APPENDIX G

Blasting Impact Assessment

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FINAL MARTINS CREEK QUARRY EIS BLASTING UPDATE REPORT – MAY 2021

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EXECUTIVE SUMMARY

A detailed Blasting Impact Assessment (BIA) has been undertaken for the Martins Creek Quarry Extension Project (the Revised Project).

The BIA includes a review of nearly 6.5 years of blast monitoring data for blast induced air overpressure and ground vibration from 158 blasts at the Martins Creek Quarry (the Quarry) over the period March 2013 to August 2019.The review considered the performance of blasting impacts relative to criteria established under the Australian and New Zealand Environmental Council (ANZEC), 1990 – Technical basis for guidelines to minimise annoyance due to blasting overpressure and ground vibration (ANZEC 1990)

Vibration & Air Overpressure

During the period of monitoring reviewed, there were no exceedances of blast induced ground vibration at residences as the readings were well below the lower limit of 5mm/s PPV in the ANZEC 1990 guidelines set for human comfort which are considerably lower than those required for onset of cosmetic damage to residences.

One blast exceeded the lower limit of 115dBL for blast induced air overpressure at one residence in 2014 recording 116.8dBL however this was within the 5% allowance for the number of blasts in that reporting year and did not exceed the absolute criteria limit of 120dBL. There were no exceedances of the 120dBL criteria. Following the 2014 exceedance of the 115 dBL lower criteria, management measures were put in place to minimise the risk of exceeding the 115dBL air overpressure criteria and monitoring indicates that no blasts have exceeded this level in the nearly 5 years of subsequent blasting.

It is therefore considered that the blast management protocols already implemented and proposed for the Project will manage blasting to meet the relevant blast criteria associated with human comfort (ANZEC 1990).

In addition to the monitoring undertaken by the site, independent monitoring of blast induced vibration and air overpressure has also been undertaken on three occasions:

1. The Martins Creek Quarry Action Group (MCQAG) commissioned a specialist consulting and blast monitoring company to undertake the first of these. The results confirmed the Quarry blast monitoring data for the blast monitored.
2. The second and far more extensive monitoring program was conducted by the EPA from the 29th March 2018 to the 27th August 2018 capturing data from13 separate blasts. The EPA concluded that the vibration and air overpressure monitoring by the licensee was appropriate for complying with the conditions set out in the licence. There were no breaches of the Licence limits.
3. The third at 24 View Street, Vacy on the 26th June 2019 which indicated and blast induced vibration of PPV = 0.81mm/S and an air overpressure of 97.92dBL which are well below the lower environmental licence limits of 5mm/s and 115dBL

The independent monitoring programs were undertaken without site knowledge. All independent monitoring program validated the Quarry blast vibration and air overpressure monitoring results.

Flyrock

There have been no incidences or records of flyrock leaving the Quarry due to the ability to control air overpressure at the Quarry to the ANZEC limits. Limited air overpressure means no flyrock as it is the same hot, high pressure post detonation gases that create air overpressure, if not contained, that are responsible for flyrock.

The BIA also reviewed the blast design process and the risk mitigation used at the Quarry and confirmed that with the continued use of the detailed blast design process that considers environmental (vibration and air overpressure), geological and then operational constraints, that the Quarry will achieve the ANZEC Guideline (1990) blasting criteria in the Revised Project.

1.0 INTRODUCTION

1.1 **Background**

The Martins Creek Quarry (the Quarry) is operated by Buttai Gravel Pty Ltd, which is part of the Daracon Group (hereafter referred to as Daracon). The Quarry is an existing hard rock quarry situated within the Dungog Local Government Area (LGA), approximately 7 kilometres (km) north of Paterson and 28 km north of Maitland, New South Wales (NSW).

The Quarry was established in 1914 by the NSW Government Railways for the purpose of supplying railway ballast and other quarry materials to both the NSW railway network and Hunter Valley / Newcastle construction projects. Until late 2012, the Quarry has been operating continuously by various NSW Government transport departments, authorities and corporations.

In December 2012, Daracon secured a long-term license of the Quarry and have been extracting Andesite (which is a local term for this material, but petrography identifies it as Latite Tuff (VGT 2020) which will be adopted in this report) to produce high quality aggregates, road base, ballast, gabion and other specified materials used in road, railway, concrete and civil construction. In 2016, Daracon submitted a development application for the Martins Creek Quarry Extension Project. An Environmental Impact Statement (EIS) was prepared and exhibited during late 2016 (Monteath & Powys, 2016). The development application is being assessed as a State Significant Development (SSD) (application number SSD 6612), requiring approval under Part 4 of the Environmental Planning and Assessment Act 1979 (EP&A Act).

Following detailed analysis of the EIS submissions, Daracon committed to key design changes and additional mitigation and management measures to minimise the Project's environmental and social amenity impacts (the Revised Project). This included reductions in the proposed extraction limits, Quarry operating hours and truck movements.

Following community engagement and feedback during 2018 and 2019 and the change to Quarry operations in September 2019, Daracon has undertaken further quarry planning and design activities to optimise the use of the existing resource and minimise environmental and community impacts. As a result, the Revised Project now includes a number of additional amendments, including further reductions in road transportation volumes, peak hourly truck movements, operational hours, as well as a reduction in the Revised Project disturbance footprint. The changes relevant to this blast assessment are limited to the reduction in proposed quarrying area.

This Blasting Impact Assessment (BIA) has been prepared to inform the Revised Project's Amended Development Application and Response to Submissions (ADA and RTS). This report responds to submissions, specifically regarding the Blasting and Vibrations report *'Martins Creek Extension Project – Blasting and Vibration for Inclusion in EIS Report'* dated November 2015 with particular attention on the Regulatory Agency comments Table 1:

Table 1 – Agency Comments

Agency	Issue	Addressed
EPA	As the blasting report is dated November 2015, and given the period of time since that report was completed, and the EIS was lodged there have been a substantial number of blasts since 17 August 2015 that should have been included in a revised assessment. This would provide a more thorough review of blasting activities at the site over the previous years.	Appendix 1, Sections 3.0 and 4.0
Department of Planning & Environment	Provide predicted blast levels for potentially affected receivers based on the different stages of the quarry extraction plan.	Section 5

1.2 Information provided or obtained

The following information was provided or obtained:

1. Quarry Plans – for the current quarry footprint, Years 2, 6, 10, 15, 20 and the Final Quarry (FQ) and distances to the closest residences in 90^{O} sectors from the quarry centroid for each of these and the Paterson Valley Estate
2. The vibration and air overpressure results from the 1st March 2013 until the 19th August 2019 to enable blast vibration and air overpressure site laws (models) to be generated. Quarry operations were placed into limited operations from September 2019, with substantially reduced blasting activity and continued use of the blasting design and controls applied during the more intense operations covered by the data analysed in this report.
3. Current techniques used to minimize blast induced vibration, air overpressure and flyrock at the Quarry.

1.3 Residence Locations

For the purposes of the assessment, the areas around the Quarry have been divided into four sectors and the closest residences in each sector to the existing and proposed Quarry area are identified below, rounded to the nearest 5m:

North

- R46 - 406 Dungog Road, Martins Creek – 540m currently, moving to 885m in Year 2, with a minimum distance of 350m in the Year 15 quarry stage
- R92 - 32 View Street, Vacy – 935m currently, with closest proposed of 760m during the Years 15 and 20 quarry stages
- R73 - 16 View Street, Vacy – 800m currently, with closest proposed being 640m during the Years 15 and 20 quarry stages

East

- R60 - 126 Merchants Road, Martins Creek –550m currently, with this minimum distance maintained during early quarry stages (Years 2 to 6), moving to 895m in Year 25

- R32 - 14 Vogeles Road, Martins Creek – 880m currently, with a minimum distance of 425m in Years 2 and 25 quarry stages
- R67 - 159 Vogeles Road, Martins Creek – 1230 m currently, with closest proposed being 880m in Year 2 and 25 quarry stages

South

- R1 - 23 Station Street, Martins Creek – 310m currently, with closest proposed being 290m in the final quarry stage (Year 25)

West

- R16 - 256 Dungog Road, Martins Creek – 345m currently, moving to 755m in Year 2 quarry stage, and closest proposed being 270m in Years 15 and 20
- R34 - 338 Dungog Road, Martins Creek – 250m currently, and greater than this for all future stages

The location of these residences in relation to existing quarry operations, and the four sectors, is shown in Figure 1. Figure 1 also shows the location of the three blast monitoring locations managed by the Quarry. Further analysis of the distance of nearest residence from each stage of quarry operations is provided in Section 3.1.2.

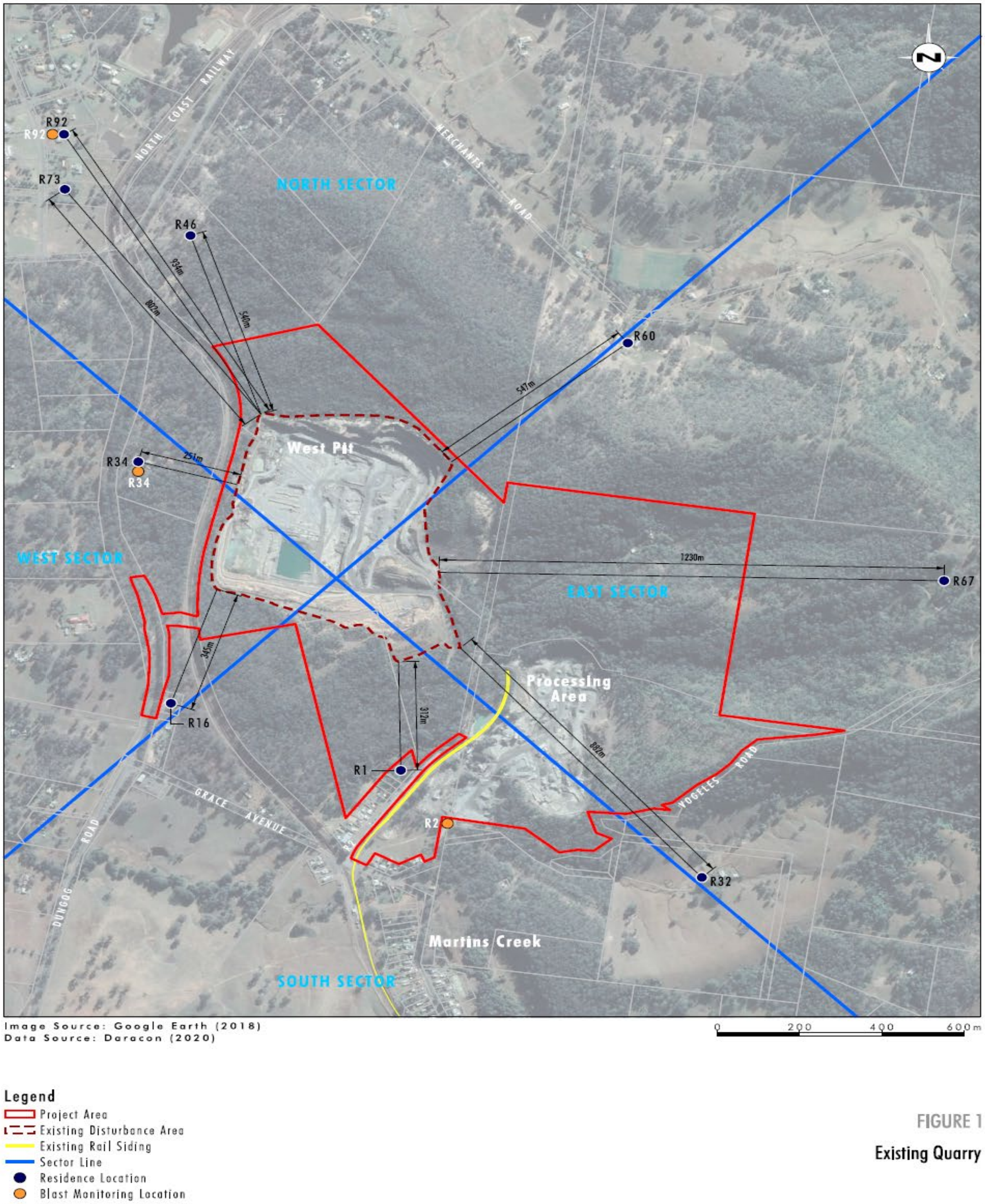

FIGURE 1

Existing Quarry

2.0 BLAST EMISSION CRITERIA

2.1 Criteria for Private Residences

2.1.1 Blast Emission Criteria - Human Comfort

The relevant blast assessment criteria associated with human comfort come from the *ANZEC 1990 Technical basis for guidelines to minimise annoyance to blasting overpressure and ground vibration (ANZEC Blast Guidelines)* are provided in Table 2. These criteria have been adopted by the NSW Environment Protection Agency (EPA) and the NSW Department of Planning, Industry and Investment (DPIE) as the relevant assessment/compliance criteria for blasting in extractive industries and mining.

Table 2- Residential Blast Impact Criteria for Human Comfort

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 12-month period	115	5% of the total number of blasts over a 12-month period
	10	0%	120	0%

1.1.2 Blast Emission Criteria – Ground Vibration

The blasting criteria for vibration at the Quarry currently prescribed by the Environment Protection Licence issued for the site (EPL 1378) are:

- 95% of the blasts in each annual reporting period must be less than or equal to 5mm/s PPV
- 5% of the blasts in any annual reporting period can be greater than 5mm/s but less than or equal to 10mm/s
- Under no circumstances shall any blast be greater than 10mm/s PPV.

1.1.3 Blast Emission Criteria – Air Overpressure

The current criteria under EPL 1378 for blast induced air overpressure for the Quarry are:

- 95% of the blasts in each annual reporting period must have air overpressures of less than or equal to 115dBL with
- 5% of the blasts allowed to be greater than 115dBL but less than or equal to 120dBL with
- No blasts shall exceed 120dBL.

1.2 Criteria for Infrastructure, Buildings and Historical Sites

The EPL does not adopt any specific criteria for blast related impacts on structures.

The ANZEC air overpressure and vibration criteria are aimed at human discomfort which is significantly lower than those that generate the onset of damage to residences and thus adherence to these minimise the possibility of residence damage caused by blasting.

Guidelines in regard to vibration limits for quarry owned 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 overpressure limit for damage control; this limit is recommended as a safe level that will prevent structural / architectural damage from blasting

These limits are used as the assessment criteria for the Revised Project.

The same limit for public roads and concrete bridges was presented in ACARP Report No. C14057. The recommendations in regard to vibration exposures for concrete bridges are also provided in the Australian Standard AS 2187.2-2006 (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 PPV
- Concrete bridges – 100 mm/s PPV

The vibration limits for railway lines have been known to vary from 50mm/s to 200mm/s PPV. This report uses 100mm/s PPV from AS2187.2-2006- Storage and Use – Use of Explosives for concrete and steel structures.

These vibration limits are used as the assessment criteria for the Revised Project.

2. METHODOLOGY

2.1 Ground Vibration Modelling

The generalised form of any blast induced ground vibration is:

$$V = K\left(\frac{R}{Q^{0.5}}\right)^{B}$$

where:

V = ground vibration as peak particle velocity (mm/s)

K = constant related to the site and rock properties

R = distance between the charge and the point of concern (m)

Q = maximum instantaneous charge weight (kg)

B = constant related to the site and rock properties (usually -1.6)

The K factor is a site constant that can only be determined accurately by evaluating a large number of blasts (generally greater than 50) as is the case with the Quarry blasting database. If the distance from the blast is known and the amount of explosive detonating in a blasthole is known then the K factor can be determined mathematically. The B factor can also be determined mathematically but it is accepted in the AS2187.2-2006 and many other publications that it is close to -1.6. Once the K and B factors are known then the blast induced ground vibration can be modelled as the amount of explosive detonating (Q) is known as is the distance to the residence or structure of interest. If the modelled blast is below the 5mm/s PPV (generally aim for about 90% of the limit or 4.5mm/s) then the design is implemented. If it is not then the blast is redesigned which is what happens at the Quarry where blast induced vibrations are minimised.

Appendix 1 contains nearly 6.5 years of blasting vibration and air overpressure data that was used to generate the 95% confidence limit K factors for each of the monitoring locations at the Quarry:

1. Paterson Valley Estate - K factor = 7400, R92, Figure 1
2. Back Gate – K factor = 1900, R2, Figure 1
3. Gully or 338 Dungog Road – K factor = 2000, R34, Figure 1

3.1.1 Review of Ground Vibration Monitoring Data

A review of nearly 6.5 years of ground vibration monitoring data was undertaken covering from the 1st March 2013 to the 19th August 2019 (158 blasts). The review identified no exceedances of ground vibration criteria at the private residences, all of which were well below the level of 5mm/s PPV (refer to Appendix 1).

The information in Appendix 1 indicates the highest ground vibration recorded during this time as being:

- 4.57mm/s PPV at the Gully Monitor at 366 Dungog Road
- 3.72mm/s PPV at the Paterson Valley Estate monitor and
- 1.78mm/s PPV at the Back-Gate Monitor.

The maximum ground vibration recorded is less than 91.4% of the 5mm/s PPV but the majority are well below the 70% indicating that the Quarry has the systems, procedures and methodologies to manage blast induced ground vibration below relevant criteria.

3.1.2 Staged Quarry Increments & Distance to Closest Residences in North, South, East & West Sectors

The assessment for both blast, induced ground vibration and air overpressure for the Quarry stages utilises four sectors being north, south, east and west, Figures 2 – 7 inclusive.

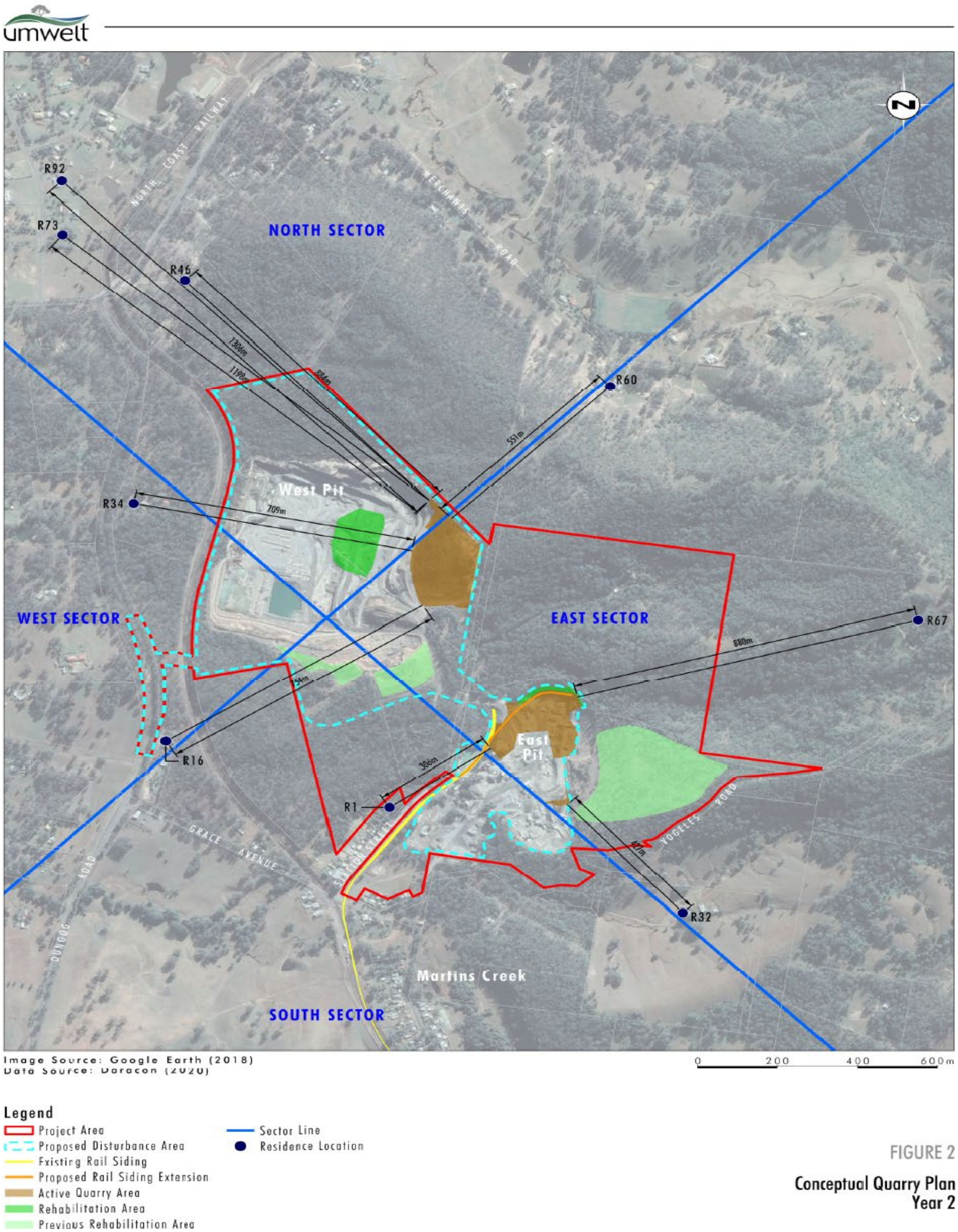

FIGURE 2

Conceptual Quarry Plan
Year 2

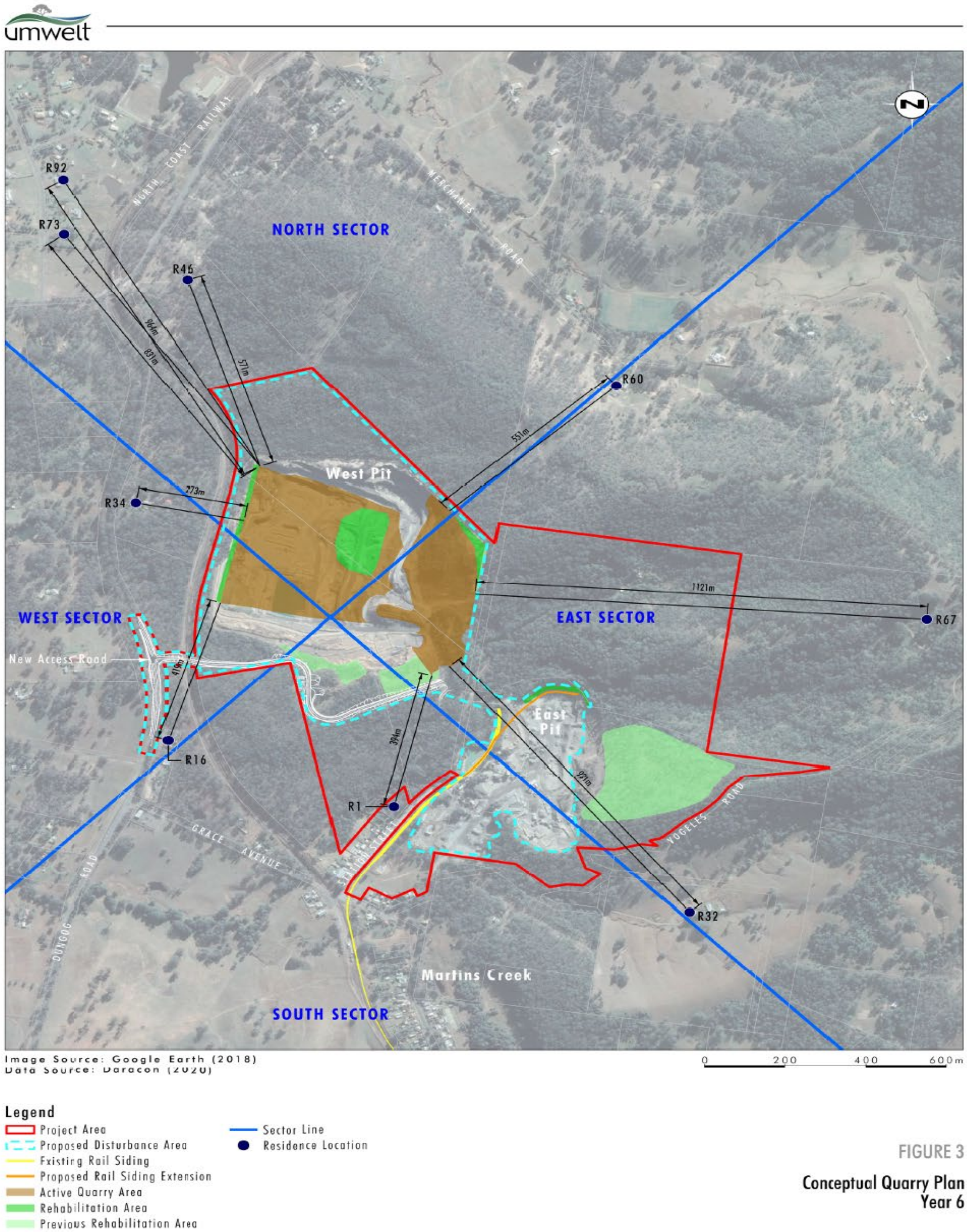

FIGURE 3

Conceptual Quarry Plan Year 6

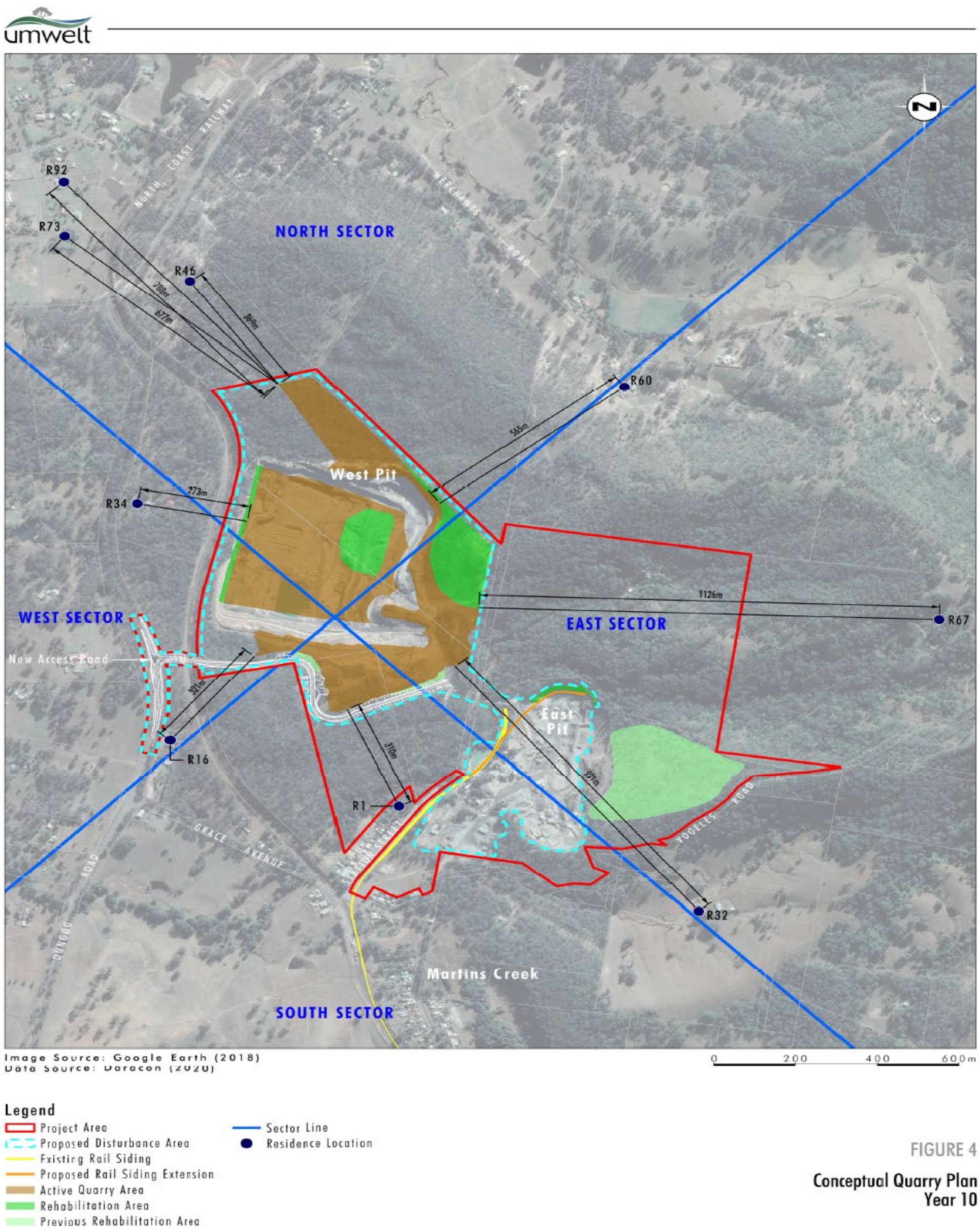

FIGURE 4

Conceptual Quarry Plan
Year 10

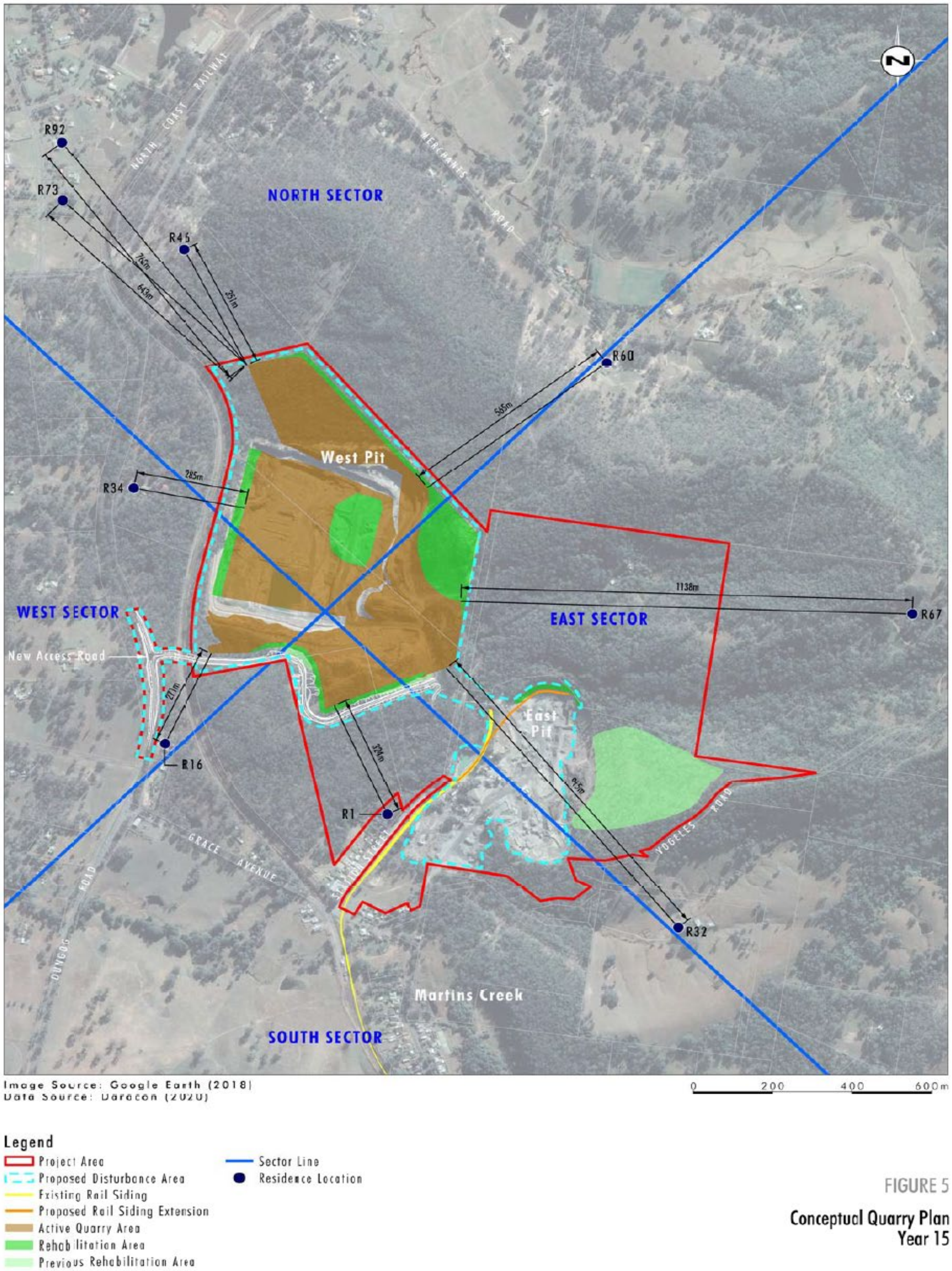

FIGURE 5

Conceptual Quarry Plan
Year 15

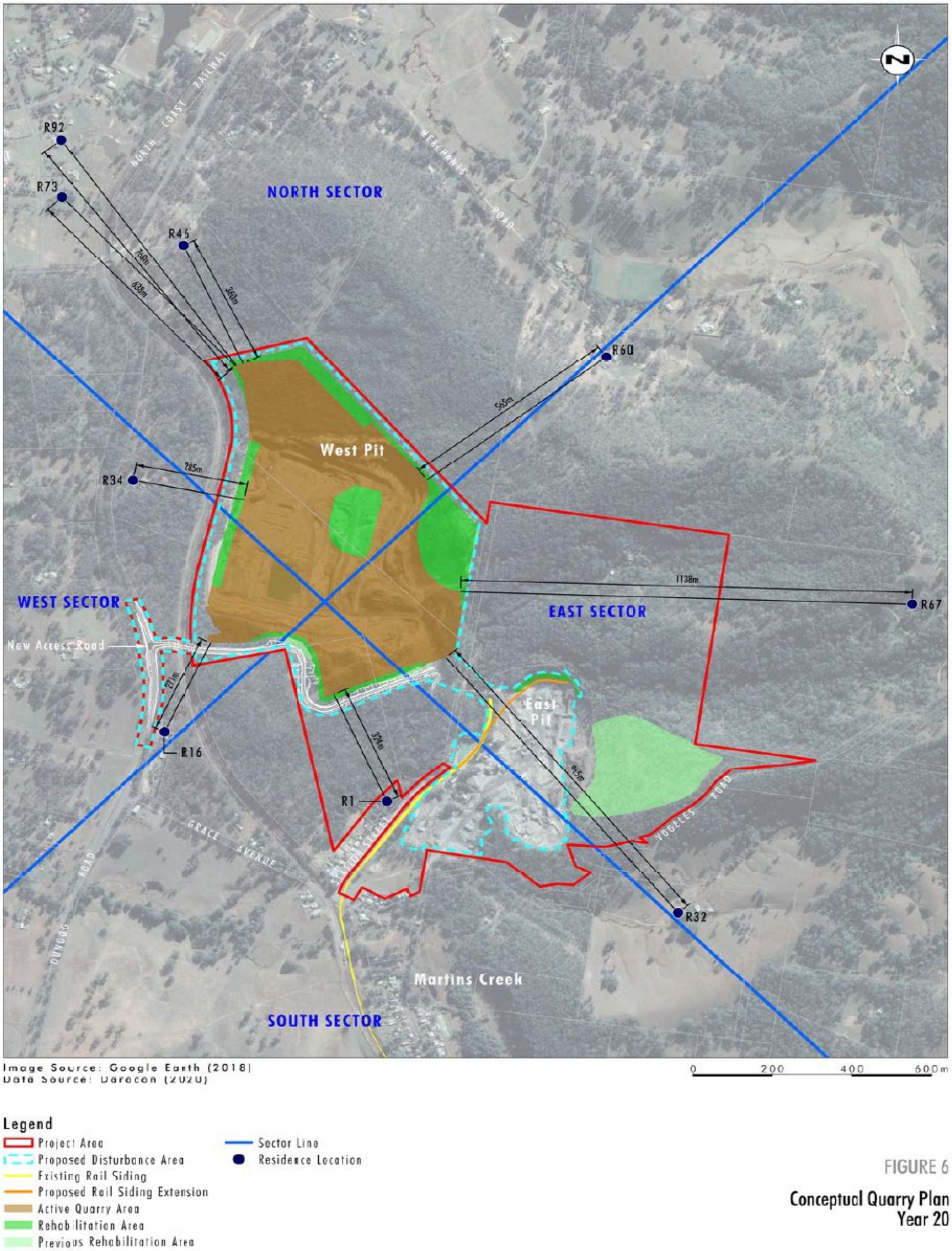

FIGURE 6

Conceptual Quarry Plan
Year 20

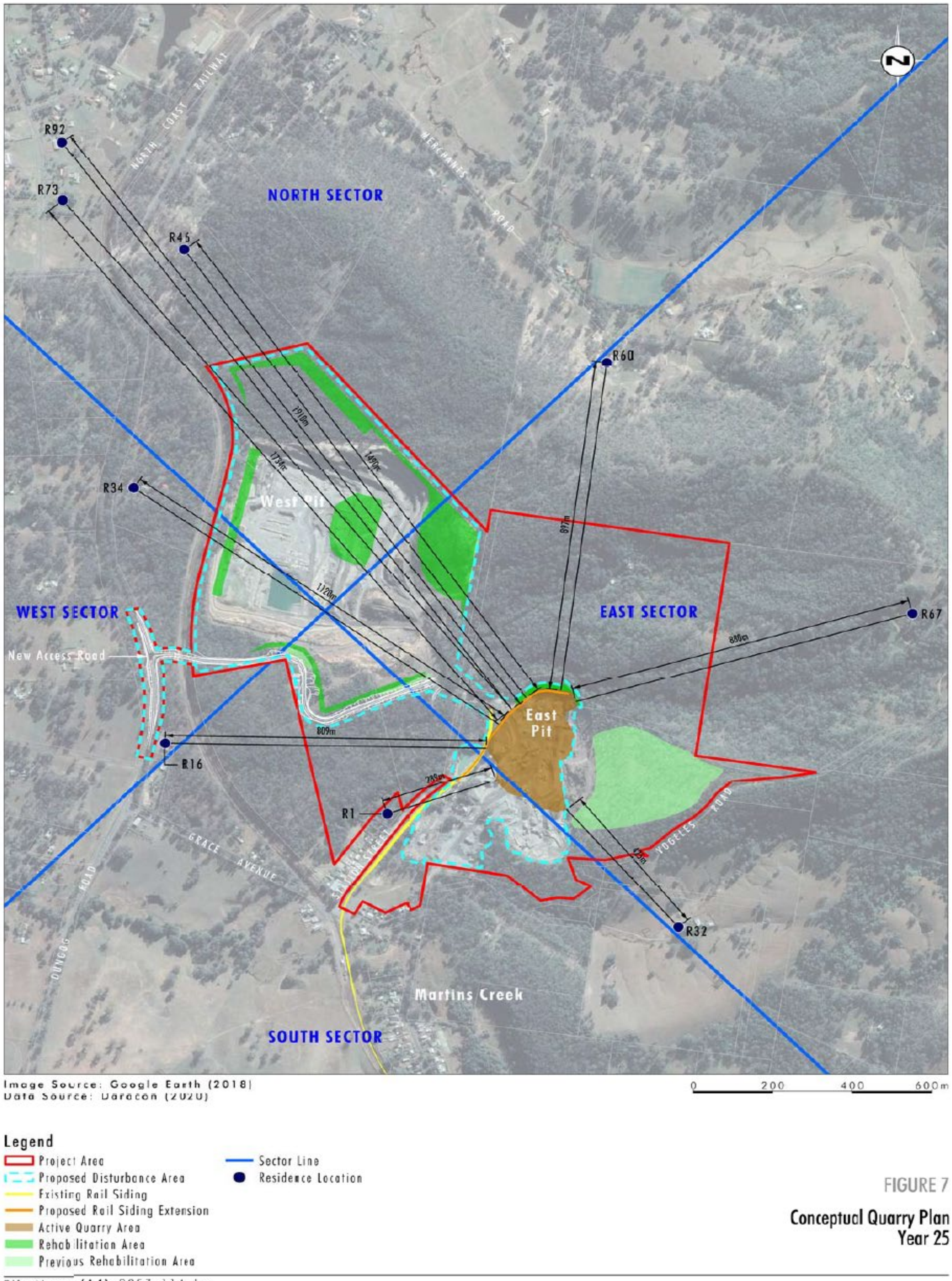

FIGURE 7

Conceptual Quarry Plan
Year 25

The data in Table 3 refers to the closest that blasting comes to each of the residences in each of the sectors for each quarry stage, rounded to the nearest 5m.

Table 3 – Closest Distances to Blasting in Metres for Each Quarry Stage

Res ID	Address	Sector	Distance to Receiver from Nearest Blast (m)						
			Current	Year 2	Year 6	Year 10	Year 15	Year 20	Year 25
R46	406 Dungog Road, Martins Creek	North	540	885	570	350	350	360	1490
R92	32 View Street, Vacy	North	935	1305	965	785	760	760	1910
R73	16 View Street, Vacy	North	800	1195	830	675	640	640	1735
R32	14 Vogeles Road, Martins Creek	East	880	425	930	930	915	915	425
R60	126 Merchants Road, Martins Creek	East	550	550	550	565	565	565	895
R67	159 Vogeles Road, Martins Creek	East	1230	880	1120	1125	1135	1135	880
R1	23 Station Street, Martins Creek	South	310	305	395	310	325	325	290
R16	256 Dungog Road, Martins Creek	West	345	755	420	320	270	270	810
R34	388 Dungog Road, Martins Creek	West	250	705	275	275	285	285	1120

The K Factors for each of the residences, Figure 1 are based on the blast monitoring data and are shown in Table 4. The K values for the South Sector residences (which is derived from monitoring at 23 Station Street, Martins Creek) has been adopted for the East Sector Residences.

Table 4– Adopted K Values and Distance to Blast

Res ID	Address	Closest Distance (m)	Sector	K Value
R46	406 Dungog Road, Martins Creek	350	North	7400
R92	32 View Street, Vacy	760	North	7400
R73	16 View Street, Vacy	640	North	7400
R32	14 Vogeles Road, Martins Creek	425	East	1900
R60	126 Merchants Road, Martins Creek	550*	East	1900
R67	159 Vogeles Road, Martins Creek	880	East	1900
R1	23 Station Street, Martins Creek	289	South	1900
R16	256 Dungog Road	271	West	2000
R34	388 Dungog Road	250*	West	2000

*Current distance – blasting moves away from receptor during life of Project.

3.2 Air Overpressure Modelling

Air overpressure levels generated from blasting have been generally modelled using the following cube root scaling formula presented in AS2187.2 -2006:

$$P = K_a \left(\frac{R}{Q^{1/3}} \right)^a$$

where
P = pressure, in kilopascals
Q = explosives charge mass, in kilograms
R = distance from charge, in metres
Ka = site constant
a = site exponent

For confined blasthole charges, such as used at the Quarry, the site exponent (a) is normally -1.45 and the site constant (Ka) is commonly in the range 5 to 100 and is based on localised site conditions. This report uses a Ka of 19 and an (a) of -1.45 based on modelling of the blasting and associated monitoring results from 1st March 2013 to 19th August 2019 covering 158 blasts.

4 METRICS/CONTROLS

4.1 Blast Induced Vibration

Blasts can be designed to ensure vibration impacts at particular locations can be met. There are a number of methods and techniques to reduce and control blast induced ground vibrations generally and specifically at the Quarry and these are summarised in Table 5.

Daracon personnel at the Quarry are committed to incorporate all relevant blast vibration reduction mitigation measures into the blast design process to minimise potential vibration impacts and achieve compliance with the relevant criteria. All previous blasting has been well under the ANZEC1990 guidelines lower limits.

As the Revised Project moves through the various stages, blasting will move closer to some residences in all sectors but blasting will always be designed to meet the blasting criteria.

Table 5 – Controls to Minimise Blast Vibration at Quarry

Primary Control	Secondary Control	Used at Quarry	Explanation
Site Laws	N/A	Yes	
Reduce charge weight/delay	Small diameter holes	Yes	
	Only 1 blast hole firing in each 8ms of time	Yes	
	Decking – 2 or more explosive charges in a hole	Yes	Used only when required
Reduce explosives confinement	Maximise the number of free faces	Yes	
	Fire op deck down	Yes	Used only when required

Primary Control	Secondary Control	Used at Quarry	Explanation
	Remove broken material from the free face	Yes	
	Reduce burden distance	Yes	
	Optimise the stem length	Yes	
	Optimise subdrill	Yes	
	Ensure that the length of the blast is a minimum of 3 times the depth	Yes	
Initiate each shot so that it fires away from the nearest residence	Portion of the design process	Yes	
Allow for variable RL	Survey used	Yes	
Use longer delays		Yes	Minimises vibration by providing more burden relief
Minimise variation in all aspects of drill and blast		Yes	Aim to reduce to as low as reasonably possible
Keep total blast duration to under 1 second		Yes	This limits the size of the larger blasts

4.2 Blast Induced Air Overpressure

There are a number of methods and techniques to reduce Air Overpressure (AOP) and flyrock in quarrying operations. The current management measures implemented at Quarry are outlined in Table 6.

Table 6 – Methods Used to Minimise AOP and Flyrock at Quarry

Method	Used at Quarry	Reason
Use Crushed Angular Aggregate Stemming	Yes	
Use adequate stem length	Yes	
Remove Toe and buffer material in front of face	Yes	
Deck through under-burdened face holes or weak rock	Yes	Visual inspection of face and location of face holes
Use correct delays	Yes	Delays conform to timing design rules
Blasts maximum 5 or 6 rows deep	Yes	
Video photograph all blasts and use to optimise future blasts to minimise air overpressure and flyrock	Yes	
Orient faces so not directly facing nearest residences and fire blasts away from potentially affected residences	Yes	Quarry implements this where possible – blast induced AOP data confirms this and the ability to control AOP
Eliminate secondary blasting	Yes	
Delay firing shots if weather/wind conditions are unfavourable	Yes	Implemented to minimise AOP caused by wind

Method	Used at Quarry	Reason
Implement methods to reduce face movement causing excessive AOP	Yes	A number of strategies routinely used at Quarry
Downloading the side and back holes of blasts	Yes	
Not firing the blast if the wind speed is greater than 2m/s	Yes	
Use 76mm diameter decked face holes	Yes	
Use 67ms on the control row and 42ms delays back through the shot	Yes	

4.3 Review of Blast Induced Air Overpressure

A review of the blast induced air over pressure monitoring data for the period 1st March 2013 to the 19th August 2019 (158 blasts) in Appendix 1 shows only in 1 instance where the 115dBL lower ANZEC 1990 guideline criteria was been exceeded. This exceedance was monitored at the Gully Monitor at 334 Dungog road with a 116.8dBL reading on the 8th October 2014. The dBL measurement technique includes the air overpressure from all sources including both wind and blasting. The investigation into this exceedance of the 115 dBL criteria indicated that this was not blast induced but mainly a wind induced air overpressure as the wind speed at the time of the blast was close to 5m/s which equates to an air overpressure of 115.9dBL. No other exceedances of the 115dBL criteria were recorded within the annual reporting period and this blast did not constitute a breach of the relevant EPL criteria.

Following the 2014 recording of the 115dBL overpressure level, additional procedures were implemented at the quarry to reduce the risk of overpressure including changes to blast timing and delays and avoiding blasting during meteorological conditions where wind exceeds 2m/s. Since the introduction of these controls, there have been no exceedances of the 115dBL at any monitoring locations.

5 BLAST IMPACT ASSESSMENT

5.1 Assessment Methodology

Six different blast designs have been assessed to identify whether the vibration and air overpressure criteria can be met at each receiver location when blasting occurs at the nearest point to that receiver. The different blast designs (refer to Table 7) include both decked blast designs and standard designs.

The different blast designs were modelled using the site-specific constants established for the quarry and discussed above in Section 3.0.

The purpose of the assessment is not to define the precise blasting parameters to be applied for each blast but rather to demonstrate that blasts can be designed such that the relevant criteria can be met. As with existing operations, each blast is designed for the specific geological conditions associated with that blast and site laws applicable to the blasts are considered in the design to ensure that relevant criteria will be met at each of the nearest sensitive receptor locations. The controls implemented include the current blast management measures identified in Tables 5 and 6.

Table 7 – Blast Designs Considered in Assessment

Parameter	Design 1	Design 2	Design 3	Design 4	Design 5	Design 6
Design Type	Main Body Decked	Main Body Decked	70mm Diameter Front Row	Main Body	Main Body	76mm Diameter Front Row
Bench Height	10m	10m	10m	10m	10m	10m
Hole Diameter	76mm	89mm	70mm	76mm	89mm	76mm
Burden	2.3m	2.6m	2.3m	2.5m	2.8m	2.5m
Spacing	2.6m	3.0m	2.6m*	2.8m	3.2m	2.8m#
Stem Length	2.3m	2.6m	2.4m for fully charged holes	2.5m	2.6m	2.5m for fully charged holes
Subdrill	0.5m	0.5m	0.5m	0.5m	0.5m	0.5m
Deck Size	2 by 3.35m	2 by 3.2m	2 by 3.3m	N/A	N/A	N/A
Intermediate Stem Deck	1.8m	1.5m	1.5m	N/A	N/A	N/A
Bulk Explosive Type	Watergel or Emulsion	Watergel or Emulsion	ANFO, Watergel or Emulsion	Watergel or Emulsion	Watergel or Emulsion	Watergel or Emulsion
Density	1.1g/cc	1.12g/cc	1.1g/cc	1.12g/cc	1.12g/cc	1.12g/cc
Hole Charge Weight	2 by 17kg charges	2 by 23kg charges	2 by 14kg charges	42kg	57kg	32kg
Powder Factor	0.57kg/bcm	0.59kg/bcm	0.64kg/bcm	0.60kg/bcm	0.64kg/bcm	0.63kg/bcm
MIC	17kg	23kg	14kg	42kg	57kg	32kg

*but really 1.3m as holes are at half spacing – every second hole charged with 3m of toe charge
but really 1.4m as holes are at half spacing – every second hole charged with 3m of toe charge

5.2 Assessment results

5.2.1 Impact on Private Residences

This section provides an assessment of the potential impact of blasting from the Revised Project on the surrounding area, specifically the residential receivers. The aim is to identify the potential ground vibration and airblast exposure which will be generated when undertaking blasting within the proposed quarry footprint boundary.

5.2.1.1 Ground Vibration

The estimated impact of ground vibrations from the Revised Project on the private residential receivers was assessed in detail using ground vibration modelling outlined in Section 3.1.

Figure 1 in Section 1 provides an aerial view of the current Quarry and the closest residences. Table 8 summarises the blast designs in Table 7 that can be implemented at the Quarry and meet relevant vibration criteria.

Table 8 – Assessment of Blast Design to Meet Vibration Criteria

Residence	Year	Distance to nearest blast (m)	Design Scenario Considered					
			Design 1	Design 2	Design 3	Design 4	Design 5	Design 6
			Main Body Decked 76mm 2x 17kg	Main Body Decked 89mm 2x23kg	Front Row Decked 70mm 2x14kg	Main Body 76mm 42kg	Main Body 89mm 57kg	Front Row Decked 76mm 32kg
406 Dungog Road	0	540	Yes	Yes	Yes	Yes	Yes	Yes
	2 to 6	889	Yes	Yes	Yes	Yes	Yes	Yes
	10	369	Yes	Yes	Yes	Yes		Yes
	15	351 to 360	Yes	Yes	Yes	Yes		Yes
	25	1490	Yes	Yes	Yes	Yes	Yes	Yes
32 View Street	All	760 to 1910	Yes	Yes	Yes	Yes	Yes	Yes
4 Vogeles Road	All	427 to 931	Yes	Yes	Yes	Yes	Yes	Yes
23 Station Street	All	289 to 394	Yes	Yes	Yes	Yes		Yes
256 Dungog Road	0 to 10	321 to 754	Yes	Yes	Yes	Yes	Yes	Yes
	15	271	Yes	Yes	Yes	Yes*		Yes*
	25	809	Yes	Yes	Yes	Yes	Yes	Yes
338 Dungog Road	0	251	Yes	Yes	Yes	Yes#		Yes#
	2	709	Yes	Yes	Yes	Yes	Yes	Yes
	6-20	270 - 285	Yes	Yes	Yes	Yes#		Yes#
	25	1120	Yes	Yes	Yes	Yes	Yes	Yes
16 View Street	0-6	802-1189	Yes	Yes	Yes	Yes	Yes	Yes
	10	677	Yes	Yes	Yes	Yes		Yes
	15-20	635 - 675	Yes	Yes	Yes			Yes
	25	1734	Yes	Yes	Yes	Yes	Yes	Yes
126 Merchants Road	All	547 to 897	Yes	Yes	Yes	Yes	Yes	Yes
159 Vogeles Road	All	880 to 1230	Yes	Yes	Yes	Yes	Yes	Yes

*Only for blasts >290m from residence

#Only for Holes > 280 from residence

It is therefore considered that the blast management protocols already implemented and proposed for the Revised Project and the use of appropriate blast designs will manage blasting to meet the relevant blast criteria associated with human comfort (ANZEC 1990).

5.2.1.2 Air Overpressure

The air overpressure modelling uses the model developed in Section 3.2 of this report with Ka of 19 and an (a) of -1.45 as this represents the actual monitoring data. The modelled air over pressures for the MICs identified as acceptable to meet vibration criteria in Table 8 are detailed below in Table 9.

Table 9 – Quarry Stages, Distance, MIC and Modelled AOP

Residence	Quarry Stage(s) Years	Minimum Distance (m)	MIC (kg)	AOP (dBL)
406 Dungog Road	Current	540	57	111
	2	884	57	103
	6	571	57	109
	10	369	42	112
	20	360	42	112
	FQ	1490	57	91
2 View Street	Current	934	57	102
	2	911	57	103
	6	964	57	102
	10 - 20	760 - 788	42	100
	FQ	1910	57	86
14 Vogeles Road	Current - FQ	1027	57	97 - 108
23 Station Street	Current - 20	310 -324	42	111 -112
	FQ	289	23	110
256 Dungog Road	Current	345	57	111
	2	756	57	100
	6	419	57	108
	10 - 20	271 - 321	42	111 - 113
	FQ	809	57	99
338 Dungog Road	Current-	251	23	112
	2	709	57	101
	6 - 20	273 - 285	23	110
	FQ	1120	57	94
16 View Street	Current	802	57	99
	2	1198	57	93
	6	831	57	98
	10 - 20	638 - 677	42	100 - 101
	FQ	1134	57	92
126 Merchants Road	Current - 20	547 - 565	57	104 - 105
	FQ	897	57	97
159 Vogeles Road	Current	1230	57	93
	2	880	57	97
	10 - 20	1121 - 1138	57	94
	FQ	880	57	97

Note – FQ is final quarry representing the end of quarrying.

As can be seen from Table 9, the blast sizes identified as being suitable to meet relevant blast induced vibration criteria would also result in the blasts meeting relevant overpressure criteria.

Ability for Quarry Blasting to Meet EPL Vibration & Air Over Pressure Limits

Both the blast induced ground vibration and air overpressure modelling at the various quarry stages indicates that the lower level ANZEC 1990 guidelines limits for both vibration and air overpressure are able to be met through appropriate blast design. This is supported by the last 6 years of blast monitoring data including the 3 independent blast monitoring programs with no exceedances of either the vibration or overpressure EPL criteria recorded and the 3 independent blast monitoring programs.

Blasting proposed as part of the Revised Project will meet the ANZEC 1990 guideline lower limits for blast induced vibration and air overpressure based on the modelling and past performance.

5.2.1.3 Flyrock

The measures to manage blast overpressure impacts (refer to Table 6 in Section 4.2) are also relevant to reduce the risk of flyrock to ALARP (As Low As Reasonably Possible). All blasts are monitored by video and there have been no flyrock incidents or events warranting investigation at the quarry since Daracon commenced operation of the quarry in late 2012.

The key measures which reduce fly rock risk are:

1. The methods and techniques detailed in Table 6
2. Downloading the sides and the backs of all blasts via the use of longer stem lengths to minimise side break and back break near the crest area which could create damaged rock increasing the potential for flyrock in the next blasts and he current blast
3. Use of slower delays across the front of the shot so there is less reinforcement from adjacent charges and hence reduced risk of flyrock
4. Use of smaller (76mm or even 70mm) diameter holes in the front row of the shot as described in Table 7
5. Use of double stitched face holes which are alternatively fully charged and then part charged with explosive as per Table 7.

With the continued implementation of the above measures, the Revised Project is not anticipated to pose a risk in terms of fly rock associated with blasting. All blasts will continue to be recorded by video. Should any unexpected instances of flyrock occur, the cause of the event will be investigated to inform any necessary changes to blast design and controls.

5.2.2 Infrastructure, Buildings and Historical Sites / Heritage Items

The analysis below presents an assessment of vibration exposures from the Revised Project on the adjacent infrastructure and historical heritage sites. As in the assessment above (Section 5.2), the analysis is based on vibration modelling using the applicable vibration predictive models, see Section 3.1. The vibration modelling estimates have been analysed, including references to relevant vibration limits.

5.2.2.1 Location of Infrastructure, Buildings and Historical Sites / Heritage Items

The relevant infrastructure and historical heritage sites are presented in Figure 8. The infrastructure and historical sites covered in this assessment include:

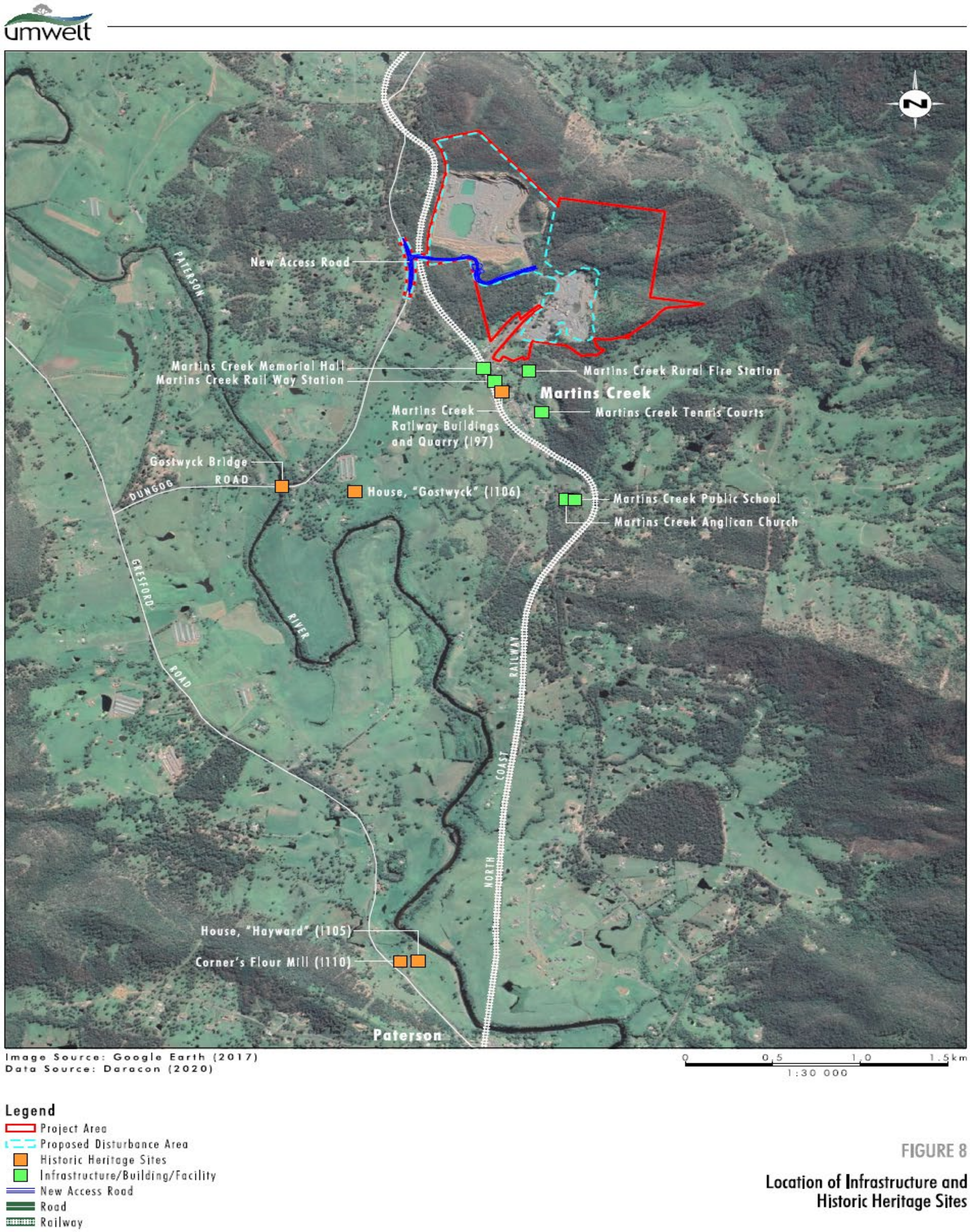

Figure 8 – Location of Infrastructure, Buildings and Historical Sites / Heritage Items

Infrastructure and buildings:

- Public infrastructure, including public roadways: Dungog Road, Gresford Road, Gostwyck Bridge, the North Coast Railway and Martins Creek Railway Station;
- Emergency services: Martins Creek Rural Fire Station;
- Martins Creek amenities: public parks, Martins Creek Anglican Church, Martins Creek Public School, tennis courts and memorial hall;
- Telecommunications Infrastructure; and
- Quarry owned infrastructure (offices, workshop, processing plant) and proposed new main access road and bridge over the railway line.

Historical Sites / Heritage Items:

- Martins Creek railway buildings and quarry (I97)
- House, "Gostwyck" (I106)
- The Gostwyck bridge (I107)
- Corner's flour mill (I110)
- House, "Hayward" (I105)

The identified infrastructure and historical sites are located at variable distances with respect to the Project Area as indicated in Table 10.

Table 10 – Distances of key infrastructure and heritage items to the quarry

Infrastructure / Heritage Item	Approximate Distance (km)
New access road	0.52
North Coast Railway line	0.32
Gostwyck Bridge	2.04
Dungog Rd	0.5
Gresford Rd	2.7
House Gostwyck (I106)	1.75
Martins Creek Anglican Church	1.3
Martins Creek Public School	1.3
Martins Creek Tennis Courts	0.73
Martins Creek RFS	0.5
Martins Creek Memorial Hall	0.64
Matins Creek Railway station	0.66
Martins Creek Railway Buildings and Quarry (I97)	0.69
House Hayward (I105)	4.48
Corners Flour Mill (I110)	4.51

5.2.2.2 Assessment Results

Ground Vibration & Air Overpressure

All relevant infrastructure and historical sites/heritage items note in Table 10 are in the southern sector of the blast vibration zones and the K factor is determined by the back-gate monitor, figure 1, which has a K factor of 1900. The highest charge for vibration and air overpressure is 42kg in blasting closest to the back-gate monitor and to meet the target 4.5mm/s PPV blast induced vibration at the closest residences in Station Street. These two parameters were used to determine the blast induced vibration on the items in Table 10.

The air overpressure modelling uses the model developed in Section 3.2 of this report with Ka of 19 and an (a) of -1.45 as this represents the actual monitoring data for the Quarry but utilising the distances and a 42kg maximum charge weight.

Both the Blast Vibration and blast induced air overpressure modelled results are detailed in Table 11

Table 11 **– Distances & modelled blast vibration & air overpressure for key infrastructure and heritage items to the quarry**

Infrastructure / Heritage Item	Approximate Distance (km)	Blast Induced Vibration (mm/s)	Blast Induced Air Overpressure (dBL)
New access road	0.52	2	104
North Coast Railway line	0.32	4.3	110
Gostwyck Bridge	2.04	0.2	83
Dungog Rd	0.5	2.1	104
Gresford Rd	2.7	0.1	79
House Gostwyck (I106)	1.75	0.3	86
Martins Creek Anglican Church	1.3	0.5	90
Martins Creek Public School	1.3	0.5	90
Martins Creek Tennis Courts	0.73	1.1	98
Martins Creek RFS	0.5	2.1	104
Martins Creek Memorial Hall	0.64	1.4	100
Matins Creek Railway station	0.66	1.3	99
Martins Creek Railway Buildings and Quarry (I97)	0.69	1.3	100
House Hayward (I105)	4.48	0.1	72
Corners Flour Mill (I110)	4.51	0.1	72

The maximum blast induced vibration is 4.3mm/s on the railway line which is well under the PPV limit of 100mm/s so will not damage the line. The second largest vibration is 2.1mm/s PPV closely followed by 2mm/s PPV which are very low and will not damage the roads as the vehicles on these roads will create far larger induced vibrations. The remainder of the blast induced vibrations are less than or equal to 1.4mm/s which is under the 2mm/s PPV required protect historic houses so can't cause damage.

The modeled air overpressures are well under that known to cause damage of 140 dBL so no damage can be caused by the proposed blasting at the Quarry to any of the infrastructure and historical buildings and sites.

5.2.3 Impact Assessment on Livestock/Animals

There are no established blasting criteria associated with comfort levels for livestock. A literature review was undertaken as part of the Wilpinjong Modification Noise and Blasting Assessment (SLR, 2013) which indicated that a ground vibration of up to 200mm/s PPV and an air overpressure limit of 125dBL may be acceptable. As previously discussed, the highest observed overpressure during a blast even in last 6 years of blast monitoring was 116.8dBL which is under half the pressure of the 125dBL maximum suggested as being acceptable to livestock. The Quarry blast induced vibration has been less than 4.6mm/s PPV and this is some 44 times under the 200mm/s PPV limit suggested by SLR (2013).

In the absence of allowable blasting criteria for livestock, even if on a conservative basis, the same criteria as the comfort level of humans are applied, no concerns for the wellbeing of livestock are identified for the Revised Project.

6 PROPOSED MANAGEMENT MEASURES

6.1 Independent Blast Monitoring

Independent Blast monitoring has been undertaken on behalf of Daracon, the EPA and Umwelt which confirmed the accuracy of the blast monitoring undertaken at the Quarry.

Daracon is committed to engaging an independent blast monitoring contractor in consultation with the EPA to monitor 3 blasts in the first year of the Revised Project, every 5 years thereafter.

6.2 General Controls

1. Daracon will continue to implement the current controls used to minimise blast induced vibration, air overpressure and flyrock and adopt the additional controls of decking and smaller diameter face holes where appropriate to ensure that relevant vibration criteria continue to be achieved
2. Daracon will continue to notify local residents of blasting dates and times by letter, and, where requested, via SMS and email.

7 CONCLUSION AND RECOMMENDATIONS

Blasting at the Martins Creek Quarry has always demonstrated compliance with relevant assessment criteria based on blast management protocols and risk mitigation already implemented. Since Daracon commenced operation of the Quarry, there have been no instances of flyrock which have warranted reporting or investigation.

This assessment has identified that all relevant blast criteria can be achieved for blasting undertaken as part of the Revised Project. In some locations, this will require management of blast sizes however this is consistent with existing and historical operations. The management of blast sizes and other proven blast design practices identified in Tables 5 and 6 where appropriate will enable the Revised Project to continue to meet all relevant assessment criteria.

The following recommendations are made:

1. The current monitor locations are appropriate as they are representative of the vast majority of residences including the closest residence

2. Independent blast monitoring for 3 blasts in the first year by an independent, qualified person, with independent monitoring conducted 3 times per year, every 5 years thereafter
3. The Revised Project continues implementing the current controls used to minimise blast induced vibration, air overpressure and flyrock and adopt the additional controls of decking and smaller diameter face holes to ensure that the assessment criteria continue to be achieved
4. The Revised Project blasting contractors adopt and modify the blast designs in this report as necessary to continue to achieve the relevant assessment criteria for blasting
5. The Revised Project continues with letter drops to those residents within 500m of the quarry and other residences that request notification of blast time the next day as well as sending an SMS or email on the day of the blast notifying neighbours who want to know the blast time that day.

8 REFERENCES

1. Australian and New Zealand Environmental Council (ANZEC), 1990 – Technical basis for guidelines to minimise annoyance due to blasting overpressure and ground vibration

2. Australian Standard, A2187.2-2006 – Explosives – Storage and use – Use of Explosives.

3. British Standard, BS7385.2, 1993

4. Dynon, L. 2019: Vibration Monitoring & Assessment, 24 View Street, Vacy.

5. Monteath & Powys, 2016 – Environmental Impact Statement For The Proposed. Martins Creek Quarry Extension US Bureau of Mines, USBM RI85

5. VGT Environmental Compliance Solutions, 2020, Martins Creek Andesite Quarry Geology Assessment, October 2020

6. Wilpinjong Modification Noise and Blasting Assessment (SLR, 2013)

APPENDIX 1 - BLAST MONITORING DATA FROM MARTINS CREEK FROM JANUARY 2013 TO AUGUST 2019

Blast Monitor Results									
				Site 1: 336 Dungog Rd		Site 2: Paterson Valley Estate		Site 3: Back Gate	
Date	Blast No	Bench	Blast Time	PPV (mm/s)	Overpressure (dBL)	PPV (mm/s)	Overpressure (dBL)	PPV (mm/s)	Overpressure (dBL)
1/03/2013	MC _P_008	3	13:49	1.89	109.3	3.72	106.4	No trigger	No trigger
20/03/2013	MC _P_009	2	12:19	1	103.4	0.76	98	No trigger	No trigger
28/03/2013	MC _P_010	4	10:39	3.15	108.5	0.88	99.3	0.62	109.7
11/04/2013	MC _P_011	4, N Face	12:15	2.06	114.6	1.34	89.4	0.58	109.2
26/04/2013	MC _P_012	2	12:18	0.79	110.7	0.53	83.4	No trigger	No trigger
17/06/2013	MC _P_013	4	14:00	1.99	83.4	0.7	101.7	0.58	113.6
24/06/2013	MC _P_014	3	12:33	3.11	87.8	1	86.9	No trigger	No trigger
4/07/2013	MC _P_015	4	12:47	1.58	106.5	1.68	92.9	1.11	106.5
2/08/2013	MC _P_016	4, S/W	11:10	1.97	112	1.12	97.3	0.34	112.4
9/08/2013	MC _P_017	Gully cnr	13:48	2.03	108.2	1.37	97.4	0.51	106.2
23/08/2013	MC _P_018	4, S/W cnr	12:19	2.36	112.6	0.89	96.6	No trigger	No trigger
17/09/2013	MC _P_019	3	12:16	1.88	111.5	0.88	91.4	No trigger	No trigger
26/09/2013	MC _P_020	4	13:54	No trigger	No trigger	1.23	114.8	No trigger	No trigger
24/10/2013	MC _P_021	4	13:12	No trigger	No trigger	0.25	113.1	No trigger	No trigger
1/11/2013	MC _P_022	3	13:04	1.23	93.8	0.85	86.9	No trigger	No trigger
7/11/2013	MC _P_023	4	11:57	2.3	112.9	1.33	101.5	No trigger	No trigger
22/11/2013	MC _P_024	3	13:28	No trigger	No trigger	1.28	104.9	No trigger	No trigger
3/12/2013	MC _P_025	2	13:09	1.16	111.6	1.67	87.7	No trigger	No trigger
23/01/2014	MC _P_026	3	12:49	1.82	110.3	1.11	87.7	No trigger	No trigger
31/01/2014	MC _P_027	0, Top Red	12:13	0.98	105.8	0.74	94.4	No trigger	No trigger
3/02/2014	MC _P_028	4	14:26	1.21	111.9	0.5	87.7	No trigger	No trigger
7/02/2014	MC _P_029	4	14:35	0.98	108.6	0.66	84.2	No trigger	No trigger
13/02/2014	MC _P_030	4	13:42	1.63	108.3	0.83	99.3	No trigger	No trigger
21/02/2014	MC _P_031	0, Mbl Crsh	14:26	0.81	107.9	No trigger	No trigger	0.47	96.6
25/02/2014	MC _P_032	3	13:56	1.2	109.3	0.89	102.4	No trigger	No trigger
27/02/2014	MC _P_033	3, 1 of 2	13:43	1.45	110.2	0.54	105.6	No trigger	No trigger
10/03/2014	MC _P_034	1	13.04	No trigger	No trigger	No trigger	No trigger	No trigger	No trigger
12/03/2014	MC _P_035	4	14:52	1.60, 1.20	106.5, 109.8	0.88	97.9	No trigger	No trigger
14/03/2014	MC _P_036	0	13:44	1.34	109	0.85	87.7	No trigger	No trigger
19/03/2014	MC _P_037	4	14:41	0.71	109.1	0.64	99.9	No trigger	No trigger

1/04/2014	MC _P_038	3	13:52	1.27	111.3	1.44	90.2	No trigger	No trigger
4/04/2014	MC _P_039	3	14:03	2.79	112.7	1.2	87.7	No trigger	No trigger
09/1/04/14	MC _P_040	1, New Orien	14:59	1.15	106.5	No trigger	No trigger	No trigger	No trigger
15/04/2014	MC _P_041	4, W Face	13:21	1.59	107.5	0.74	84.2	0.86	106.4
23/04/2014	MC _P_042	3, S/W Red Cnr	13.17	1.13	111.3	No trigger	No trigger	No trigger	No trigger
6/05/2014	MC _P_043	1	13:04	0.64	112.1	No trigger	No trigger	No trigger	No trigger
23/05/2014	MC _P_044	4	13:46	2.57	115	1.42	97.9	No trigger	No trigger
2/06/2014	MC _P_045	3	13:42	2.4	113.5	1.09	90.2	No trigger	No trigger
10/06/2014	MC _P_046	3	13:31	No trigger	No trigger	1.73	105	1.33	107
27/06/2014	MC _P_047	4	13:38	1.36	105.6	No trigger	No trigger	0.56	100.9
3/07/2014	MC _P_048	4	13:20	2.03	105	1.62	93.7	0.32	84.2
14/07/2014	MC _P_049	4	11:17	1.92	111	1.77	97.9	No trigger	No trigger
18/07/2014	MC _P_050	0	11:51	1.17	85	1.05	92.1	No trigger	No trigger
25/07/2014	MC _P_051	1	12:29	No trigger	No trigger	0.96	84.2	No trigger	No trigger
6/08/2014	MC _P_052	4	13:49	1.99	112.2	1.35	95.1	0.3	101.9
18/08/2014	MC _P_053	0	12:21	0.44	107.5	0.74	97.2	No trigger	No trigger
22/08/2014	MC _P_054	1	14:53	0.57	113.6	0.95	82.4	0.98	99.7
5/09/2014	MC _P_055	4	13:23	2.05	111.3	2.19	85.9	1.01	84.2
15/09/2014	MC _P_056	1	12:49	0.75	109.8	0.53	91.9	0.38	90.2
8/10/2014	MC _P_057	2	13:46	1.17	116.3	1.16	82.4	0.56	103.5
31/10/2014	MC _P_058	4	13:46	2.2	105.8	1.72	90.3	0.53	104.1
25/11/2014	MC _P_059	1	13:06	0.73	98.8	0.43	99.8	0.38	103
16/12/2014	MC _P_060	4	11:07	1.4	109	1.16	96	0.57	102.9
20/01/2015	MC_P_061	1	9:35	0.61	109.4	0.60	98.5	0.33	104.2
3/02/2015	MC_P_062	1	14:12	0.70	111.2	0.85	103.3	0.59	102.6
13/02/2015	MC_P_063	4	11:41	3.63	114.3	0.89	103.3	0.59	109
3/03/2015	MC_P_064	4	13:11	1.44	113.9	1.21	98.2	0.82	103.8
19/03/2015	MC_P_065	4	13:08	3.23	107.4	1.16	96.6	No trigger	No trigger
24/04/2015	MC_P_066	2	15:00	0.66	113.7	No trigger	No trigger	0.83	82.9
29/04/2015	MC_P_067	2	13:32	1.06	103	1.94	102.9	1.78	103.4
4/05/2015	MC_P_068	1	13:04	0.89	102.1	0.89	90.3	0.89	103.3
14/05/2015	MC_P_069	3	13:39	0.78	109.6	0.92	95	0.35	109.6
4/06/2015	MC_P_070	2	12:09	0.56	109.8	0.70	97.7	0.75	97.1

26/06/2015	MC_P_071	4	13:41	2.41	108.2	1.55	99.1	1.02	106.1
28/07/2015	MC_P_072	2	13:19	1.17	113	0.57	106.9	0.72	97.7
4/08/2015	MC_P_073	4	12:34	1.58	105.9	0.70	93.4	0.21	109.8
11/08/2015	MC_P_074	4	12:34	0.77	109.4	0.55	100.6	0.52	98.5
17/08/2015	MC_P_075	4	12:34	1.58	109.8	0.88	98.2	0.53	98.5
25/08/2015	MC_P_076	4	13:01	3.02	105.9	1.73	97.5	0.46	107
9/09/2015	MC_P_077	4	12:48	2.24	104.5	1.02	94.6	0.46	107
17/09/2015	MC_P_078	4	12:32	2.04	111.8	1.74	102	0.28	111
30/09/2015	MC_P_079	1	13:40	0.96	114.3	1.48	103.8	0.39	98.5
14/10/2015	MC_P_080	4	12:34	1.97	109.6	1.02	101.3	No trigger	No trigger
6/11/2015	MC_P_081	4	14:28	2.63	108.5	1.20	97.1	0.44	108.8
11/11/2015	MC_P_082	4	13:52	1.20	111.6	0.88	108.8	No trigger	No trigger
24/11/2015	MC_P_083	3	13:02	0.74	109.4	0.97	97.1	0.45	102.6
11/12/2015	MC_P_084	3	11:02	1.21	110.1	1.37	104.6	0.56	105.6
18/12/2015	MC_P_085	2	12:02	1.09	110.4	0.75	96.9	No trigger	No trigger
22/01/2016	MC_P_086	2	13:57	0.87	110.1	0.53	98.3	No trigger	No trigger
8/02/2016	MC_P_087	2	13:57	1.55	112	0.62	102.9	0.63	99.7
19/02/2016	MC_P_088	2	13:57	0.25	103.5	No trigger	No trigger	No trigger	No trigger
21/03/2016	MC_P_089	3 & 4	13:41	2.54	114.6	0.48	104.4	0.37	105.7
12/04/2016	MC_P_090	3	12:40	0.90	114.3	0.91	106.4	No trigger	No trigger
12/04/2016	MC_P_091	1	12:41	0.68	110.1	0.91	100.4	No trigger	No trigger
13/05/2016	MC_P_092	2	12:58	0.95	111.7	No trigger	No trigger	No trigger	No trigger
31/05/2016	MC_P_093	3	11:50	1.16	109.7	0.99	103.2	No trigger	No trigger
17/06/2016	MC_P_094	4	12:30	1.84	112.4	2.02	98.8	No trigger	No trigger
28/06/2016	MC_P_095	3	12:46	1.43	111.8	1.42	95.5	0.33	99.8
5/07/2016	MC_P_096	4	12:32	1.38	114.2	1.28	96.9	0.52	104.8
15/07/2016	MC_P_097	3	12:28	1.11	113.8	0.68	96.7	No trigger	No trigger
22/07/2016	MC_P_098	4	12:58	2.04	106.1	0.68	90.9	0.45	109.9
28/07/2016	MC_P_099	3	13:32	1.56	114.1	1.24	98.8	No trigger	No trigger
12/08/2016	MC_P_100	1	14:24	1.06	104.8	1.05	96.9	0.5	104
20/09/2016	MC_P_101	1	13:04	1.39	106.8	1.25	96	0.62	104
6/10/2016	MC_P_102	3	12:43	1.01	113.1	0.87	92.4	No trigger	No trigger

6/10/2016	MC_P_103	2	12:43	0.86	106.8	0.67	94.9	No trigger	No trigger
21/10/2016	MC_P_104	4	13:42	2.25	108.4	1.75	94.9	No trigger	No trigger
17/11/2016	MC_P_105	4	14:03	1.76	112.1	1.88	99.2	0.55	104.5
9/12/2016	MC_P_106	2	13:04	0.84	112.1	1.4	101	0.66	101.7
1/02/2017	MC_P_107	3 (toe)	11:30	No trigger	No trigger	No trigger	No trigger	No trigger	No trigger
3/02/2017	MC_P_108	2	13:16	0.88	110.9	1.06	98.05	No trigger	No trigger
21/02/2017	MC_P_109	3&4	13:12	1.14	111.5	1.2	90.9	No trigger	No trigger
6/03/2017	MC_P_110	4	12:06	1.63	113.9	2.18	98.6	No trigger	No trigger
14/03/2017	MC_P_111	3 / 4&5	11:45	0.57	107.2	1.22	99.2	No trigger	No trigger
17/03/2017	MC_P_112	3	13:01	1.04	108.8	1.396	97.8	No trigger	No trigger
23/03/2017	MC_P_113	3	12:47	0.98	107.5	0.806	96.98	0.681	93.06
28/03/2017	MC_P_114	2	11:48	0.83	105.7	1.28	93.8	No trigger	No trigger
11/04/2017	MC_P_115	3	12:01	1.25	108.7	1.45	94.5	No trigger	No trigger
12/05/2017	MC_P_116	3 &4	13:25	1.52	109.1	1.77	99.7	0.32	105.5
24/05/2017	MC_P_117	4	11:59	1.44	103.7	1.58	95.8	No trigger	No trigger
9/06/2017	MC_P_118	2	10:12	0.63	103.4	1.85	97.9	No trigger	No trigger
16/06/2017	MC_P_119	4	13:05	2.16	109.5	2.21	92.9	No trigger	No trigger
28/06/2017	MC_P_120	1	13:09	0.6	107.8	0.98	102.9	No trigger	No trigger
21/07/2017	MC_P_121	3	13:36	2.06	109.7	1.86	96.2	No trigger	No trigger
8/08/2017	MC_P_122	3	12:50	0.92	110	1.71	95.5	No trigger	No trigger
7/09/2017	MC_P_123	3	13:52	No trigger	No trigger	No trigger	No trigger	No trigger	No trigger
27/09/2017	MC_P_124	5	13:41	1.28	106.1	1.11	98.9	No trigger	No trigger
6/10/2017	MC_P_125	2	13:04	0.58	114.2	0.68	107.9	No trigger	No trigger
17/10/2017	MC_P_126	3	12:47	2.16	106.8	2.36	101	0.66	98.1
2/11/2017	MC_P_127	4	14:24	1.42	113	1.5	98.3	No trigger	No trigger
30/11/2017	MC_P_128	5	13:43	2.2	110.6	1.31	99.7	0.56	108.6
12/01/2018	MC_P_129	5	11:07	2.49	107.8	1.34	98.1	0.6	104.7
19/01/2018	MC_P_130	4	11:01	3.34	108.1	1.2	97.6	0.41	101.7
30/01/2018	MC_P_131	5	12:43	2.53	106.4	1.95	95	No trigger	No trigger
7/02/2018	MC_P_132	1,2	13:36	2.87	112.3	1.43	101.7	No trigger	No trigger
23/02/2018	MC_P_133	5	12:06	4.17	109.8	2.09	96.8	0.72	110.4
7/03/2018	MC_P_134	3	11:05	0.81	108.3	1.04	102.9	0.6	99.3
29/03/2018	MC_P_135	4	13:40	1.16	110.2	1.24	95.7	No trigger	No trigger
10/04/2018	MC_P_136	3 & 4	12:04	0.8	111.2	0.59	98.8	No trigger	No trigger
16/04/2018	MC_P_137	2	11:34	0.41	107.6	0.45	90.8	No trigger	No trigger

20/04/2018	MC_P_138	3-4	11:40	2.12	104.8	1.65	92.5	No trigger	No trigger
1/05/2018	MC_P_139	2-3	12:25	0.91	109.2	1.55	94.3	0.49	104.6
7/05/2018	MC_P_140	2-4	12:24	2.08	105.9	0.87	94.3	0.32	99.3
15/06/2018	MC_P_141	2-4	12:15	2.08	101.8	No trigger	No trigger	No trigger	No trigger
22/06/2018	MC_P_142	2	10:13	0.71	104.3	1.54	90.9	No trigger	No trigger
3/07/2018	MC_P_143	4	11:29	0.87	112.3	1.22	108.3	0.46	102.9
6/07/2018	MC_P_144	2	11:46	0.75	107.8	1.89	90.8	0.64	106.1
23/07/2018	MC_P_145	2	11:38	No trigger	No trigger	0.42	103.2	0.61	99.6
13/08/2018	MC_P_146	2 & 4	13:41	1.66	109.8	1.44	93.8	No trigger	No trigger
27/08/2018	MC_P_147	4	13:37	1.52	110.1	1	102.8	0.47	100.7
12/09/2018	MC_P_148	2 & 4	12:30	0.54	107.3	0.08	100.3	1.12	101.4
26/09/2018	MC_P_149	5	12:50	2.78	108.9	0.84	98.5	0.64	103.9
12/10/2018	MC_P_150	2 & 4	12:28	0.56	110.7	0.32	103.4	1.37	106.5
18/10/2018	MC_P_151	3 & 4	11:33	1.18	113.3	0.95	100.3	0.68	98.6
26/10/2018	MC_P_152	3	11:59	1.09	111.9	1	101	No trigger	No trigger
13/11/2018	MC_P_153	5	12:55	1.67	108.6	0.45	99.6	No trigger	No trigger
23/11/2018	MC_P_154	4 & 5	13:17	2.05	107.7	0.76	101	0.37	106.3
13/12/2018	MC_P_155	5	11:27	2.77	111.2	0.74	100.7	0.8	107.3
21/12/2018	MC_P_156	4	11:07	2.08	114.2	No trigger	No trigger	No trigger	No trigger
17/01/2019	MC_P_157	4 & 5	11:29	3.45	110	No trigger	No trigger	No trigger	No trigger
5/02/2019	MC_P_158	2 & 5	13:11	4.57	111.2	0.586	101.5	No trigger	No trigger
21/02/2019	MC_P_159	5	12:54	3.76	113.5	0.61	106.1	No trigger	No trigger
27/03/2019	MC_P_160	5	11:00	3.12	107.8	No trigger	No trigger	No trigger	No trigger
24/04/2019	MC_P_161	5	12:15	3.5	109.9	1.29	99.8	No trigger	No trigger
17/05/2019	MC_P_162	5	13:02	2.36	111.9	2.19	101.5	No trigger	No trigger
7/06/2019	MC_P_163	5	13:40	3.18	106	0.55	98.8	0.63	103.7
26/06/2019	MC_P_164	5	13:31	1.93	104.7	0.57	98.2	1.38	103.4
19/08/2019	MC_P_165	5	14:12	2.2	104.4	No trigger	No trigger	No trigger	No trigger

Note: Quarry operations were placed into limited operations from September 2019, with substantially reduced blasting activity and continued use of the blasting design and controls applied during the more intense operations covered by the data in the above Table.