APPENDIX 8A

Blast Impact Assessment




ENVIRO STRATA CONSULTING Pty Ltd
A.B.N. 35 122 301 795

24 Albert Street
Valentine NSW 2280
T: (02) 4946 1864
M: 0407 005 352
Email: enviro.strata@gmail.com

Thomas Lewandowski
B.E. (Mining), M.M.Mgt,
M.Aus.I.M.M.,
M.I.S.E.E.,
M.EFEE.

UMWELT AUSTRALIA ON BEHALF OF MOUNT OWEN PTY LIMITED

BLAST IMPACT ASSESSMENT OF THE MOUNT OWEN CONTINUED OPERATIONS MODIFICATION 2

FINAL

REPORT NO. UM-1706-240518

Thomas Lewandowski
24th May 2018

UMWELT AUSTRALIA ON BEHALF OF MOUNT OWEN PTY LIMITED

BLAST IMPACT ASSESSMENT OF THE MOUNT OWEN CONTINUED OPERATIONS MODIFICATION 2

FINAL

REPORT NO. UM-1706-240518

TABLE OF CONTENTS

1.0 INTRODUCTION 3

2.0 PROJECT DETAILS 4

3.0 CONCEPTUAL BLAST DESIGN 7

4.0 GROUND VIBRATION AND AIRBLAST PREDICTIVE MODELS 12

4.1 PREDICTIVE MODELS 12
4.1.1 GROUND VIBRATION PREDICTIVE MODEL FOR SURFACE CONDITIONS 12
4.1.2 AIRBLAST OVERPRESSURE PREDICTIVE MODEL 14
4.2 BLAST EMISSION CRITERIA 16
4.2.1 CRITERIA FOR PRIVATE RESIDENCES 16
4.2.2 CRITERIA FOR HISTORICAL SITES, INFRASTRUCTURE AND MAIN CREEK 17

5.0 BLAST IMPACT ASSESSMENT 23

5.1 COMMUNITY 23
5.1.1 INTRODUCTION 23
5.1.2 LOCATION OF PRIVATE RESIDENTIAL RECEIVERS 23
5.1.3 ASSESSMENT RESULTS 26
5.1.3.1 GROUND VIBRATION 26
5.1.3.2 AIRBLAST OVERPRESSURE 28
5.1.3.3 FLYROCK AND OTHER ISSUES 31
5.2 HISTORICAL SITES, INFRASTRUCTURE AND MAIN CREEK 31
5.2.1 LOCATION OF HISTORICAL SITES, INFRASTRUCTURE AND MAIN CREEK 31
5.2.2 ASSESSMENT RESULTS 36
5.2.2.1 GROUND VIBRATION 36
5.2.2.2 AIRBLAST 39
5.2.2.3 FLYROCK 40

6.0 DATA GAP ANALYSIS 40

7.0 MANAGEMENT AND MITIGATION MEASURES 41

8.0 CONCLUSIONS 45

REFERENCES 47

APPENDICES 49

ENVIRO STRATA CONSULTING Pty Ltd
A.B.N. 35 122 301 795

24 Albert Street
Valentine NSW 2280
T: (02) 4946 1864
M: 0407 005 352
Email: enviro.strata@gmail.com

Thomas Lewandowski
B.E. (Mining), M.M.Mgt,
M.Aus.I.M.M.,
M.I.S.E.E.,
M.EFEE.

1.0 INTRODUCTION

Enviro Strata Consulting Pty Limited (ESC) was engaged by Umwelt (Australia) Pty Limited (Umwelt) to undertake a Blast Impact Assessment (BIA) for the Mount Owen Continued Operations Modification 2 (Proposed Modification) on behalf of Mt Owen Pty Limited (Mount Owen).

The Mount Owen Complex is located within the Hunter Coalfields in the Upper Hunter Valley of New South Wales (NSW), approximately 20 kilometres (km) north-west of Singleton, 24 km south-east of Muswellbrook and to the north of Camberwell. Mt Owen Pty Limited (Mount Owen), a subsidiary of Glencore Coal Pty Limited (Glencore), currently owns three existing open cut operations in the Mount Owen Complex; Mount Owen (North Pit) and associated infrastructure, Ravensworth East (Bayswater North Pit (BNP)) and Glendell (Barrett Pit).

Mount Owen received development consent (SSD-5850) from the Planning Assessment Commission for the Mount Owen Continued Operations Project (Continued Operations Project) in November 2016. The Continued Operations Project development consent incorporates all previously approved operations at the Mount Owen Mine and Coal Handling and Preparation Plant (CHPP) and Ravensworth East Mine and allows for continued and expanded mining until 2031, now referred to as the 'Approved Operations'. Glendell Mine operates under a separate consent (DA 80/952) and does not form part of the Approved Operations.

In September 2017 Mount Owen modified SSD-5850 (Modification 1) to allow for the construction of a water pipeline from the Integra Underground Mine to the Mount Owen Complex and allow the integration of the Integra Underground Mine into the Greater Ravensworth Area Water and Tailings Scheme (GRAWTS). Mount Owen now proposes to further modify development consent SSD-5850 to allow for the optimisation of the North Pit mine plan to access coal reserves from the mining tenements obtained by Glencore through its acquisition of the Integra Underground Mine (the Proposed Modification).

This BIA has been prepared by ESC on behalf of Umwelt as part of the Statement of Environmental Effects for the Proposed Modification.

The BIA will assess the impact of the Proposed Modification on the following:

- local community; including private residences,
- historic / heritage points of interest,
- existing and proposed infrastructure, including adjacent mines, and
- neighbouring Main Creek area.

The BIA includes ground vibration and airblast overpressure modelling, utilising parameters representative for the Mount Owen conditions. The blasting methods remain the same as for the Approved Operations. The results of this assessment are presented in the context of the relevant vibration and overpressure limits for the local community, historical sites and infrastructure as outlined in the current Approved Operations development consent (SSD-5850).

2.0 PROJECT DETAILS

Mount Owen Continued Operations Modification 2

The Proposed Modification will enable access to approximately 35 million tonnes (Mt) of additional run-of-mine (ROM) coal from the North Pit. Recovery of the additional coal reserves will result in approximately 46 hectares (ha) of additional disturbance (Proposed Disturbance Area), refer to **Figure 1**, representing an increase of approximately 1.8 per cent to the total disturbance area currently approved, and require an increased depth in the North Pit to provide for mining down to the Hebden Seam. The change to the North Pit mine plan will require the extension of the mine life through to 2037 (an additional 6 years).

Prior to the acquisition of the Integra Underground mining tenements, the mine plan design for the North Pit did not allow access to the deeper coal seams and was restricted to the east of the approved North Pit footprint. This resulted in the pit floor 'stepping up' as it progressed further southwards and the 'stepping in' of the mine plan along its eastern boundary. The acquisition of the Integra Underground Mine and associated mining tenements has removed this previous constraint and allows for deeper and extended coal extraction across the proposed modified North Pit.

The Proposed Disturbance Area extends further east from the Proposed Modification pit boundary to provide for additional infrastructure such as water management structures and access. In addition, the northern extent of the Proposed Disturbance Area is identified to provide for earthworks to shape and improve the final landform of the North Pit to tie into the surrounding topography, these works are located in proximity to the existing approved Bettys Creek diversion. It is not proposed to modify the existing Bettys Creek diversion in this area which continues through the South East Offset and South East Corridor Offset areas into Main Creek.

No changes are proposed to current mining methods, extraction limits, transportation methods, operational hours or workforce numbers. The Proposed Modification will utilise existing and approved infrastructure with the exception of proposed water management structures to manage water from the mining operation.

Table 1 provides a comparison between the Approved Operations and the Proposed Modification.

Table 1: Comparison between the Approved Operations and the Proposed Modification

Component	Approved Operations	Proposed Modification
Mining Method	Truck and excavator	No change to mining methods
Target Seams	Down to Hebden Seam Down to approximately 300 m depth	No change to target seams Down to approximately 380 m depth (average 340 m)
Total Reserve Recovered	Total of 257 Mt ROM coal (Ravensworth East – 48 Mt Mount Owen – 209 Mt)	Additional approximately 35 Mt ROM coal over the life of the mine (approximately 13% of total approved reserve)
Disturbance Area	Approved Disturbance Area of 2534 ha	Additional 46 ha disturbance (increase of 1.8% of total Approved Disturbance Area) Modification to SSD-5850 consent boundary to include Proposed Disturbance Area
Annual Production	Ravensworth East – 4 Mtpa Mount Owen – 10 Mtpa	No change to annual production limit
Mine Life	2031	2037
CHPP Capacity	Up to 17 Mtpa	No change to CHPP capacity
Management of Mining Waste	Emplacement of waste in-pit and out-of-pit, up to maximum existing approved height of 230 m. Tailings emplacement in Ravensworth East voids (including West Pit), within in-pit tailings cells in North Pit and/or BNP, and transfer under the GRAWTS to Liddell (subject to relevant approvals)	Emplacement of waste in Approved Disturbance Areas (up to maximum existing approved height) Tailings emplacement within West Pit, in-pit tailings cells in North Pit and/or BNP, and transfer under the GRAWTS
Water Management	Upper and Middle Bettys Creek Diversions Management of water within the water management system and GRAWTS Works to provide flood attenuation for Yorks Creek	No changes to existing approved creek diversions Extension of water management system to Proposed Disturbance Area and continued management of water within the GRAWTS Proposed amendments to design of existing water management system to provide flood attenuation for Yorks Creek
Operational Workforce	Up to approximately 660 at Mount Owen and up to 260 at Ravensworth East	Continued employment of existing Mount Owen workforce (up to approximately 660) for an additional 6 years
Hours of Operation	24 hours, 7 days per week	No change to hours of operation
Interactions with Integra Underground	Minimum 250 m separation subject to strict safety and operational controls	No change to minimum separation – implementation of safety and operational controls through integration of Glencore owned mining operations
Final Landform	Final voids at BNP and North Pit Final landform approved with commitments relating to landform design (including micro relief), conservation and water management considerations as part of further detailed mine design	No additional void in final landform Proposed changes to the final void arrangement in North Pit Final landform to be designed to incorporate detailed design commitments relating to landform design (including micro relief), conservation and water management considerations and be consistent with the existing progressive rehabilitation objectives in the development consent

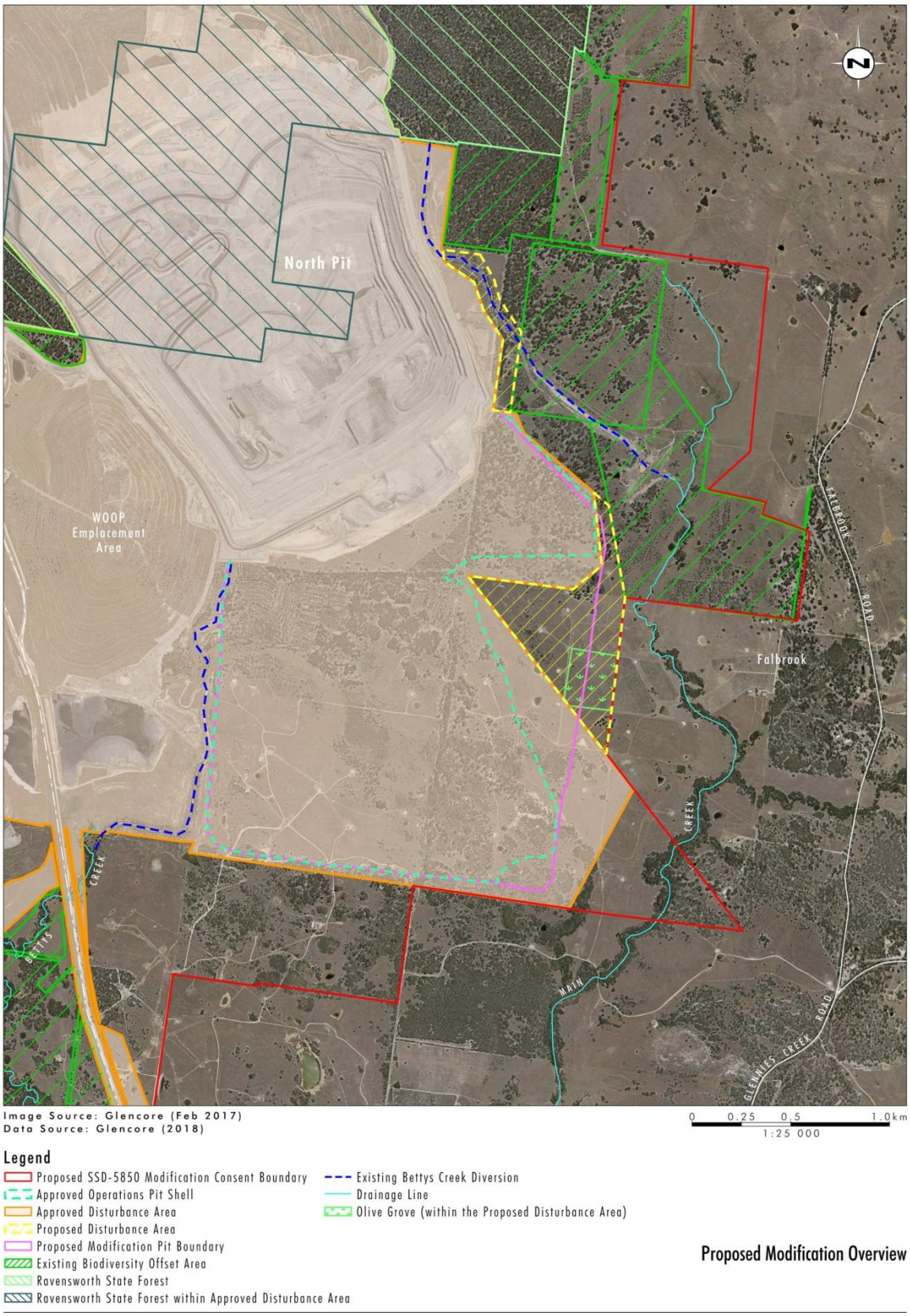


Figure 1 – Proposed Modification Overview (after Umwelt, 2017)

3.0 CONCEPTUAL BLAST DESIGN

Mining Stages

The Proposed Modification Pit Shell and Proposed Disturbance Area are shown in **Figure 1**. The Proposed Modification requires revisions to the current approved mine plans, the anticipated pit shells for Stage 1, Stage 2 and Stage 3 corresponding to operating year 2, 8 and 15 respectively, are highlighted in **Figure 2**. The mine plans for Stage 1, Stage 2 and Stage 3 are representative of the mine plans for the life of the North Pit, as modified; the corresponding boundaries capture the possible worst case impacts associated with the Proposed Modification.

The conceptual mine stage plans (Stage 1, Stage 2 and Stage 3) were selected as they are considered to be representative of the key features of the proposed mining progression for the North Pit as outlined below:

- **Stage 1**: This stage represents the continuation of mining activities in the south-east direction, i.e. the current direction of the North Pit area. The extent of Stage 1 corresponding to year 2 of the modified operations is marked in blue. This stage will allow for an efficient continuation of approved mining within the North Pit. Mining activities (primarily pre strip operations and top seam extraction) will be undertaken to the south-east into the Proposed Disturbance Area.
- **Stage 2**: Stage 2 marked in yellow corresponds to year 8 of the modified operations. During this stage the pit direction turns from the original south-east to a southerly direction along the modified eastern boundary of the pit shell. With the pit progression, there is potential for blast impacts to the south – affecting the south-eastern neighbouring residents in Middle Falbrook and to the east – residents in Falbrook, i.e. this will primarily occur as the most southern and eastern extraction pit boundaries are reached during this stage.
- **Stage 3**: Stage 3 marked in green corresponds to year 15 of the modified operations. Stage 3 represents the southernmost extent of the North Pit shell and the closest point where blasting will be undertaken with respect to private residences located to the south and southeast. As such there is potential for impact on the residents to the south-east and east affecting Middle Falbrook and Falbrook residents. In the southern direction residents of Camberwell will be at their closest to the pit and are considered to receive low to negligible blasting impacts of blasting. It is noted that the southern extent of the Proposed Modification is generally consistent with the current Approved Operations.

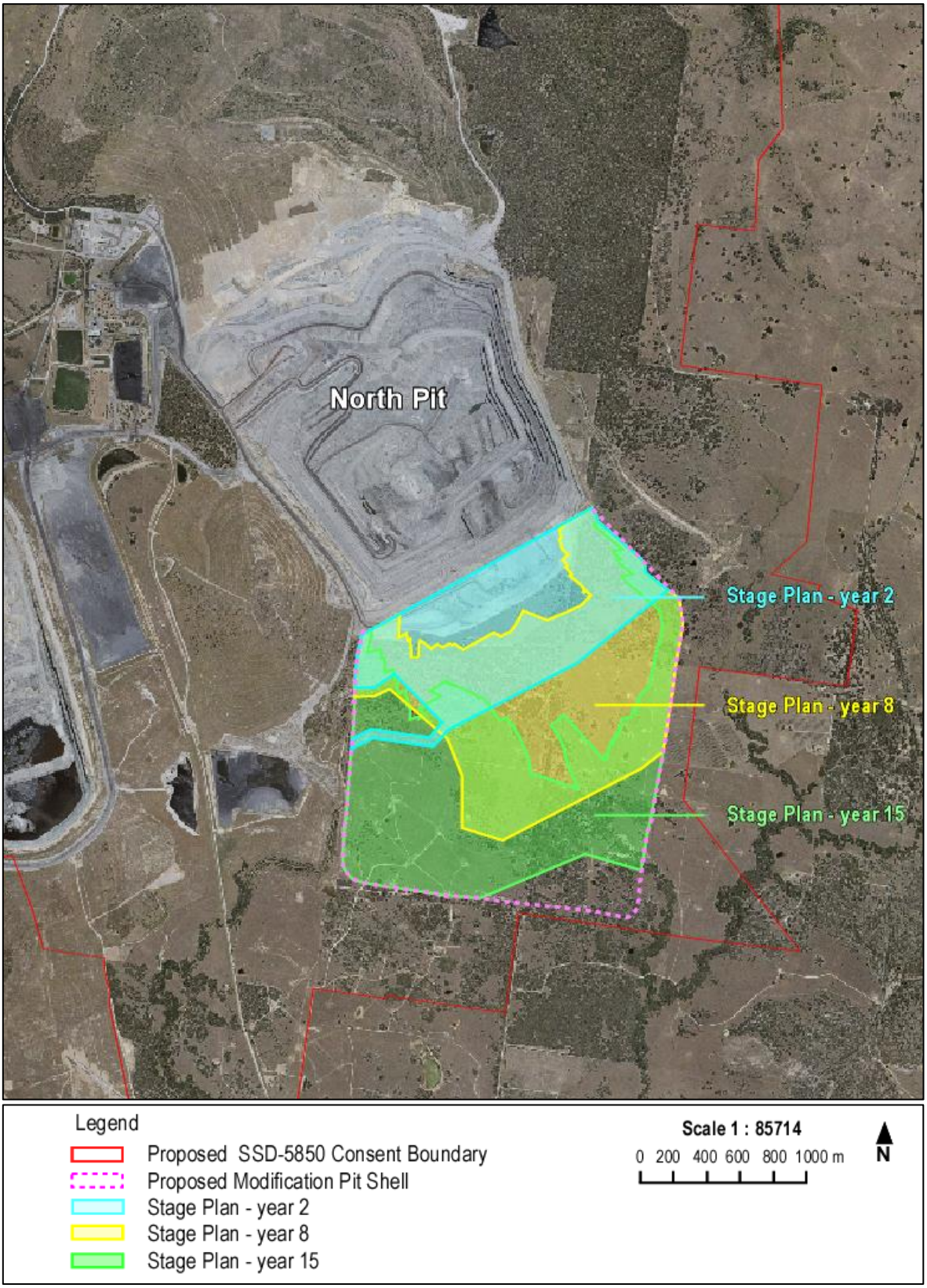


Figure 2 – The Proposed Modification Pit Shell Boundaries by Selected Modelling Year

Typical Blast

The coal recovery at Mount Owen includes drilling and blasting activities followed by excavation and rock / coal haulage for further disposal or processing.

The operation sequence commences with an initial blast design followed by a bench survey and bench drilling using a drill rig. A typical bench is rectangular in shape with approximately 600 holes and a uniform drilling pattern. The holes are loaded with explosive material and then the top part of the holes is filled with a gravel material (i.e. stemming) to ensure that the energy is contained and a low airblast emission is achieved (i.e. lower environmental impact). Due to the through seam blasting specific for Mount Owen conditions, typically the loaded explosives are then initiated through an electronic detonator system which delivers a signal to the primer / booster placed within each hole. The primer / booster then initiates the explosives. As an electronic detonator system is employed precise timing can be achieved which allows for single hole initiation allowing for a small and precise delay between each blasted hole. This particular system controls the ground and air vibration impacts to the highest degree (i.e. facilitates lower environmental impact). When blasting single deck areas of the pit a nonel system might also be employed where the blast can still be designed to deliver well controlled ground vibrations and airblast. Following firing of the blast, the blasted and fractured rock strata is then removed using a truck and shovel method for further coal processing in the coal processing plant or direct disposal as waste rock. also

As the need arises, other blast design controls are implemented to minimise impacts including limiting charge mass, introduction of deck charges and also the use of predictive meteorological monitoring of the surrounding area. The process for the implementation of these controls is detailed in the approved Mount Owen Complex Blast Management Plan (BMP) (2017) under SSD-5850 for the Approved Operations.

Blasting Frequency and Impact Assessment Criteria

The Approved Operations development consent (SSD-5850) conditions of consent limit blasting times to 9 am to 5 pm Monday to Saturday inclusive and allow for up to 12 blasts per year between 7 am and 9 am Monday to Saturday and excluding public holidays. Up to two blasts per day are permitted or 8 blasts a week, averaged over a calendar year.

The same conditions will apply to the Proposed Modification.

In addition, to minimise cumulative impacts of blasting the Approved Operations development consent (SSD-5850) conditions require that all reasonable endeavours be undertaken in order to co-ordinate the timing of blasting at the site with any nearby mines (including the Glendell and Rix's Creek North Mines).

A list of blasting criteria for a number of receivers is specified under the Approved Operations development consent (SSD-5850). These blasting criteria will be used to assess blasting impacts and are outlined in **Table 3** in Section 4.2.2.

Mount Owen Blast Details

The drill and blasting activities for the Proposed Modification will be generally consistent with the current blasting activities undertaken by Mount Owen. The primary focus of the

drill and blasting activities will be to uncover coal material by blasting the interburden rock strata material for further handling. The Proposed Modification will continue the extraction of a number of coal seams down to the Lower Hebden Seam (on average 340 m from the surface with a maximum depth of 380 m). The mine operates up to 133 working sections with over 8 major coal seams.

The Proposed Modification will continue with open cut extraction activities utilising the drill and blasting method for coal recovery. The blasting activities are undertaken according to the conditions of consent for the Approved Operations development consent (SSD-5850). The blasting is undertaken conforming to the specified limits of 5 and 10 mm/s (for ground vibrations) and 115 and 120 dBL (for air vibrations), as indicated in the Blasting section under Blasting Criteria (Table 4, SSD-5850). The blasting also conforms to other blast vibration criteria listed under the Approved Operations development consent (SSD-5850); these are outlined in Section 4.2.

Blasting is conducted in accordance with an approved Mount Owen Complex Blast Management Plan (BMP) (2017). The BMP enables the design of each blast to minimise dust, fumes and airblast overpressure on the surrounding environment, while at the same time maximise blast efficiency. The implementation of the approved BMP provides for compliance with the site specific blasting conditions.

Blasting activities at the Mount Owen Complex generally utilise combinations of products including standard ammonium nitrate fuel oil (ANFO) for dry conditions, and Heavy ANFO and emulsion blends for wet conditions, see explosive specification presented in **Table 2A**. The same explosive materials are proposed to be used for the Proposed Modification.

All of these details were taken into consideration when undertaking vibration modelling.

Table 2A: Typical Blasting Product Specifications

Products Used	Product Density (kg/m^3)
ANFO	820
Titan 2010	860
Titan 2020	970
2030 Heavy ANFO	1,100
Titan 2040	1,300
Titan 2050	1,200
Titan 2060	1,275
2070 Emulsion	1,350
Stemming	2,300

The mine typically utilises a 229 mm diameter drill rig size. Due to the complexity of the geology, the mine undertakes through seam blasting and presplit type blasting. Typical blasting parameters for through seam blasting are specified in **Table 2B**. Generally, the

blasted benches could vary between 5 and 15 m (plus typically 1 m sub drill). The parameters listed in the table were used in modelling the blast impacts of the Proposed Modification, including minimum and maximum charge masses for dry and wet conditions (i.e. ranging between 33 and 601 kg).

The typical presplit blast design parameters are presented in **Table 2C**, and include a Maximum Instantaneous Charge (MIC) in the order of 450 kg.

Table 2B: Typical Drilling and Blasting Design Details for Through Seam Blasting

Parameter		Value
Drill Rig Hole Diameter (mm)		229
Number of Holes per Blast		620 typically
Drill Pattern		Staggered
Burden (m)		6 – 7*
Spacing (m)		7.5 – 8*
Bench Height (m)		5 – 15 (plus 1 m of sub drill)
Stemming (m)		4.2
MIC (kg) (Dry / Wet)	- 5 m bench	(33 / 56)
	- 15 m bench	(356 / 601)
Blast Size (t)		450,000 typically

* - *(burden x spacing) can vary depending on extracted seam*

Table 2C: Typical Drilling and Blasting Design Details for Presplit Blasting

Parameter	Value
Drill Rig Hole Diameter (mm)	229
Number of Holes per Blast	200 typically
Drill Pattern	Single line
Burden (m)	-
Spacing (m)	3
Bench Height (m)	30
Stemming (m)	3
MIC (kg)	450 (5 holes at 90 kg/hole)
Initiation	5 holes fired simultaneously with 20 ms delay between

4.0 GROUND VIBRATION AND AIRBLAST PREDICTIVE MODELS

4.1 PREDICTIVE MODELS

4.1.1 Ground Vibration Predictive Model for Surface Conditions

To provide an indication about potential vibration levels generated from the Proposed Modification for a given point of concern, including residential receivers, infrastructure, historic heritage items and Main Creek, a site law formula was developed. The site law formula recommended by the Australian Standard (AS 2187.2-2006) is accepted by relevant NSW Government agencies as being appropriate for mining blast assessments and has been used in determining the existing site law for the Approved Operations.

The site law formula is specified as follows:

$$PPV = k\left(\frac{D}{\sqrt{m}}\right)^{a}$$

where:
- PPV = Ground vibration as vector Peak Particle Velocity (mm/s)
- D = Distance between charge and point of measurement (m)
- m = Maximum Instantaneous Charge (MIC), effective charge mass per delay (kg)
- a = Site exponent
- k = Site constant

For ground vibration assessment the square-root scaled distance is more appropriate than a cube-root scaled distance and is widely used across the mining industry.

The ground vibration predictive model used in the assessment is based on the model developed for the Continued Operations Project blast impact assessment (used in a 2013 study, ESC 2013) and supplemented by the latest data from ongoing monitoring completed throughout December 2016 to October 2017. The vibration monitoring data was collected at several locations from various blasts undertaken within the Mount Owen Complex and hence is considered fully representative for the Proposed Modification. The analysed sample of data incorporates data from the original 2011 / 2012 monitoring program representing in excess of 170 blasts collected over a one year period and from the latest ongoing monitoring conducted in 2016 / 17 representing 89 blasts. Multiple vibration readings were collected for each blast.

The vibration monitoring data used in the assessment includes monitoring results from the monitoring stations used by Mount Owen Complex. These stations are strategically distributed in all directions in relation to the North Pit, see **Figure 7**. The collated results were used to develop a site law formula, which is specific for the North Pit conditions, see **Figure 3**, which is generally site specific for the given strata conditions. The collected monitoring results were plotted using a standard log / log plot.

The parameters governing ground vibration behaviour for North Pit conditions derived through the site law analysis (corresponding to the 95% confidence level) are specified as follows:

- site exponent a = -1.6
- site constant k = 2,165

The formula used for modelling purposes is therefore:

$$\mathbf{PPV} = 2{,}165 \left(\frac{D}{\sqrt{m}} \right)^{-1.6}$$

Where: **PPV** = Ground Vibration as vector Peak Particle Velocity (mm/s)
D = Distance between charge and point of measurement (m)
m = Maximum Instantaneous Charge (MIC), effective charge Mass per delay (kg)

The 95% confidence level, advocated by the Australian and New Zealand Environment and Conservation Council (ANZECC) guidelines (1990), allows for an inherent variation in emission levels. This is by allowing for a 5% exceedance of the general blast criterion.

Also, for completeness, the site law diagram includes a median level, that is, Peak Particle Velocity (PPV) 50% level. The parameters summarising the site law analysis for a 50% level are specified as follows:

- site exponent a = -1.6
- site constant k = 686

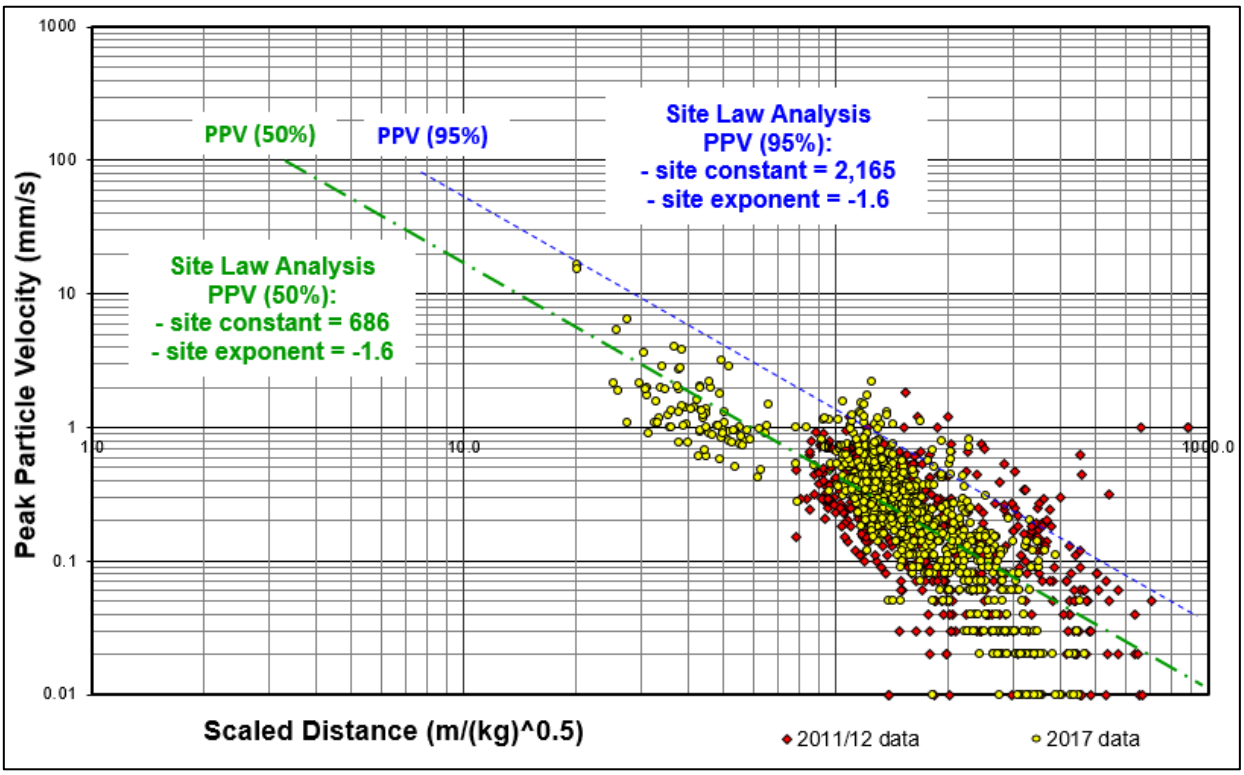


Figure 3 – Site Law Analysis for Mount Owen Complex Surface Conditions

4.1.2 Airblast Overpressure Predictive Model

Similarly to the ground vibration model, to address the airblast overpressure (or air vibration) impacts from the Proposed Modification on the adjacent area, including residential receivers, infrastructure and historic heritage sites, an airblast predictive model has been developed.

As in the ground vibration model, actual monitoring data has been sought from Mount Owen Complex blast monitoring stations to emulate potential airblast overpressure impacts. The analysed sample of data is in excess of 170 blasts collected over a one year period from the original study for the Approved Operations (2011 / 12) and 90 blasts from the latest ongoing monitoring conducted throughout December 2016 to October 2017. Multiple airblast overpressure readings from a number of locations were collected for each blast. The results were recorded by stations located in all directions around the North Pit, and considered fully representative for the Proposed Modification, see **Figure 7**.

The impact of the generated airblast levels from the source of the blast is generally guided by the sonic decay law as recommended in the Australian Standard (AS 2187.2-2006). For the airblast impact assessment, the cube-root scaled distance is more appropriate than the square root used for ground vibration as detailed in the Australian Standard (AS 2187.2-2006).

The sonic decay formula is specified as follows:

$$P = k\left(\frac{D}{\sqrt[3]{m}}\right)^{a}$$

Where:

P	=	Peak Pressure (kPa)
D	=	Distance between charge and point of measurement (m)
m	=	Maximum Instantaneous Charge (MIC), effective charge Mass per delay (kg)
a	=	Site exponent
k	=	Site constant

There are some limitations to this type of assessment as air vibrations are affected by a number of factors. The major limitation is the exclusion of stemming column height in the analysis. This can significantly alter the airblast emission impact on the surrounding area.

Other factors, for example topographical features, blast confinement and weather conditions, are also excluded from this calculation. This can, generally be justified as the impact of some of these factors can be controlled or eliminated by an appropriate pre-blasting assessment procedure (which are implemented at Mount Owen as detailed in the BMP 2017 - Section 3.1) which can, as an example, postpone blasting in adverse weather conditions to minimise potential impacts.

The airblast monitoring measurements were plotted and together with other parameters gave rise to the models shown in **Figure 4.** The presented sonic decay law analysis features two lines corresponding to the median of the measured data set (marked as Sound Pressure

Level (SPL) 50%) and SPL 95% corresponding to 95% of the total population of data. Note that the 95% criterion is utilised following ANZECC guidelines (1990), which allow for an inherent variation in emission levels, by allowing a 5% exceedance of the general blast criterion.

To facilitate the accuracy of the assessment the forced exponent of -1.45 has been used, which corresponds to an attenuation rate of 8.6 dBL with a doubling of distance, as specified in Australian Standard, Explosives – Storage and use, Part 2 – Use of explosives (AS 2187.2-2006).

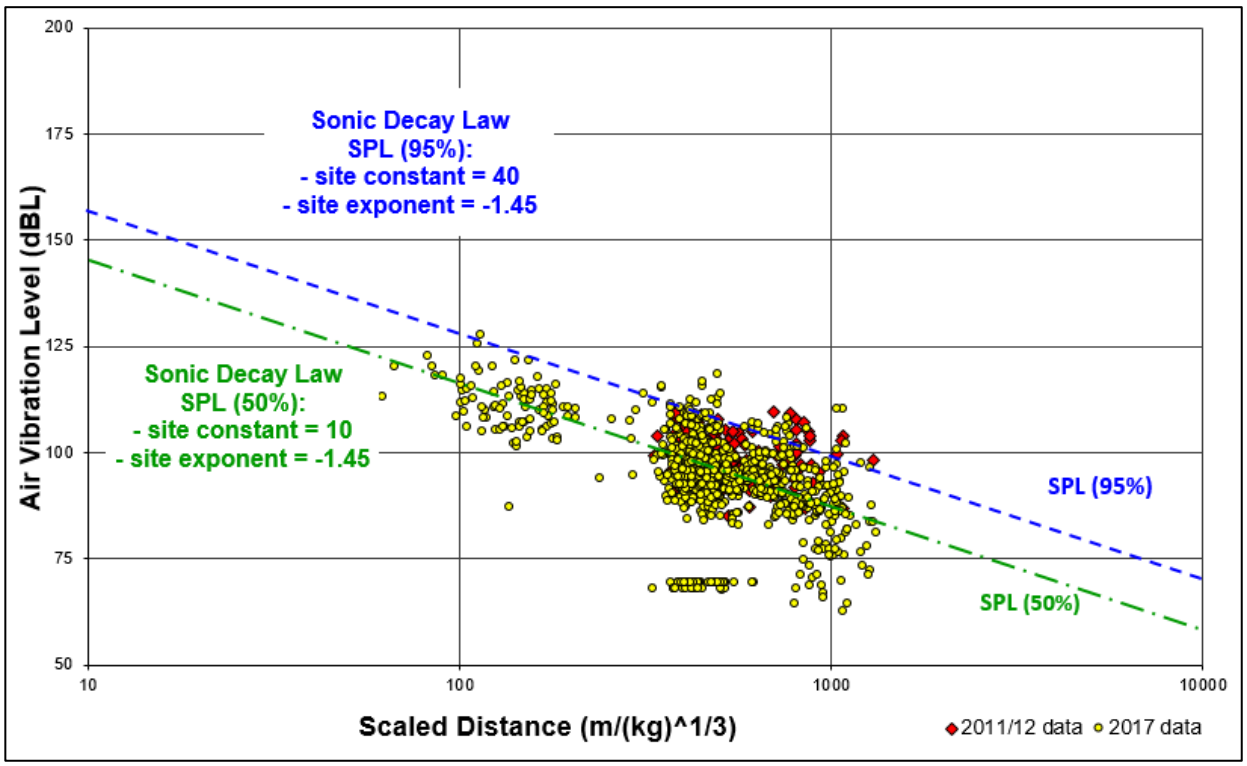


Figure 4 – Sonic Decay Law for Mount Owen Complex Conditions

Therefore, based on the above assessment, the estimated sonic decay parameters (using the 95% confidence level), used in the presented BIA, are as follows:

- site exponent a = -1.45
- site constant k = 40

The formula used for modelling purposes is therefore:

$$\boldsymbol{P} = 40\left(\frac{D}{\sqrt[3]{m}}\right)^{-1.45}$$

Where:

$\boldsymbol{P}$	=	Peak Pressure (kPa)
$\boldsymbol{D}$	=	Distance between charge and point of measurement (m)
$\boldsymbol{m}$	=	Maximum Instantaneous Charge (MIC), effective charge Mass per delay (kg)

For completeness, the parameters summarising the site law analysis for a 50% level are specified as follows:

- site exponent a = -1.45
- site constant k = 10

4.2 BLAST EMISSION CRITERIA

4.2.1 Criteria for Private Residences

The existing ground vibration and airblast emission criteria for private residences are presented below as well as summarised in **Table 3**. The location of private residences and their distance from the Proposed Modification Pit Shell is described in Section 5.1.

Blast Emission Criteria for Human Comfort

To minimise the impact on residential receivers, the Office of Environment and Heritage (OEH) adopts the ANZECC (1990) guidelines "Technical Basis for Guidelines to Minimise Annoyance due to Blasting Overpressure and Ground Vibration". The guidelines indicate the following:

- The general criterion for ground vibration is 5 mm/s, Peak Particle Velocity (PPV).
- The PPV of 5 mm/s may be exceeded on up to 5% of the total number of blasts over a period of 12 months. The upper PPV level of 10 mm/s should not be exceeded at any time.
- The general airblast criterion is 115 dBL (decibel Linear).
- The level of 115 dBL may be exceeded on up to 5% of the total number of blasts over a period of 12 months. The airblast level should not exceed 120 dBL at any time.

The same criteria are specified in the conditions of the Approved Operations development consent (SSD-5850). Therefore, the impacts of the Proposed Modification have been assessed against the existing consent conditions.

These criteria are applied to private residential locations, as specified in the BMP 2017.

Blast Damage Criteria – Ground Vibration

For blast damage criteria for residential structures the Australian Standard AS2187.2-2006, refers to other available standards, such as British Standard BS 7385-2:1993 and American (USBM) RI8507, see **Appendices 1A** and **1B**.

The blast damage criteria are frequency dependant; based on the British Standard BS 7385-2:1993 for unreinforced or light framed structures (such as residential) these range from 15 mm/s at 4 Hz, 20 mm/s at 15 Hz increasing to 50 mm/s at 40 Hz and above, see **Appendix 1A**. The lowest transient vibration value for cosmetic damage is estimated as 15 mm/s at 4 Hz. The cited range is well above the blast emission criteria for human comfort (i.e. 5 mm/s and 10 mm/s) as discussed above. It therefore follows that when vibration limits for human

comfort are imposed, compliance with blast damage criteria for residential structures will be achieved.

Blast Damage Criteria – Airblast

The Australian Standard AS2187.2-2006, specifies a conservative limit of 133 dBL as a safe level, implying no damage to the structure. AS2187.2-2006 also states that damage to windows (regarded as the most fragile / sensitive material) is considered improbable for airblast level exposures below 140 dBL.

Therefore, when vibration limits for human comfort are imposed (i.e. 115 and 120 dBL, as indicated above), by default, the possibility of structural damage for the surrounding residential structures is eliminated.

4.2.2 Criteria for Historical Sites, Infrastructure and Main Creek

The existing and proposed ground vibration and airblast emission criteria for the identified infrastructure and relevant historical sites are presented below as well as summarised in **Table 3**. The location of the relevant infrastructure and historical sites and their distance from the Proposed Modification Pit Shell is described in Section 5.2.

St Clements Anglican Church, Camberwell – historical building

The applicable vibration limit criteria for St Clements Anglican Church, located in Camberwell, are specified in the Approved Operations development consent (SSD-5850). These are specified as follows:

- The PPV of 2 mm/s may be exceeded on up to 5% of the total number of blasts over a period of 12 months,
- The upper PPV level of 5 mm/s should not be exceeded at any time; and
- The level of 115 dBL may be exceeded on up to 5% of the total number of blasts over a period of 12 months. The airblast level should not exceed 120 dBL at any time.

In addition, to address community concerns regarding protection of the church, Mount Owen have committed to designing blasts to achieve vibration levels not exceeding 2 mm/s as outlined in the BMP 2017. These criteria will continue to apply to the Proposed Modification.

Ravensworth Homestead – historical building

The Ravensworth Homestead is a historic site comprising of a farmhouse and several associated out-buildings. The Ravensworth Homestead is located to the west of the Proposed Modification Pit Shell. The recommended vibration limits specified in the Approved Operations development consent (SSD-5850) conditions are specified as follows:

- 5 mm/s - for ground vibration; and
- 126 dBL - for airblast.

These vibration limits are used as the assessment criteria for the Proposed Modification.

Chain of Ponds Inn

The Inn is located to the west of the Proposed Modification Pit Shell. The applicable vibration limits specified in the Approved Operations development consent (SSD-5850) conditions are:

- 133 dBL - for airblast; and
- 10 mm/s - for ground vibration

These vibration limits are used as the assessment criteria for the Proposed Modification.

Former Dulwich Homestead (Kangory Homestead)

The Dulwich Homestead is located to the south of the Proposed Modification Pit Shell. The applicable vibration limits specified in the Approved Operations development consent (SSD-5850) conditions are as follows:

- 5 mm/s - for ground vibration; and
- 126 dBL - for airblast.

These vibration limits are used as the assessment criteria for the Proposed Modification.

Former Hebden Public School and John Winter Memorial Site – historical sites

The former Hebden Public School and John Winter Memorial sites are located to the north-west of the Proposed Modification Pit Shell. The assessment of the site conditions and the applicable vibration limit criteria for former Hebden Public School and John Winter Memorial were addressed in detail in a previous assessment (ESC 2014). The applicable vibration limit criteria specified in the Approved Operations development consent (SSD-5850) conditions are specified as follows:

- 16 mm/s for ground vibrations for the former Hebden Public School; and
- 250 mm/s for John Winter Memorial.

These vibration limits are used as the assessment criteria for the Proposed Modification.

Ravensworth Public School (former), Community Hall in Camberwell, Greylands and Outbuilding

All the above listed dwellings are of local heritage significance. These buildings represent industrial type buildings and sheds.

The applicable vibration limits based on Australian Standard (AS 2187.2-2006) are:

- 25 mm/s - for ground vibration (applicable to occupied non-sensitive sites); and
- 133 dBL - for airblast – recommended airblast limit for damage control – this limit is recommended as a safe level that will prevent structural / architectural damage from blasting.

These vibration limits are used as the assessment criteria for the Proposed Modification.

Middle Falbrook Bridge over Glennies Creek and Camberwell Glennies Creek Underbridge

The Middle Falbrook bridge and Camberwell Glennies Creek underbridge are of state and local heritage significance, respectively. Both bridges are classed under the 'all other public infrastructure' category. The recommended vibration limit specified in the Approved Operations development consent (SSD-5850) conditions is specified as:

- 50 mm/s - for ground vibration

Therefore, this vibration limit is used as the assessment criterion for the Proposed Modification.

Electricity Transmission Lines

The powerlines and transmission towers (i.e. free standing and tension towers) located in proximity to the Proposed Modification Pit Shell are owned by Ausgrid (NSW electricity grid operator).

A vibration limit criterion of 50 mm/s (applicable to transmission power poles and electricity transmission lines) is specified in the Approved Operations development consent (SSD-5850).

This vibration limit is used as the assessment criterion for the Proposed Modification.

Prescribed Dams

A prescribed dam, Tailings Pit 1 (TP1), is located within the Mount Owen Complex to the north-west of the Proposed Modification Pit Shell. The vibration limit applicable to the dam wall is 50 mm/s, as imposed by the Dam Safety Committee (Annexure "D" Standard Mining Conditions, 2011).

The adjacent open cut, Ashton Coal proposed prescribed dam Clean Water Dam 1, is yet to be constructed. The dam is to be located to the south-west of the Proposed Modification Pit Shell. For the purpose of this assessment, the criterion outlined above for TP1 has also been adopted for Clean Water Dam 1.

Therefore, a 50 mm/s vibration limit is to be used as the assessment criterion for the Proposed Modification.

Railway Lines - Main Northern Rail Line

The Main Northern Rail Line is located to the south west and west of the Proposed Modification Pit Shell. The applicable vibration limit specified in the Approved Operations development consent (SSD-5850) is:

- 25 mm/s - for ground vibration

This vibration limit is used as the assessment criterion for the Proposed Modification.

Public Roads and Bridges

A comprehensive overview of the existing allowable vibration limits for various infrastructure (including public roads and concrete bridges) was presented in ACARP

Report No. C14057. The recommendations in regards to vibration exposures for concrete bridges are also provided in Australian Standard AS2187.2-2006 (i.e. for unoccupied structures of reinforced concrete or steel construction). Vibration levels for roadways / concrete bridges are specified as follows:

- Public roads – 100 mm/s
- Concrete bridges – 100 mm/s

These vibration limits are used as the assessment criteria for the Proposed Modification.

Community and Private Infrastructure

The following items represent community infrastructure in the proximity of the Proposed Modification Pit Shell: Glennies Creek Community Hall, Glennies Creek Rural Fire Service, Mt Pleasant Primary School and Hebden Community Hall. The site office of Daracon Mining Pty Limited was identified as private infrastructure.

All the above listed dwellings represent industrial type buildings and sheds. The applicable vibration limits for these items based on Australian Standard (AS 2187.2-2006) are:

- 25 mm/s - for ground vibration (applicable to occupied non-sensitive sites); and
- 133 dBL - for airblast – recommended airblast limit for damage control – this limit is recommended as a safe level that will prevent structural / architectural damage from blasting.

These vibration limits are used as the assessment criteria for the Proposed Modification.

Mine-owned Surface Infrastructure (Integra Underground Mine and Mount Owen Complex) – Glencore Facilities

There is a range of mine-owned surface infrastructure (including Mount Owen Complex and Integra Underground Mine) in operation in the vicinity of the Proposed Modification Pit Shell. The blast impact assessment for all these infrastructure items will be managed internally according to the vibration limits as specified in the BMP 2017. The specified vibration limit criteria are as follows:

- 25 mm/s for occupied non-sensitive sites, such as factories and commercial premises
- 100 mm/s for unoccupied structures of reinforced concrete or steel construction

The same vibration limit criteria had been postulated in Australian Standard AS 2187.2-2006 “Explosives - Storage and Use - Part 2: Use of Explosives”. Blast impacts for these infrastructure facilities will be managed internally (according to the BMP 2017) to maintain safe working practices.

Integra Underground Mine’s Underground Workings – Glencore Underground Mine

There are Integra Underground Workings (currently in operation) in the vicinity of the Proposed Modification Pit Shell, including areas where the mining operations overlap in different coal seams. The blast impact assessment for underground workings will be managed internally according to the vibration limits as specified in the BMP 2017. The specified vibration limit criteria are as follows:

- 10 mm/s – used as a "safety and personnel withdrawal limit for occupied underground workings "
- 250 mm/s – used as a "structural limit for unoccupied workings"

Therefore blast impacts for Integra will be managed (according to the BMP 2017) to maintain safe working practices between the operations. As outlined above, the Integra Underground Mine is now in Glencore ownership and management which provides for further efficiencies in managing any potential blast interactions.

Adjacent Mines - Rix's Creek North and Ashton Coal Project Infrastructure

Rix's Creek North and Ashton Coal mines represent the closest non-Glencore owned open cut mining operations. There is a range of infrastructure including offices, processing plants, workshops and others.

Guidelines in regards to vibration limits for mine infrastructure are provided in Australian Standard AS 2187.2-2006 "Explosives - Storage and Use - Part 2: Use of Explosives". The relevant vibration limits include:

- 25 mm/s for occupied non-sensitive sites, such as factories and commercial premises
- 100 mm/s for unoccupied structures of reinforced concrete or steel construction
- 133 dBL - recommended airblast limit for damage control; this limit is recommended as a safe level that will prevent structural / architectural damage from blasting

These vibration limits are used as the assessment criteria for the Proposed Modification.

Main Creek and Associated Alluvium

Main Creek and its associated alluvium are located to the east of the Proposed Modification. An area located at the closest point between the eastern edge of the Proposed Modification Shell and the top of high bank of Main Creek (160 m distant) have been assessed for potential risks of strata fracturing from blasting. The results of the assessment and proposed allowable vibration limit for Main Creek and associated alluvium are presented in ESC report (2017). The applicable vibration limit based on this study is:

- 100 mm/s - for ground vibration for Main Creek

This vibration limit is used as the assessment criterion for the Proposed Modification.

Mount Owen will continue to undertake site inspections including inspections along the eastern high wall of the Proposed Modification Pit Shell. Site inspections including inspections along the eastern high wall of the Proposed Modification Pit Shell aimed to identify and monitor blast induced surface impacts such as cracking. This would allow for an accurate assessment of rock strata response when blasting in the vicinity.

A summary of blast emission criteria used in this assessment is presented in **Table 3.**

Table 3: Summary of Blast Emission Criteria used in the assessment (adopted from Table 4 of Approved Operations development consent (SSD-5850) with inclusion of additional items)

Receiver	Peak Particle Velocity (mm/s)	Allowable Exceedance	Overpressure (dBL)	Allowable Exceedance
Residence on privately-owned land	5	5% of the total number of blasts over a period of 12 months	115	5% of the total number of blasts over a period of 12 months
	10	0%	120	0%
Historic Buildings and Structures				
St Clements Church, Camberwell	2	5% of the total number of blasts over a period of 12 months	115	5% of the total number of blasts over a period of 12 months
	5	0%	120	0%
Ravensworth Homestead	5	0%	126	0%
Chain of Ponds Inn	10	0%	133	0%
Former Dulwich Homestead (Kangory)	5	0%	126	0%
Former Hebden Public School	16	0%	n/a	n/a
John Winter Memorial	250	0%	n/a	n/a
Ravensworth Public School (former)[1], Community Hall in Camberwell[1], Greylands and Outbuilding[1]	25	0%	133	n/a
Middle Falbrook Bridge over Glennies Creek[1], Camberwell Glennies Creek Underbridge[1]	50	0%	n/a	n/a
Infrastructure				
Electricity Transmission Lines	50	0%	n/a	n/a
Prescribed Dams	50	0%	n/a	n/a
Main Northern Rail Line (including culverts and bridges)	25	0%	n/a	n/a
Public Roads	100	0%	n/a	n/a

Receiver	Peak Particle Velocity (mm/s)	Allowable Exceedance	Overpressure (dBL)	Allowable Exceedance
Concrete Bridges[1]	100	0%	n/a	n/a
Industrial type buildings and sheds[1]	25	0%	133	0%
Surface Mine Infrastructure -occupied	25	0%	n/a	n/a
Surface Mine Infrastructure -unoccupied	100	0%	n/a	n/a
Integra Underground Mine's Underground Workings	10 or 250[2]	0%	n/a	n/a
All other public infrastructure	50	0%	n/a	n/a
Main Creek[1]	100[3]	0%	n/a	n/a

1 – Item not listed under Approved Operations development consent (SSD-5850)

2 – 10 mm/s safety and personnel withdrawal limit for occupied underground workings and 250 mm/s structural limit for unoccupied workings.

3 – Refer to ESC (2017) for definition of this criterion

5.0 BLAST IMPACT ASSESSMENT

5.1 COMMUNITY

5.1.1 Introduction

The section presented below addresses the potential blast impacts associated with the Proposed Modification on the surrounding area, specifically the private residential receivers. The aim is to identify the potential impacts including ground vibration and airblast exposure as well as flyrock, which will be generated when undertaking blasting within the Proposed Modification. The estimated ground and air vibration exposure levels are discussed in the context of applicable ground and air vibration limits detailed in Section 4.

5.1.2 Location of Private Residential Receivers

The outline of the Proposed Modification Pit Shell as well as the location of the adjacent residential receivers, is shown on **Figure 5.** The residences shown on **Figure 5** are all privately-owned (excludes mine owned residences). The main points of note regarding the distribution of the privately-owned residences are specified as follows:

- The closest private residences representing the Middle Falbrook area (located to the south-east of the Proposed Modification Pit Shell) are widely spread. The closest private residential receiver (ID 114) is located at a distance of 1.98 km (at the closest point) away from the Proposed Modification Pit Shell. This private residence is subject to acquisition rights under Approved Operations development consent (SSD-5850).
- The Proposed Modification Pit Shell is located away from any significant cluster of private residential receivers. The closest, however widely spread cluster of private residences, is located to the north-east of the Proposed Modification Pit Shell, it represents the Goorangoola community and is in excess of 4 km distant.
- Residential receivers located to the south-west in the vicinity of Camberwell are located in excess of 4 km from the Proposed Modification Pit Shell and are therefore considered to receive low to negligible blasting impacts.

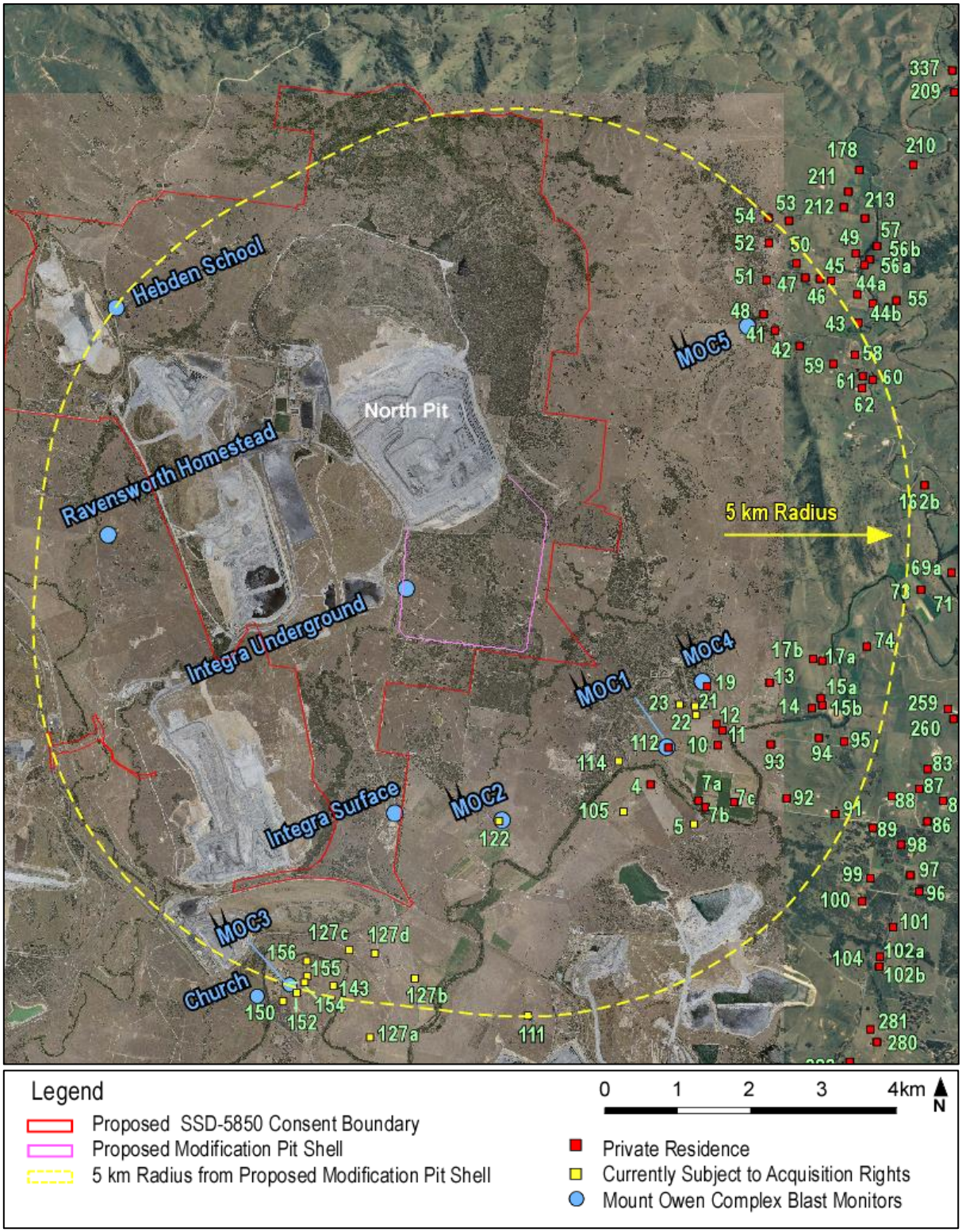


Figure 5 - Locations of Privately-owned Residences and Blast Monitors in Relation to the North Pit

5.1.3 Assessment Results

5.1.3.1 Ground Vibration

The potential impact of ground vibrations from the Proposed Modification on private residential receivers was assessed in detail using ground vibration modelling. The modelling utilised the site law formula for Mount Owen Complex conditions as explained in Section 4.1.1.

The ground vibration modelling provides ground vibration estimates for residential receivers located within a 5 km radius of the Proposed Modification Pit Shell, see **Figure 5**. The impact of blasting on residences located beyond the 5 km radius is considered negligible (i.e. beyond a human perception level).

There were several different simulations performed involving charge masses ranging from 33 to 601 kg, representative of the range of MIC's to be used during the Mount Owen Mine lifetime (according to the proposed bench heights). Modelling results for seven cases of different charge masses are presented in **Table 4**.

The modelling accounts for the worst case scenario, i.e. blasting from the edge of the Proposed Modification Pit Shell, which corresponds to the minimum distance between the blasting area and residential receivers. In other words, the table highlights the maximum vibrations that will be generated during the lifetime of the Mount Owen Mine. **Table 4** shows the distances for each potentially affected private residence within a 5 km radius and the estimated vibration using variable charge masses.

Table 4: Results of Ground Vibration Modelling for Privately-owned Residences – Maximum Vibration Estimates – within a 5 km Radius

Residential ID	Min. Distance (m)	Estimated Max Ground Vibration (mm/s)						
		MIC (kg)						
		5 m	8 m bench			15 m bench		
		ANFO	ANFO	Heavy ANFO	Emulsion 2070	ANFO	Heavy ANFO	Emulsion 2070
		33	132	181	222	356	489	601
4	2,510	0.1	0.4	0.5	0.6	0.9	1.1	1.3
5^	3,310	0.1	0.3	0.3	0.4	0.6	0.7	0.8
7A	3,120	0.1	0.3	0.4	0.4	0.6	0.8	0.9
7B	3,250	0.1	0.3	0.3	0.4	0.6	0.7	0.9
7C	3,520	0.1	0.2	0.3	0.3	0.5	0.6	0.8
10	2,930	0.1	0.3	0.4	0.5	0.7	0.9	1.0
11	2,910	0.1	0.3	0.4	0.5	0.7	0.9	1.0
12	2,800	0.1	0.3	0.4	0.5	0.7	0.9	1.1
13	3,370	0.1	0.2	0.3	0.4	0.5	0.7	0.8

Residential ID	Min. Distance (m)	Estimated Max Ground Vibration (mm/s)						
		MIC (kg)						
		5 m	8 m bench			15 m bench		
		ANFO	ANFO	Heavy ANFO	Emulsion 2070	ANFO	Heavy ANFO	Emulsion 2070
		33	132	181	222	356	489	601
14	4,000	0.1	0.2	0.2	0.3	0.4	0.5	0.6
15A	4,090	0.1	0.2	0.2	0.3	0.4	0.5	0.6
15B	4,130	0.1	0.2	0.2	0.3	0.4	0.5	0.6
17A	4,020	0.1	0.2	0.2	0.3	0.4	0.5	0.6
17B	3,890	0.1	0.2	0.2	0.3	0.4	0.6	0.7
19	2,530	0.1	0.4	0.5	0.6	0.9	1.1	1.3
21^	2,440	0.1	0.4	0.5	0.6	0.9	1.2	1.4
22^	2,500	0.1	0.4	0.5	0.6	0.9	1.1	1.3
23^	2,240	0.2	0.5	0.6	0.7	1.0	1.3	1.6
41	4,010	0.1	0.2	0.2	0.3	0.4	0.5	0.6
42	4,160	0.1	0.2	0.2	0.3	0.4	0.5	0.6
46	4,930	< 0.1	0.1	0.2	0.2	0.3	0.4	0.4
47	4,790	< 0.1	0.1	0.2	0.2	0.3	0.4	0.5
48	4,040	0.1	0.2	0.2	0.3	0.4	0.5	0.6
50	4,830	< 0.1	0.1	0.2	0.2	0.3	0.4	0.5
51	4,370	0.1	0.2	0.2	0.2	0.4	0.5	0.5
52	4,780	< 0.1	0.1	0.2	0.2	0.3	0.4	0.5
58	4,770	< 0.1	0.1	0.2	0.2	0.3	0.4	0.5
59	4,450	0.1	0.2	0.2	0.2	0.3	0.4	0.5
60	4,850	< 0.1	0.1	0.2	0.2	0.3	0.4	0.5
61	4,740	< 0.1	0.1	0.2	0.2	0.3	0.4	0.5
62	4,670	< 0.1	0.1	0.2	0.2	0.3	0.4	0.5
74	4,600	< 0.1	0.1	0.2	0.2	0.3	0.4	0.5
91	4,790	< 0.1	0.1	0.2	0.2	0.3	0.4	0.5
92	4,110	0.1	0.2	0.2	0.3	0.4	0.5	0.6
93	3,590	0.1	0.2	0.3	0.3	0.5	0.6	0.7
94	4,190	0.1	0.2	0.2	0.3	0.4	0.5	0.6
95	4,540	0.1	0.2	0.2	0.2	0.3	0.4	0.5
105^	2,580	0.1	0.4	0.5	0.6	0.8	1.1	1.3
111^	4,990	< 0.1	0.1	0.2	0.2	0.3	0.4	0.4
112	2,370	0.1	0.4	0.6	0.7	0.9	1.2	1.4
114^	1,980	0.2	0.6	0.7	0.9	1.3	1.6	1.9
122^	2,370	0.1	0.4	0.6	0.7	0.9	1.2	1.4
127A^	5,470	< 0.1	0.1	0.1	0.2	0.2	0.3	0.4
127B^	4,640	< 0.1	0.1	0.2	0.2	0.3	0.4	0.5
127C^	4,380	0.1	0.2	0.2	0.2	0.4	0.5	0.5

Residential ID	Min. Distance (m)	Estimated Max Ground Vibration (mm/s)						
		MIC (kg)						
		5 m	8 m bench			15 m bench		
		ANFO	ANFO	Heavy ANFO	Emulsion 2070	ANFO	Heavy ANFO	Emulsion 2070
		33	132	181	222	356	489	601
127D^	4,370	0.1	0.2	0.2	0.2	0.4	0.5	0.5
143^	4,870	< 0.1	0.1	0.2	0.2	0.3	0.4	0.5
150^	5,250	< 0.1	0.1	0.2	0.2	0.3	0.3	0.4
152^	5,080	< 0.1	0.1	0.2	0.2	0.3	0.4	0.4
154^	4,930	< 0.1	0.1	0.2	0.2	0.3	0.4	0.4
155^	4,850	< 0.1	0.1	0.2	0.2	0.3	0.4	0.5
156^	4,640	< 0.1	0.1	0.2	0.2	0.3	0.4	0.5

^ *Residence already subject to acquisition rights*

The results of the ground vibration modelling are summarised as follows:

- The impacts of vibration will be highly variable, dependent upon the charge mass; with negligible impact (i.e. below a human perception level) for low charge masses (i.e. 33 kg) and increasing for higher charge masses.
- The estimated vibration exposure for all residences using variable charge masses of 33 to 601 kg is in the order of 0.1 to 1.9 mm/s. This is below the applicable vibration limits specified as 5 mm/s (for 95% of blasts) and 10 mm/s (not to be exceeded) consistent with existing criteria under SSD-5850.

5.1.3.2 Airblast Overpressure

To perform the airblast overpressure modelling the sonic decay formula specified in Section 4.1.2 was utilised.

The modelling provides estimations of airblast levels using the same variable charge masses as used for ground vibration. The impact of blasting is highly variable as it depends on the actual distance to the blast.

The results were examined and collated into a table of overpressure estimates. **Table 5** presents detailed estimations for the private residences located within a 5 km radius of the Proposed Modification Pit Shell.

The modelling accounts for the worst case scenario, i.e. blasting from the edge of the Proposed Modification Pit Shell. The table therefore highlights the maximum airblast levels that will be generated during the lifetime of the Proposed Modification.

Table 5: Results of Airblast Modelling for Privately-owned Residences – Maximum Airblast Estimates

Residential ID	Min. Distance (m)	Estimated Max Airblast Overpressure (dBL)						
		MIC (kg)						
		5 m	8 m bench			15 m bench		
		ANFO	ANFO	Heavy ANFO	Emulsion 2070	ANFO	Heavy ANFO	Emulsion 2070
		33	132	181	222	356	489	601
4	2,510	102	108	109	110	112	113	114
5^	3,310	99	104	106	107	109	110	111
7A	3,120	99	105	107	107	109	111	112
7B	3,250	99	105	106	107	109	110	111
7C	3,520	98	104	105	106	108	109	110
10	2,930	100	106	107	108	110	111	112
11	2,910	100	106	107	108	110	112	112
12	2,800	101	107	108	109	111	112	113
13	3,370	98	104	106	106	108	110	111
14	4,000	96	102	103	104	106	108	108
15A	4,090	96	102	103	104	106	107	108
15B	4,130	96	102	103	104	106	107	108
17A	4,020	96	102	103	104	106	107	108
17B	3,890	97	102	104	105	107	108	109
19	2,530	102	108	109	110	112	113	114
21^	2,440	102	108	110	110	112	114	115
22^	2,500	102	108	109	110	112	113	114
23^	2,240	104	109	111	112	114	115	116
41	4,010	96	102	103	104	106	108	108
42	4,160	96	102	103	104	106	107	108
46	4,930	94	99	101	102	104	105	106
47	4,790	94	100	101	102	104	105	106
48	4,040	96	102	103	104	106	107	108
50	4,830	94	100	101	102	104	105	106
51	4,370	95	101	102	103	105	106	107
52	4,780	94	100	101	102	104	105	106
58	4,770	94	100	101	102	104	105	106
59	4,450	95	101	102	103	105	106	107
60	4,850	94	100	101	102	104	105	106
61	4,740	94	100	101	102	104	105	106
62	4,670	94	100	101	102	104	106	106
74	4,600	94	100	102	102	104	106	107
91	4,790	94	100	101	102	104	105	106
92	4,110	96	102	103	104	106	107	108

Residential ID	Min. Distance (m)	Estimated Max Airblast Overpressure (dBL)						
		MIC (kg)						
		5 m	8 m bench			15 m bench		
		ANFO	ANFO	Heavy ANFO	Emulsion 2070	ANFO	Heavy ANFO	Emulsion 2070
		33	132	181	222	356	489	601
93	3,590	98	103	105	106	108	109	110
94	4,190	96	101	103	104	106	107	108
95	4,540	95	100	102	103	105	106	107
105^	2,580	102	108	109	110	112	113	114
111^	4,990	93	99	101	101	103	105	106
112	2,370	103	109	110	111	113	114	115
114^	1,980	105	111	112	113	115	116	117
122^	2,370	103	109	110	111	113	114	115
127A^	5,470	92	98	99	100	102	104	104
127B^	4,640	94	100	102	102	104	106	107
127C^	4,380	95	101	102	103	105	106	107
127D^	4,370	95	101	102	103	105	106	107
143^	4,870	94	100	101	102	104	105	106
150^	5,250	93	99	100	101	103	104	105
152^	5,080	93	99	100	101	103	105	105
154^	4,930	94	99	101	102	104	105	106
155^	4,850	94	100	101	102	104	105	106
156^	4,640	94	100	102	102	104	106	107

^ *Residence already subject to acquisition rights*

Shaded cells show overpressure levels of 115 dBL or above. The corresponding MIC's need to be adjusted for the indicated distances to ensure compliance with specified airblast criteria.

The results of the airblast overpressure modelling are summarised as follows:

- The airblast impacts will be highly variable dependent upon the charge mass. The estimated airblast exposure for residences using variable charge masses of 33 to 601 kg is in the order of 93 to 117 dBL.
- The results of the modelling show that impacts on the surrounding private residences can be managed effectively (to remain below the imposed airblast criteria) by using lower charge masses, consistent with existing blast management practices as outlined in the BMP 2017. This can be achieved either by blasting smaller benches or by the application of deck charges, together with the application of precise initiation timing. For example, based on the table above, the predicted airblast level for the property ID 114 is 117 dBL at 1.98 km to the blast (this distance corresponds to blasting in

modelled year 15). The airblast level can be managed by decreasing the charge mass (to approximately 222 kg) to achieve a predicted airblast value of 113 dBL which is below the 115 dBL airblast limit.

- There is no restriction on the proposed charge mass of 601 kg required for blasting undertaken during the Year 2 and Year 8 stage plans as private residences will be in excess of 2.5 km from the Proposed Modification Pit Shell.

5.1.3.3 Flyrock and Other Issues

Mount Owen Complex operates using a standard 0.5 km exclusion zone (all land within a 0.5 km radius of the Proposed Modification Pit Shell is owned by Mount Owen Complex). This distance is considered appropriate for managing the risk of flyrock as it is used widely across the mining industry.

The closest private residence (i.e. ID 114 in a south-east direction) is located approximately 1.98 km from the Proposed Modification Pit Shell therefore the potential risks of flyrock on the surrounding private receivers are considered negligible.

The potential impacts of blast fume are assessed in the Air Quality Impact Assessment for the Proposed Modification.

5.2 HISTORICAL SITES, INFRASTRUCTURE AND MAIN CREEK

The analysis presented below is an assessment of ground vibration, and where relevant airblast, exposures from the Proposed Modification on the adjacent infrastructure, historical sites and Main Creek. The analysis is based on vibration modelling using the applicable vibration predictive models, see Section 4.1. The vibration modelling estimates have been analysed, including references to relevant vibration limit criteria.

5.2.1 Location of Historical Sites, Infrastructure and Main Creek

The historical sites and infrastructure specified below were assessed in this report. Refer to **Figure 6A** which shows the locations of the identified community infrastructure and historical sites, while **Figure 6B** highlights the location of the infrastructure. The historical sites and infrastructure covered in this report include:

- Historic Buildings and Structures:
    - Ravensworth Homestead,
    - Ravensworth Public School (former),
    - St Clements Anglican Church, Camberwell,
    - Community Hall, Camberwell,
    - Camberwell Glennies Creek Underbridge,
    - Chain of Ponds Inn,

    - Middle Falbrook Bridge over Glennies Creek,
    - Greylands and Outbuildings,
    - Former Dulwich Homestead (Kangory Homestead),
    - Former Hebden Public School and John Winter Memorial Site.

- Infrastructure:
    - 132 kV and 330 kV Powerlines including Tension Towers and Substation,
    - Prescribed dams including TP1 and Ashton Coal Clean Water Dam 1,
    - Main Northern Rail line,
    - Local roadways including Hebden Road, Falbrook Road and Glennies Creek Road,
    - Hebden Road infrastructure including a rail overpass and Bowmans Creek Bridge approved under SSD-5850 (currently under construction).

- Community Infrastructure:
    - Glennies Creek Community Hall,
    - Glennies Creek Rural Fire Service,
    - Mt Pleasant Primary School,
    - Hebden Community Hall.

- Private Infrastructure:
    - Daracon Mining Pty Limited – Site Office.

- Adjacent mines:
    - Ashton Coal Project,
    - Rix's Creek North,
    - Integra Underground Mine.

The identified historical sites and infrastructure are located at variable distances with respect to the Proposed Modification Pit Shell ranging from 1.1 km for Falbrook Road to 9 km for the Hebden Community Hall.

The location of Main Creek and associated alluvium with respect to the Proposed Modification Pit Shell is shown in **Figure 6C**. The closest point from the top of high bank of Main Creek to the Proposed Modification Pit Shell is approximately 160 m. The shortest distance to the associated alluvium is 150 m.

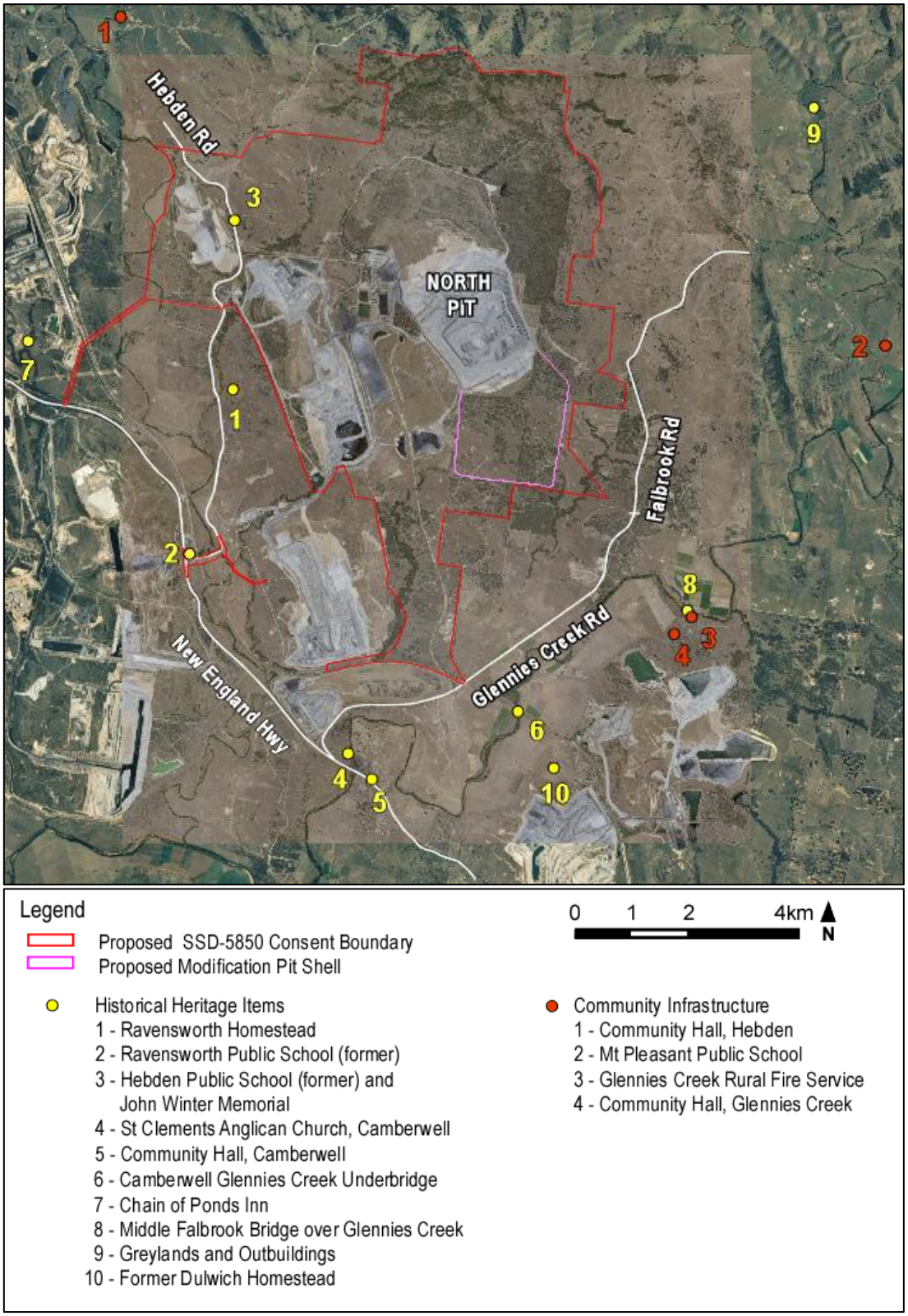


Figure 6A – Locations of Community Infrastructure and Historical Sites in the Vicinity of the Proposed Modification

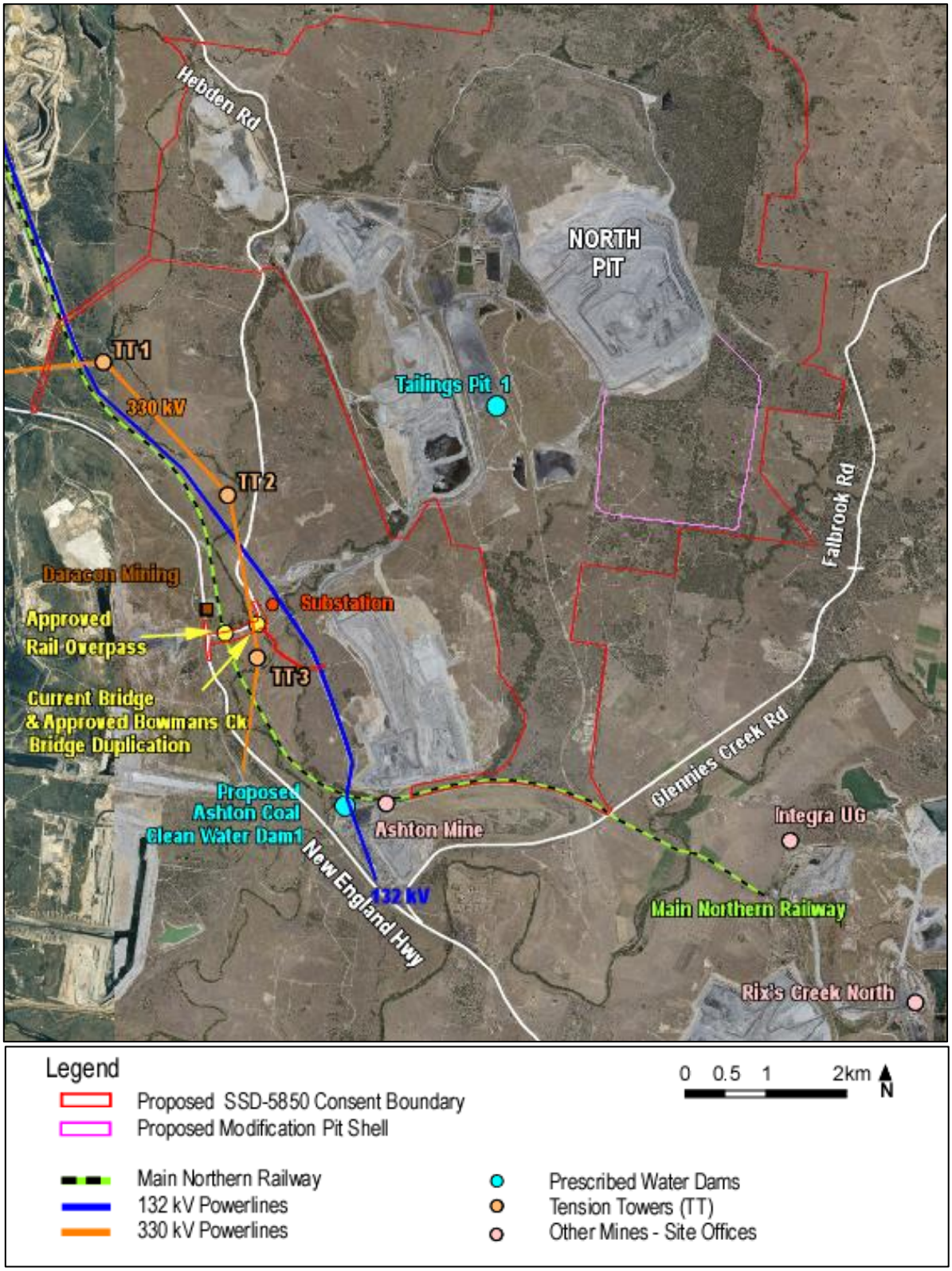


Figure 6B – Locations of Infrastructure in Relation to the Proposed Modification

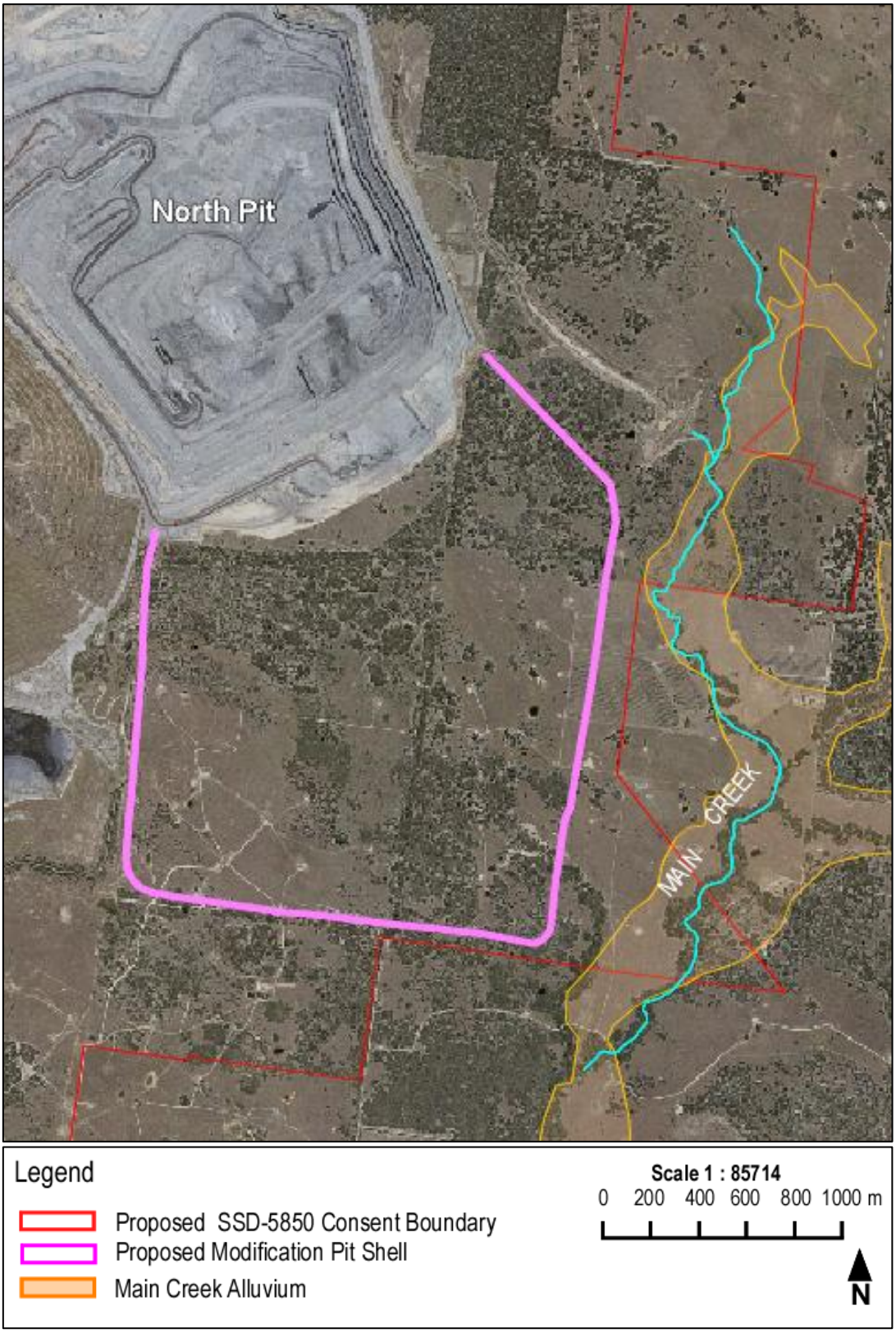


Figure 6C – Location of Main Creek and Associated Alluvium with Respect to the Proposed Modification

5.2.2 Assessment Results

5.2.2.1 Ground Vibration

The assessment undertaken included seven different simulations, incorporating different bench sizes and blasting products, to be used at the North Pit. The results of the modelling are summarised in **Table 6**. The vibration modelling undertaken in this section has been performed according to the formula specified in Section 4.1.1.

The analysis can be summarised as follows:

- The vibration exposures for historic buildings and structures including heritage listed items, all located in excess of 3.26 km are no higher than 1 mm/s, which is below the applicable criteria for any of the considered heritage items and historical sites.
- The closest infrastructure, prescribed dam TP1 is located in excess of 1.23 km from the Proposed Modification Pit Shell and will be exposed to vibrations no higher than 5 mm/s. This is well below the vibration criterion of 50 mm/s.
- The closest public roadways including Falbrook and Glennies Creek Roads, which will be located in excess of 1.1 and 1.4 km respectively from the Proposed Modification Pit Shell, will be exposed to vibration levels no higher than 6 mm/s. This is well below the vibration criterion of 100 mm/s.
- All other infrastructures, including community and private infrastructures, are located in excess of 3.39 km from the Proposed Modification Pit Shell and will be exposed to vibration levels no higher than 1 mm/s, which is well below any of the applicable criteria.
- The vibration exposures for site offices of adjacent coal mines located in excess of 3.9 km will be below 1 mm/s, which is well below any of the applicable criteria.
- At the shortest distance from the top of high bank of Main Creek (160 m), expected vibration levels will be no higher than 108 mm/s. The vibrations can be managed to below the assessment criterion of 100 mm/s by modifying the blast design according to blast management practices as outlined in the BMP 2017. In addition as part of a revised BMP further monitoring will be completed when blasting within 0.3 km of Main Creek, and if required the blast design can be modified to reduce predicted vibration levels further as necessary.

Table 6: Results of Ground Vibration Modelling for Historical Sites, Infrastructure and Main Creek – Maximum Vibration Estimates

Infrastructure	Min. Distance (m)	Estimated Max Ground Vibration (mm/s)						
		MIC (kg)						
		5 m	8 m bench			15 m bench		
		ANFO 33	ANFO 132	Heavy ANFO 181	Emulsion 2070 222	ANFO 356	Heavy ANFO 489	Emulsion 2070 601
Historic Buildings and Structures (Heritage Listed Items)								
Ravensworth Homestead	4,030	0.1	0.2	0.2	0.3	0.4	0.5	0.6
Ravensworth Public School (former)	4,940	< 0.1	0.1	0.2	0.2	0.3	0.4	0.4
St Clements Church, Camberwell	5,330	< 0.1	0.1	0.2	0.2	0.3	0.3	0.4
Community Hall, Camberwell	5,640	< 0.1	0.1	0.1	0.2	0.2	0.3	0.4
Camberwell Glennies Creek Underbridge	4,030	0.1	0.2	0.2	0.3	0.4	0.5	0.6
Chain of Ponds Inn	7,730	< 0.1	0.1	0.1	0.1	0.1	0.2	0.2
Middle Falbrook Bridge, Glennies Creek	3,260	0.1	0.3	0.3	0.4	0.6	0.7	0.9
Greylands and Outbuilding	6,500	< 0.1	0.1	0.1	0.1	0.2	0.2	0.3
Former Dulwich Homestead (Kangory)	4,970	< 0.1	0.1	0.2	0.2	0.3	0.4	0.4
Hebden Public School (former) and John Winter Memorial (not-listed heritage items)	5,050	< 0.1	0.1	0.2	0.2	0.3	0.4	0.4
Infrastructure								
Powerlines								
132kV Powerlines	3,920	0.1	0.2	0.2	0.3	0.4	0.5	0.6
330kV Powerlines	4,410	0.1	0.2	0.2	0.2	0.4	0.5	0.5
Tension Tower 1	6,160	< 0.1	0.1	0.1	0.1	0.2	0.3	0.3
Tension Tower 2	4,510	0.1	0.2	0.2	0.2	0.3	0.4	0.5
Tension Tower 3	4,560	< 0.1	0.2	0.2	0.2	0.3	0.4	0.5
Substation	4,160	0.1	0.2	0.2	0.3	0.4	0.5	0.6

Infrastructure	Min. Distance (m)	Estimated Max Ground Vibration (mm/s)						
		MIC (kg)						
		5 m	8 m bench			15 m bench		
		ANFO 33	ANFO 132	Heavy ANFO 181	Emulsion 2070 222	ANFO 356	Heavy ANFO 489	Emulsion 2070 601
Prescribed Dams								
TP1 Wall	1,230	0.4	1.2	1.6	1.9	2.7	3.5	4.1
Ashton Coal Clean Water Dam 1 (proposed)	4,780	< 0.1	0.1	0.2	0.2	0.3	0.4	0.5
Railway								
Main Northern Rail Line	3,430	0.1	0.2	0.3	0.4	0.5	0.7	0.8
Local Roads, Bridge								
Falbrook Road	1,100	0.5	1.5	1.9	2.2	3.2	4.2	4.9
Glennies Creek Road	1,430	0.3	1.0	1.2	1.5	2.1	2.7	3.2
Hebden Road	4,270	0.1	0.2	0.2	0.3	0.4	0.5	0.6
Current Bridge, Hebden Road	4,410	0.1	0.2	0.2	0.2	0.4	0.5	0.5
Approved Hebden Road Infrastructure (currently under construction)								
Bowmans Creek Bridge	4,400	0.1	0.2	0.2	0.2	0.4	0.5	0.5
Rail Overpass	4,830	< 0.1	0.1	0.2	0.2	0.3	0.4	0.5
Community Infrastructure								
Glennies Creek Community Hall	3,400	0.1	0.2	0.3	0.4	0.5	0.7	0.8
Glennies Creek Rural Fire Service	3,390	0.1	0.2	0.3	0.4	0.5	0.7	0.8
Mt Pleasant Primary School	5,670	< 0.1	0.1	0.1	0.2	0.2	0.3	0.4
Hebden Community Hall	9,000	< 0.1	0.1	0.1	0.1	0.1	0.1	0.2
Private Infrastructure								
Daracon Mining Pty Limited – Site Office	4,950	< 0.1	0.1	0.2	0.2	0.3	0.4	0.4
Adjacent Mines								
Ashton Coal Project – Site Office	4,460	0.1	0.2	0.2	0.2	0.3	0.4	0.5

Infrastructure	Min. Distance (m)	Estimated Max Ground Vibration (mm/s)						
		MIC (kg)						
		5 m	8 m bench			15 m bench		
		ANFO 33	ANFO 132	Heavy ANFO 181	Emulsion 2070 222	ANFO 356	Heavy ANFO 489	Emulsion 2070 601
Rix's Creek North – Site Office	6,220	< 0.1	0.1	0.1	0.1	0.2	0.3	0.3
Integra Underground – Site Office	3,880	0.1	0.2	0.3	0.3	0.4	0.6	0.7
Main Creek Area								
Main Creek - Top of High Bank	160	11	32	41	49	71	91	108

5.2.2.2 Airblast

Generally, infrastructure items and natural features like Main Creek are not assessed in terms of airblast exposure as levels required to inflict damage are not applicable and/or not reached.

Historic items can, however, be assessed when applicable airblast limits are imposed. The estimated airblast exposures according to the airblast predictive model for listed heritage items of state and local significance with imposed limits, using the proposed range of MIC's of 33 to 601 kg are assessed as follows:

- The estimated airblast overpressure exposure for the Chain of Ponds Inn (located in excess of 7.7 km) is predicted to be in the order of 88 to 100 dBL. This is below the imposed airblast criterion limit of 133 dBL.
- The estimated airblast overpressure exposure for the Ravensworth Homestead and former Dulwich Homestead (Kangory) (located in excess of 4.0 and 4.9 km respectively) is predicted to be no higher than 108 and 106 dBL respectively. This is below the imposed airblast criterion of 126 dBL.
- The estimated airblast overpressure exposure for St Clements Anglican Church (located in excess of 5.3 km) is predicted to be in the order of 93 to 105 dBL. This is below the imposed airblast criterion of 115 dBL (for 95% of blasts).
- There are no airblast overpressure limits applicable to the other historical sites. The estimated airblast overpressure exposure is no higher than 111 dBL (which is below any of the discussed criteria applicable for the historical sites with imposed limits) and is considered as low or negligible.

Following are the results of the estimated airblast exposures for the assessed infrastructure:

- Community and private infrastructure will be exposed to a maximum of 111 dBL which is below the applicable criterion of 133 dBL.
- Site offices of the adjacent mines will be exposed to a maximum of 109 dBL which is below the applicable criterion of 133 dBL.

5.2.2.3 Flyrock

As indicated previously, the North Pit will operate using an appropriate exclusion zone to manage the risk of flyrock, i.e. 0.5 km exclusion zone as indicated in the BMP (2017). The 0.5 km distance is used as a standard exclusion zone for flyrock control.

Based on the above assessment, the heritage items / historical sites are located in excess of 3.26 km from the North Pit. The infrastructure facilities identified are located in excess of 1.1 km. As none of the historical sites or infrastructure are located within the 0.5 km exclusion zone of the Proposed Modification Pit Shell the risk of flyrock is minimal.

As Main Creek at its closest is located at a distance of 160 m, it is possible that there will be some flyrock occurrence. However due to the nature of the assessed item (i.e. creek embankment), the impact of flyrock is considered to be negligible.

6.0 DATA GAP ANALYSIS

A detailed gap analysis was undertaken by ESC (2017) and included a review of ground vibration and airblast overpressure monitoring results for the 2014 – mid 2017 period. In addition, the analysis aimed to assess the adequacy of the coverage of the existing blast monitoring system. A summary of the gap analysis is presented **Table 7**.

Table 7: Gap Analysis for Years 2014 to mid-2017

Assessment Type	Strategic Objective	Current Standing	Deficiency	Action Plan
Quantitative	No more than 5% of all yearly blasts may produce vibration values between 5mm/s and 10mm/s	0% of yearly blasts have produced vibration values between the specified limits, this applies to the years 2014 to mid-2017	None	Continue mining operations without any major procedural alterations.
Quantitative	No single blast may exceed 10mm/s	No single blast has exceeded the vibration limit	None	Continue mining operations without any major procedural alterations
Quantitative	No more than	Year 2014 - 1.0%	None	Continue mining

	5% of all yearly blasts may produce overpressure values between 115dBL and 120dBL	Year 2015 - 0% Year 2016 - 2.3% Year 2017 - 2.3% percentage of yearly blasts with overpressure values between the specified limits		operations without any major procedural alterations.
Quantitative	No single blast may exceed 120dBL	No single blast has exceeded the airblast limit	None	Continue mining operations without any major procedural alterations

The study concluded the following:

- The gap analysis included a review of ground vibration and airblast overpressure monitoring results for the 2014 – mid-2017 period. The results were analysed in the context of airblast overpressure and ground vibration limits imposed on the mine.
- The assessment concluded a good overall blast performance with a low impact on the local community.
- The current Mount Owen Complex multi-station vibration monitoring system was assessed due to its location and proximity to the monitored receivers. The stations are placed strategically in all directions with five of the stations monitoring private residences and seven dedicated to infrastructure and historic sites. It was concluded that the current monitoring system is considered to provide adequate coverage to monitor vibration impacts of the Proposed Modification for private residences, infrastructure and historic sites.

7.0 MANAGEMENT AND MITIGATION MEASURES

Mount Owen currently utilises a number of blast control measures and technologies (as detailed in the current BMP 2017), which minimise blast impacts and enable blasts to be designed to comply with the relevant criteria. Blast impacts associated with the Proposed Modification can be effectively managed in accordance with the existing BMP (2017), a summary of the management measures is provided below:

Control measures for ground vibration:

- Use of an appropriate charge mass design and loading procedure;
- Use of an appropriate initiation sequence to minimise the possibility of hole interaction;

- Use of a ground vibration predictive model to estimate potential ground vibration levels to aide with the blast design.

Control measures for airblast:

- Use of an appropriate charge mass design and avoid overcharging holes;
- Maintain appropriate blasting parameters, especially for the front row holes (to avoid face burst);
- Use of an appropriate initiation sequence to minimise the possibility of hole interaction;
- Undertake an alternative blast design around identified geological features to avoid face burst and excessive airblast emission;
- Use of an appropriate quality stemming material and stemming height to enable correct confinement of explosive charges;
- Use of an airblast predictive model to estimate potential airblast overpressure levels to aide with the design of blasting parameters;
- Continue with an appropriate pre-blast meteorological condition protocol to avoid blasting in unfavourable weather conditions.

Control measures for flyrock:

- Maintain appropriate burden specifications for the front row holes to avoid face bursts and related flyrock incidents;
- Use of a modified blast design around identified geological features to avoid a potential flyrock incident;
- Use of an appropriate quality stemming material and stemming height to minimise the possibility of a potential flyrock incident.

Based on the results of modelling, all blasts will be managed to meet the specified criteria utilising the methods outlined above.

Blast Monitoring System

Continued monitoring of blasts utilising the current multi-station vibration monitoring system at Mount Owen Complex, see **Figure 7**.

Mount Owen will continue to undertake site inspections including inspections along the eastern high wall of the Proposed Modification Pit Shell to identify and monitor blast induced surface impacts such as cracking. This would allow for an accurate assessment of rock strata response when blasting in the vicinity of Main Creek.

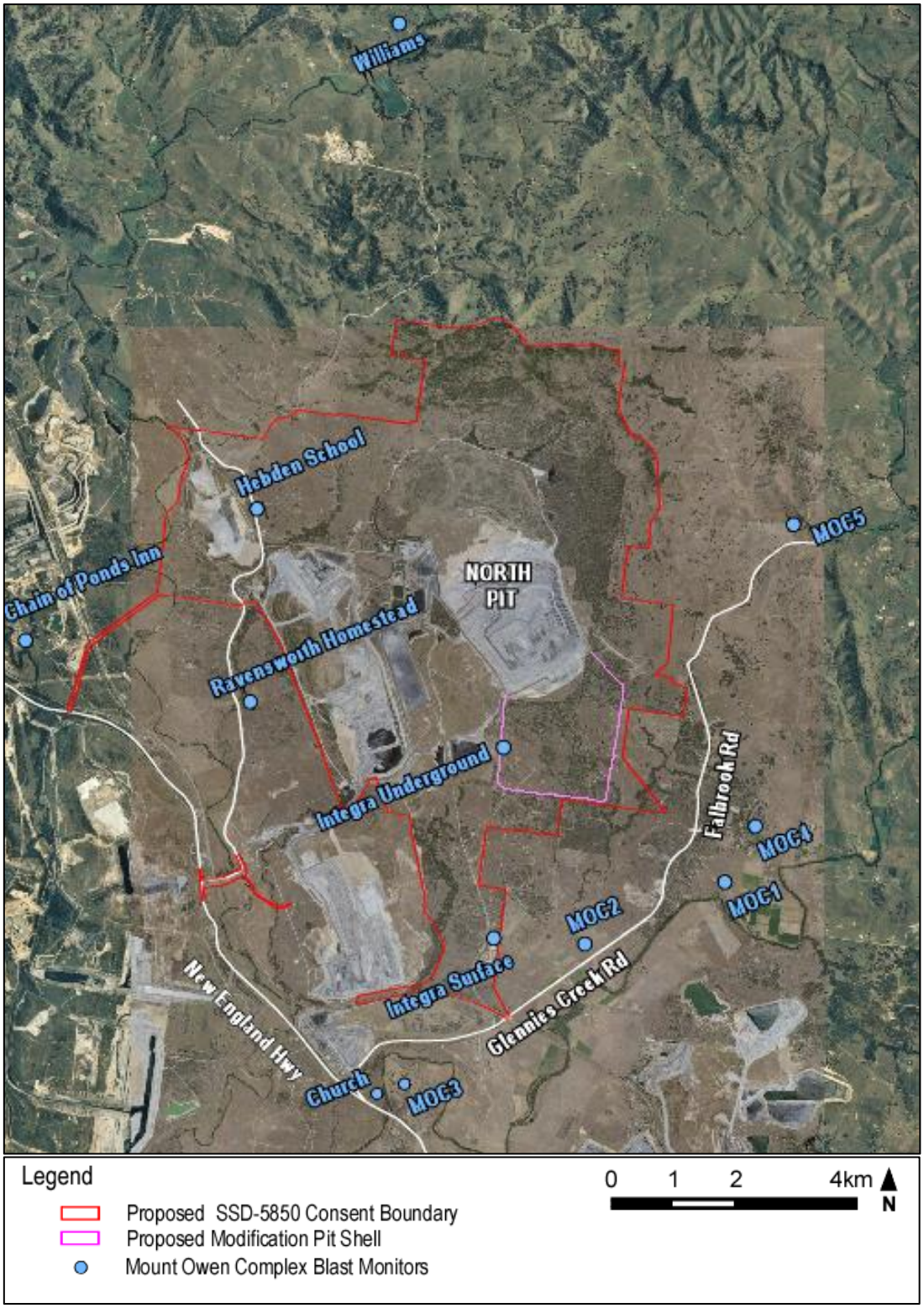


Figure 7 – Location of the Monitoring Stations

Pre-Blast Assessment Protocol

The Proposed Modification will result in an ongoing relocation of the blasting operations in relation to the adjacent residences. Based on the proposed plans, and due to the change in distances to private residences with time, it is recommended that the pre-blast check protocol be reviewed once a year.

Weather Monitoring and Assessment System

The weather conditions can potentially affect the blast impact outcome (especially noise distribution and intensity), as well as post-blast dust distribution.

Mount Owen Complex operates using a well-developed weather assessment protocol utilising two weather monitoring stations (i.e. altogether three Glencore stations in this area available) and the ENVMET weather predictive model. Weather impacts are assessed in the morning when an initial decision on whether to blast or not is undertaken. This is followed by a second review of weather impacts just prior to the blast firing time.

The system operates effectively and therefore no changes to the system are recommended.

Interaction with Nearby Mines

The risks associated with two different open cut operations acting simultaneously can be effectively managed via the implementation of an appropriate protocol.

There is a well-developed system of email notification and interaction with the adjacent mines already in place. This system is used to avoid concurrent blasts and therefore minimise blast impacts on the adjacent community. The system operates effectively and therefore no changes to the system are recommended.

Interaction with Integra Underground Mine

The Integra Underground Mine is located immediately adjacent to the Mount Owen Complex with the southwest corner of the North Pit overlapping the northern end of the Integra Underground Mine workings. The impact of blasting within the North Pit was assessed in detail for the Continued Operations Project (ESC 2013).

The modelling undertaken for the Continued Operations Project revealed that there is a high degree of variability in the potential vibration exposures for various sections of the Integra Underground Mine and it is very much dependent upon the distance between the blasting area and the actual section of the Underground Mine being worked at the time of the blast. The modelling results indicated that during blasting activities longwalls both immediately beneath the blasting zone and in close proximity would experience blast vibration levels in excess of the 10 mm/s criteria and personnel withdrawal for the affected longwall areas would be required during blasting. The vibration modelling revealed that vibration estimations for the underground workings were in the order of 0.1 – 26 mm/s, based on modelled blasting scenarios (i.e. MIC of 33 - 791 kg). This is below the 250 mm/s vibration limit specified as a structural limit for unoccupied underground workings (for the rock strata) and above the 10 mm/s vibration limit used as a limit for underground personnel withdrawal. Both limits are referenced in the BMP 2017. Therefore, the blasting impact will

warrant underground personnel withdrawal for occasional blasts exceeding the 10 mm/s vibration limit, without major risks of rock strata damage.

There will be no change to the minimum separation distance of 250 m between the proposed North Pit floor and the approved Integra Underground mining operations as a result of the Proposed Modification.

Although there are risks associated with the two different operations (i.e. open cut and underground) acting simultaneously this has been effectively managed at the Mount Owen Complex via the implementation of the existing blast protocol with Integra. All operational and safety measures currently implemented will continue and will be enhanced through the common ownership of these mining operations by Glencore. Therefore, the risks between the two operations in such close contact will be managed effectively.

8.0 CONCLUSIONS

The report presents an assessment of blast impacts associated with the Proposed Modification on the surrounding environment, including private residences, infrastructure, historical / heritage sites and Main Creek. The results of the assessment are summarised as follows:

- The Proposed Modification will result in changes to the currently approved progression of mining within the North Pit and an extension of the Proposed Disturbance Area to the southeast towards Main Creek. The blasting parameters were reviewed based on the geological model of the area. For the assessment, blasting benches were identified as a maximum of 15 m for production blasts and 30 m for presplit blasts. The charge masses were identified and are in the order of 33 to a maximum of 601 kg.
- The impacts of air and ground vibrations on the surrounding residences, infrastructure and historic / heritage sites were assessed using ground vibration and airblast predictive models developed for Mount Owen Mine conditions; the models are considered fully representative for the Proposed Modification Pit Shell.

- GAP ANALYSIS:
  - The undertaken gap analysis included a review of ground vibration and airblast overpressure monitoring results for the 2014 – mid-2017 period. The results were assessed in the context of airblast overpressure and ground vibration limits imposed on the mine. The assessment concluded a good overall blast performance with a low impact on the local community. The current multi-station vibration monitoring system was determined to provide adequate coverage for the Proposed Modification on vibration monitoring impacts for private residences, infrastructure and historic sites.

- IMPACT ON PRIVATE RESIDENCES:
  - The blast emission and blast damage criteria for private residences were specified in the report. The current operational vibration limits for the Approved Operations are specified as 5 mm/s allowed for 95% of blasts and 10 mm/s not to be exceeded. The operational airblast limits are 115 dBL allowed for 95% of blasts

and 120 dBL not to be exceeded. The assessment was undertaken using the same criteria.

- The ground vibration modelling for private residences within a 5 km radius revealed that vibration impacts can be managed effectively within the specified blasting parameters. The estimated vibration exposure for all residences using specified charge masses is predicted to be less than 1.9 mm/s. This is below the applicable vibration limit specified as 5 mm/s.
- The airblast modelling for private residences within a 5 km radius revealed that airblast impacts can be managed effectively within the specified blasting parameters. The estimated airblast exposure for all private residences using specified charge masses is predicted to be under 115 dBL. The model indicates that by decreasing the charge mass the airblast emission can be effectively managed maintaining the predicted emissions below the required limit of 115 dBL. This can be achieved by blasting smaller benches or by the application of deck charges and the use of precise initiation timings.
- Due to the substantial distances to private residences (i.e. closest private residence ID 114 – 1.98 km) the issue of flyrock impact on the adjacent residences is considered to be fully managed and the potential risks are considered negligible.

- IMPACT ON HISTORICAL SITES AND INFRASTRUCTURE:
  - The blast emission criteria for historical sites and infrastructure are specified in Section 4.2.2.
  - The assessment identified that the closest historical site, Middle Falbrook Bridge at Glennies Creek is located in excess of 3.26 km from the Proposed Modification Pit Shell. Air and ground vibration modelling identified that the predicted vibrations for all historical sites will be well below the imposed limit criteria and/or damage levels.
  - The assessment identified that the closest infrastructure Falbrook Road, is located in excess of 1.1 km from the Proposed Modification Pit Shell. Ground vibration modelling identified that the predicted vibrations for all infrastructure will be well below the imposed limit criteria and/or damage levels.
  - The Proposed Modification will operate using a standard 0.5 km exclusion zone for flyrock management. The closest public infrastructure will be in excess of 1.1 km and the closest historical site will be in excess of 3.26 km from the Proposed Modification Pit Shell. The issue of flyrock impact is therefore considered to be fully managed and the potential risks are considered negligible.

- IMPACT ON MAIN CREEK AND ASSOCIATED ALLUVIUM:
  - The assessment identified that the vibration exposure for the high bank of Main Creek (minimum distance of 160 m) can be managed effectively to below the assessment criterion of 100 mm/s by modifying the blast design and applying blast management practices as outlined in the BMP 2017.
  - The assessment of the blast impacts on the alluvium strata (minimum distance of 150 m) concluded low / negligible risks of strata fracturing and subsequent water seepage from the Main Creek. The study concluded that for the geological

conditions of the area and proposed blasting parameters the maximum strata damage will be limited to approximately 12 m from the pit edge.

- IMPACT ON MINE-OWNED INFRASTRUCTURE AND INTEGRA UNDERGROUND MINE:
  - The impacts on mine-owned infrastructure and Integra Underground Mine will continue to be managed in order to maintain safe work practices. All operational and safety measures currently implemented through the existing protocol will continue and will be enhanced through the common ownership of these mining operations by Glencore.

- INTERACTIONS WITH NEARBY MINES:
  - The Mount Owen Complex has already implemented a successful process of liaising with the operators of nearby mines in relation to the coordination of blasts to avoid concurrent blasting and therefore reduce the potential for cumulative airblast and vibration impacts.

- MANAGEMENT AND MITIGATION MEASURES:
  - The results of the assessment indicate that all impacts on residential receivers, infrastructure and historical / heritage sites can be managed effectively (i.e. complying with the vibration and airblast criteria as specified in Section 4).
  - To facilitate the Proposed Modification's compliance with vibration and airblast limits it is recommended to continue with the existing management measures identified in Section 7 and currently implemented on site in accordance with the BMP 2017.
  - Mount Owen will continue to undertake site inspections including inspections along the eastern high wall of the Proposed Modification Pit Shell to identify and monitor blast induced surface impacts such as cracking. This would allow for an accurate assessment of rock strata response when blasting in the vicinity of Main Creek.

REFERENCES

1. ACARP Report Reference No. C14057 'Effect of Blasting on Infrastructure' Alan Richards, Adrian Moore, 2008

2. Australian & New Zealand Environment and Conservation Council (ANZECC) 'Guidelines Technical Basis for Guidelines to Minimise Annoyance due to Blasting Overpressure and Ground Vibration' September 1990.

3. Australian Standard AS 2187.2:2006, Explosives – Storage and use, Part 2 – Use of explosives (AS 2187 Part 2).

4. Blast Management Plan Mount Owen Complex, April 2017. Document number: XMO-SD-EXT-0150-MOC-Blast-Management-Plan.

5. British Standard BS 7385-2:1993, Evaluation and measurement for Vibration in Buildings – Part 2: Guide to Damage Levels from Ground Borne Vibration.

6. Dam Safety Committee NSW 2011, Annexure "D" Standard Mining Conditions. Correspondence regarding 'Xstrata Mount Owen Pty Ltd application to open cut mine adjustment to Mount Owens Rail Loop Tailings Dam within the Mount Owen Notification Area', 16.12.2011.

7. Enviro Strata Consulting (ESC) Report, November 2013, 'Blast Impact Assessment of the Mount Owen Continued Operations Project on the Adjacent Community, Infrastructure and Underground Mine', Report no. UM-1219-281113.

8. Enviro Strata Consulting (ESC), Report, September 2014, "Vibration Limits for Former Hebden Public School and John Winter's Memorial Site", Report no. UM-1411- 040914.

9. Enviro Strata Consulting (ESC), Report, September 2017, "Gap Analysis – Blast Impacts From Mount Owen Mine On The Local Community", Report no. UM-1708-200917.

10. Enviro Strata Consulting (ESC), Report, October 2017, "Review of the Impact of Blasting on Rock Strata Fracturing on Main Creek", Report no UM-1705-270917.

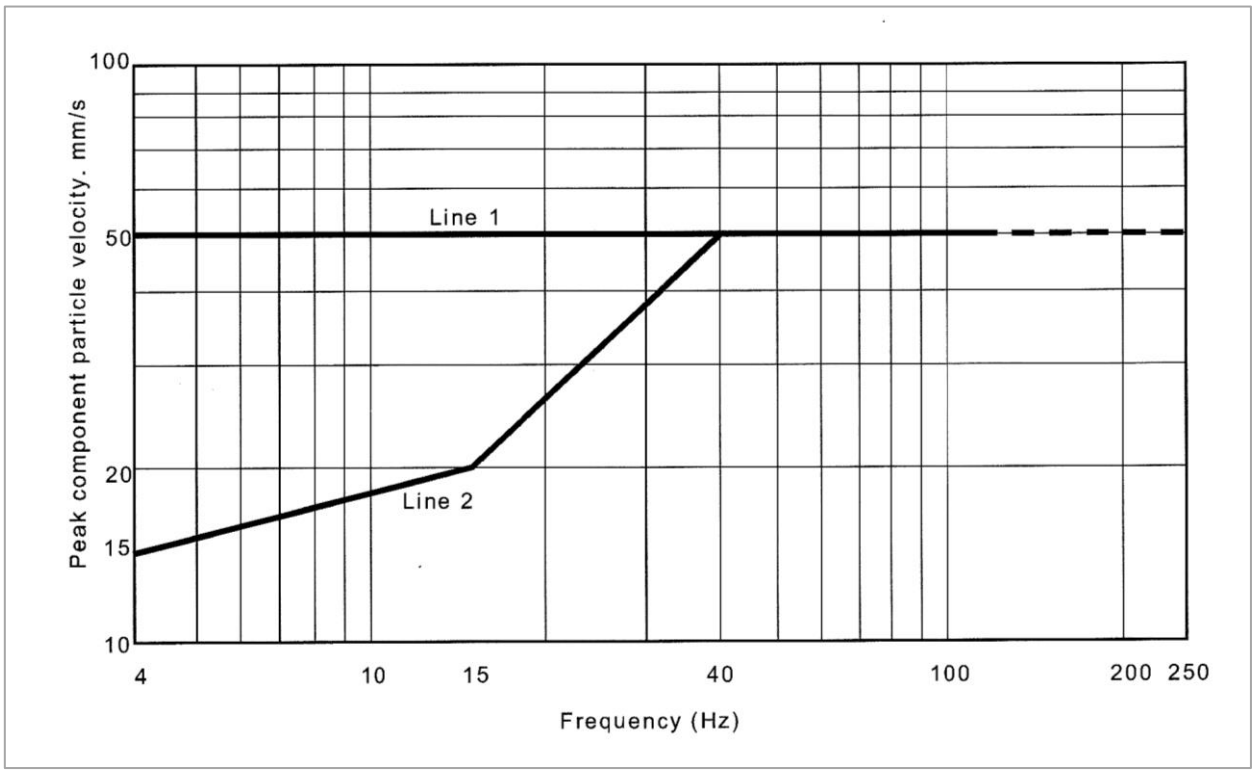
11. Mount Owen Continued Operations Project Development Consent, 2004. (SSD-5850).

12. US Bureau of Mines, USBM RI8507.

Thomas Lewandowski
24th May 2018
Enviro Strata Consulting

APPENDICES

Appendix 1A – Transient Vibration Guide Values for Cosmetic Damage - British Standard (BS 7385-2:1993)



Appendix 1B – Safe Level Ground Vibration Blasting Criteria from USBM RI8507