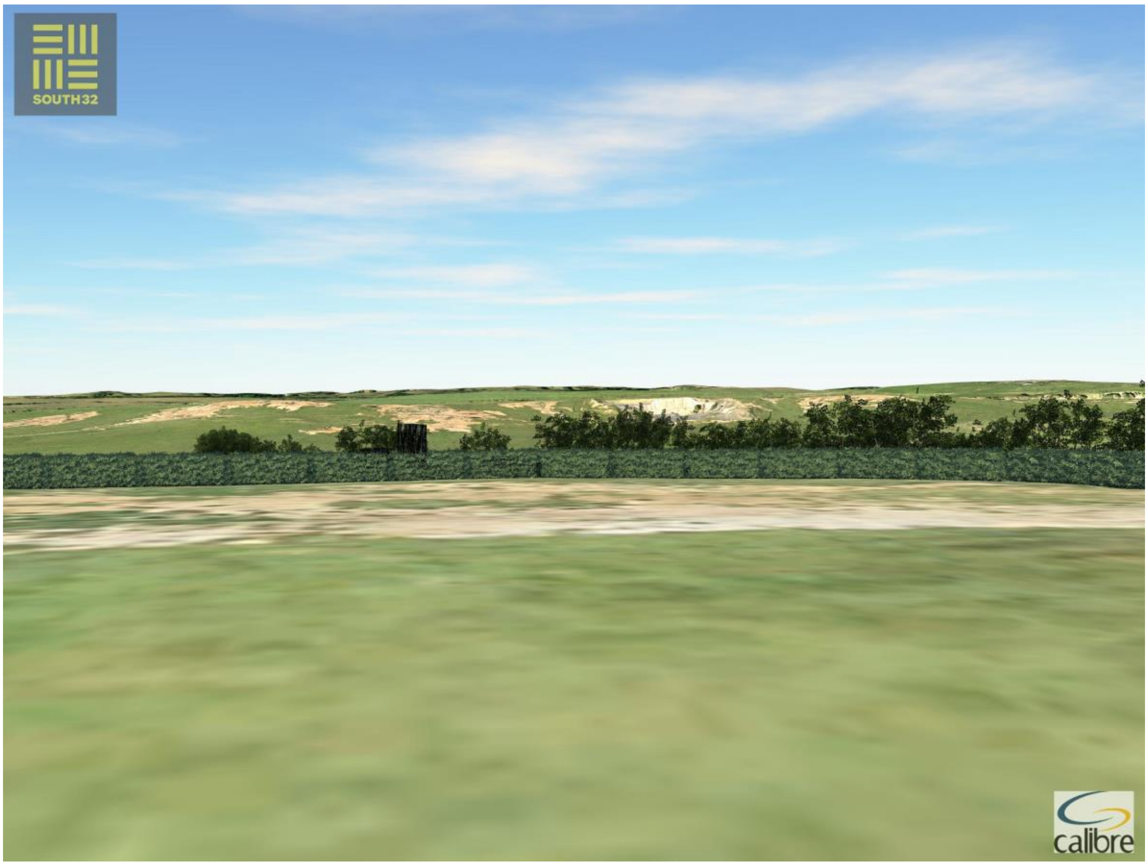


Figure 17- 30 Finns Road Pool Viewpoint - 1.2m Hedge and Boundary Tree - Tree Maturity

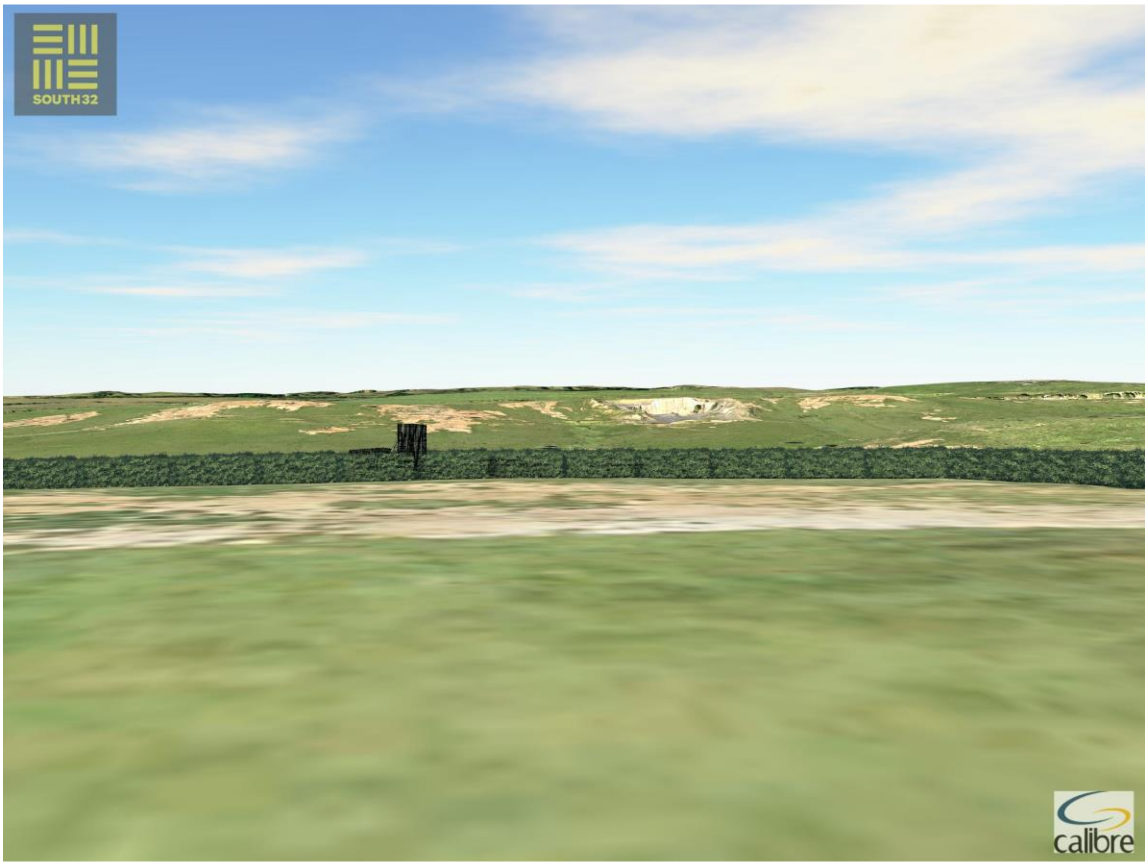


Figure 18 - 30 Finns Road Pool Viewpoint - 1.2m Hedge and Boundary Tree - Trees 3 Years

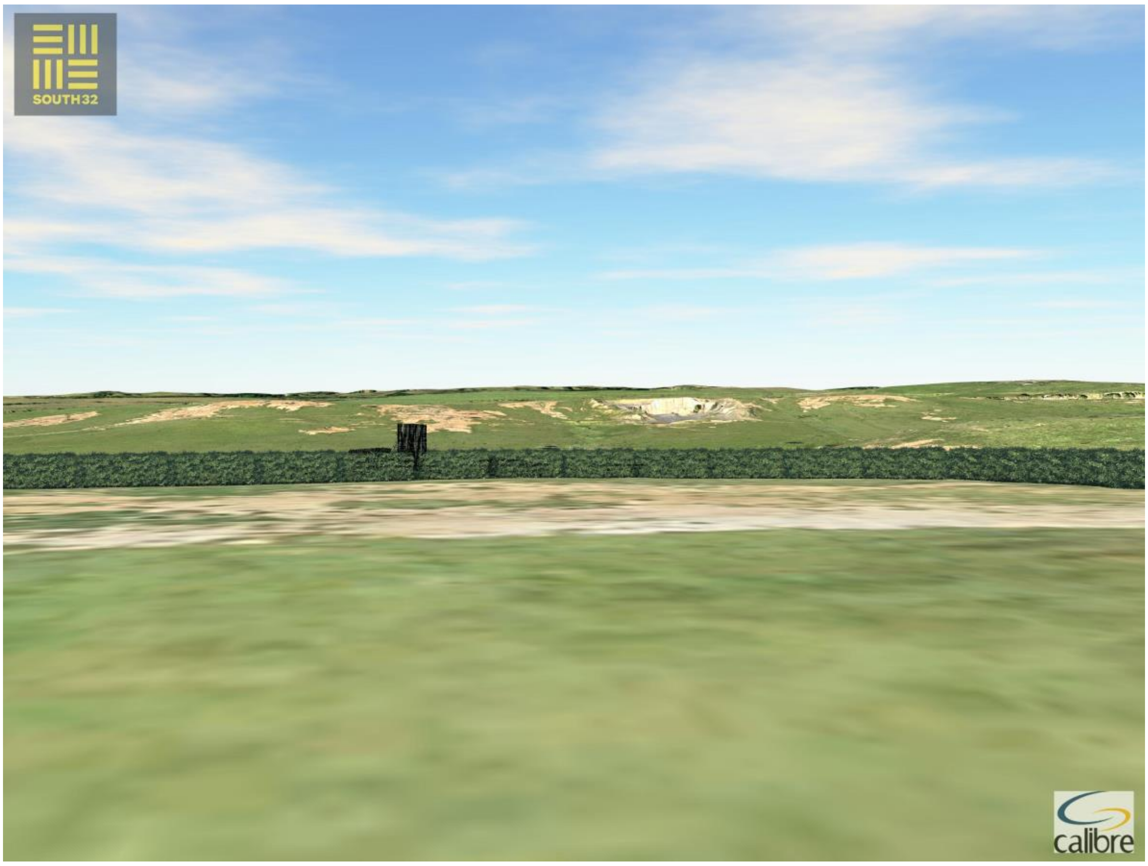


Figure 19 - 30 Finns Road Pool Viewpoint - 1.2m Hedge and Boundary Tree - 5 Years

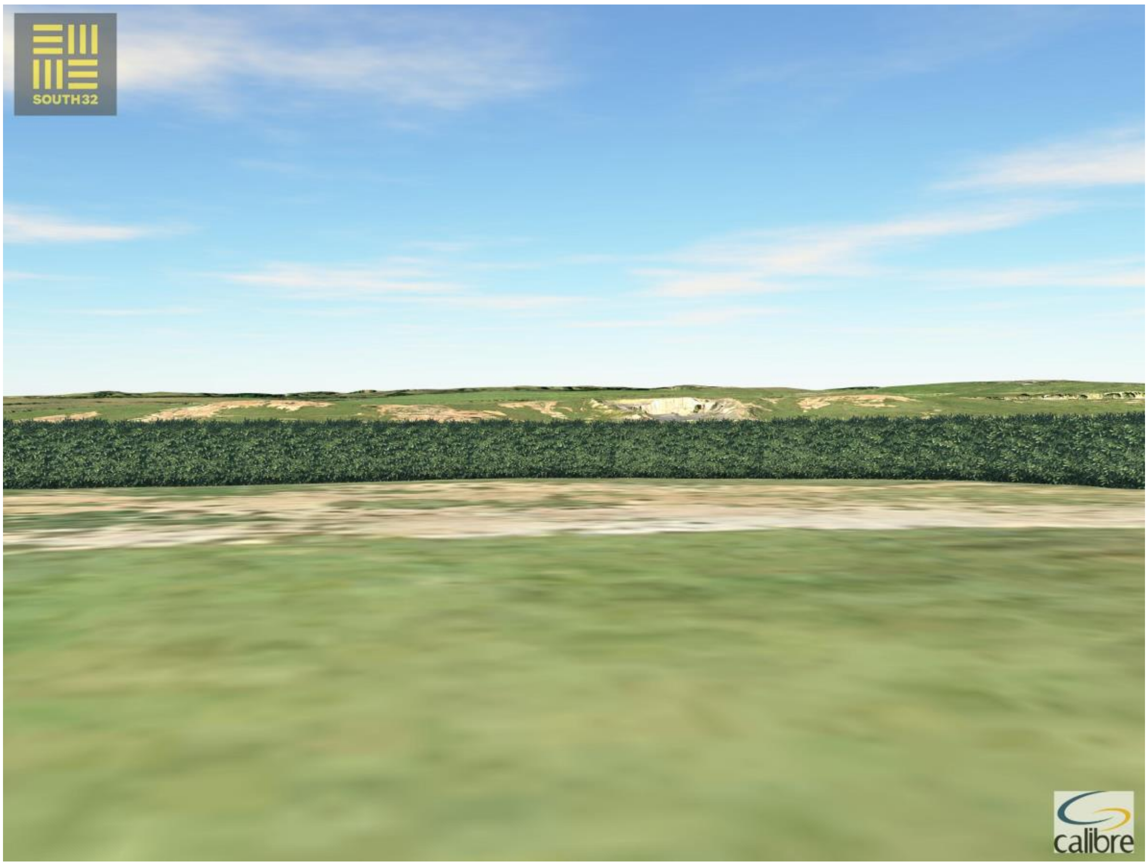


Figure 20 - 30 Finns Road Pool Viewpoint - 2.1m Hedge and Boundary Tree - 5 Years