VIBRATION MONITORING AND MANAGEMENT PLAN

Red Hill Quarry

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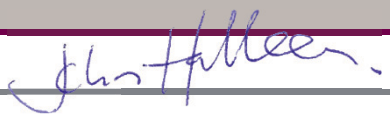
J. Halleen  28 June 2021

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1 SUMMARY

This Vibration Monitoring and Management Plan (VMMP) has been prepared to satisfy condition 13 of Ministerial Statement (MS) 912 for the Red Hill Quarry extension (the Project) by Hanson Construction Materials Pty Ltd (Hanson). And comprises minor amendments to the approved Vibration Monitoring and Management Plan (Strategen 2016) to address non-compliance with condition 13-3 of Ministerial Statement 912.

The VMMP has been prepared in accordance with Environmental Assessment Guideline No. 17 for the preparation of management plans under Part IV of the *Environmental Protection Act 1986* (EPA 2015).

Table 1 below presents the environmental management targets to measure achievement of the conditions environmental objective that must be met through implementation of the VMMP.

Table 1: Environmental management targets

Required information	Response	
Title of proposal	Red Hill Quarry Development, Gidgegannup, City of Swan	
Proponent name	Hanson Construction Materials Pty Ltd	
Ministerial Statement number	912	
Purpose of the Vibration Monitoring and Management Plan	The Vibration Monitoring and Management Plan is submitted to fulfil the requirements of condition 13 of MS 912	
EPA's environmental objective for the key environmental factors	Environmental factor	EPA environmental objective
	Amenity	To ensure that impacts to amenity are reduced as low as reasonably practicable
	Heritage	To ensure that historical and cultural associations, and natural heritage, are not adversely affected
Management targets	Amenity	To minimise the impact of vibration emissions from the quarry operation on nearby residents
	Heritage	To minimise the impact of vibration emissions on the nearby Ancestral Owl Stone formation

Corporate endorsement

I hereby certify that to the best of my knowledge, the management provisions within this Vibration Monitoring and Management Plan are true and correct and address the legal requirements of condition 13 of Ministerial Statement No.912.

[Signature of duly authorised proponent representative]

Name: Damon Case Signed: 

Designation: Development Manager Date: 28/06/2021

2 CONTEXT, SCOPE AND RATIONALE

Hanson operates the Red Hill Quarry located on Lot 11 Toodyay Road, Red Hill. The Red Hill Quarry is situated on the southern side of Susannah Brook, extending to Toodyay Road, on the Darling Scarp (Figure 1).

In February 2007, Hanson applied to extend the Red Hill Quarry, including an exclusion zone considering a 250 m buffer surrounding the Ancestral Owl Stone (Owl Stone). This was formally assessed under Part IV of the EP Act. The EPA subsequently set the level of assessment at PER. This was approved under Statement 912 on 9 October 2012.

The VMMP has been prepared in accordance with findings and recommendations of a number of reports including the following:

- Stability Assessment of Heritage Listed Rock Formations (Coffey 2010)
- Vibration Management Report (Maxam 2014; 2015; 2016)
- Owl Stone Monitoring – Red Hill Quarry (LandSurveys 2015)
- Red Hill Quarry Displacement Monitoring (Blast It Global 2016a)
- Independent review of Red Hill Vibration Management Plan (Blast It Global 2016b).
- Blast Vibration Management Plan Hanson - Red Hill Quarry (Orica Pty Ltd 2018)
- Hanson Red Hill Blast Management Plan (Orica Pty Ltd 2021).

2.1 Scope

Condition 13 of MS 912 requires the proponent prepare a VMMP to manage blasting operations (for the western extension of the Red Hill Quarry) to ensure that Aboriginal Heritage sites in the West Quarry Pit Extension Area B, in particular the Ancestral Owl Stone, are not impacted by ground vibrations. In addition, the VMMP will ensure the management of vibration to ensure no impacts to nearby residents.

2.1.1 Key environmental factors

The environmental factors, EPA objectives and environmental aspects of the project are presented in Table 2.

Table 2: Key environmental factors, objectives, and project environmental aspects

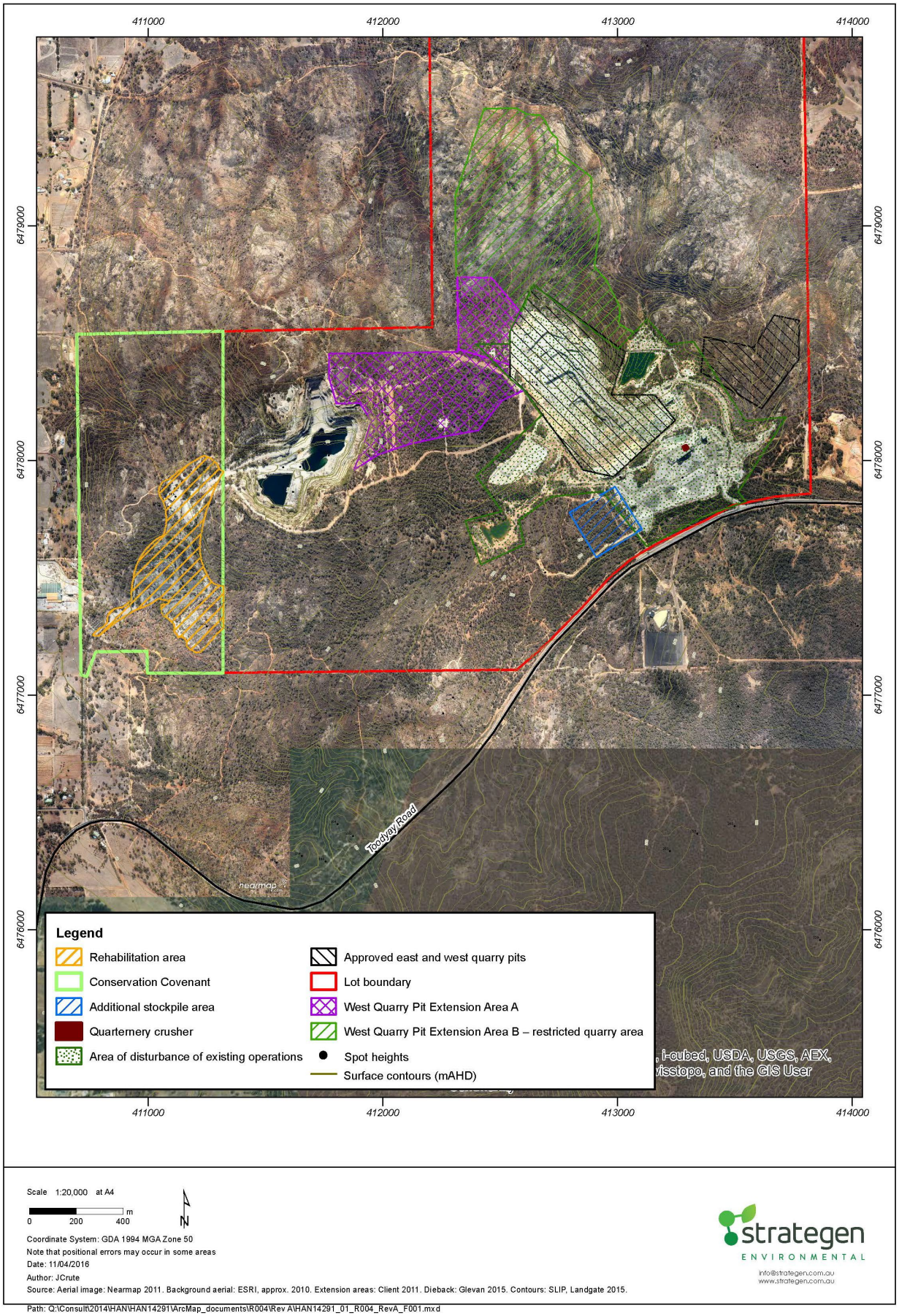
Factor	EPA objective	Environmental aspects of the project
Amenity	To ensure that impacts to amenity are reduced as low as reasonably practicable	Drilling and blasting resulting in impacts to amenity of nearby residents
Heritage	To ensure that historical and cultural associations, and natural heritage, are not adversely affected	Vibration caused by quarrying activities reducing the structural integrity of the Ancestral Owl Stone

2.2 Requirements of MS 912

This VMMP has been prepared to satisfy Condition 13 of Statement 912, as detailed in Table 3. This VMMP will apply to all works (current and future) at the Red Hill Quarry.

Table 3: Requirements of condition 13 of MS 912

Condition no.	Condition	VMMP section
13-1	Prior to the commencement of ground disturbing activities for this proposal, the proponent shall prepare a Vibration Monitoring and Management Plan to the requirements of the CEO on the advice of the Department of Environment and Conservation.	VMMP
	The objective of this Plan is to manage blasting operations to ensure that Aboriginal heritage sites in West Quarry Pit Extension Area B, in particular the Ancestral Owl Stone, are not impacted by ground vibrations.	2.1
13-2	In preparing the Vibration Monitoring and Management Plan referred to in condition 13-1, the proponent is to consult with the Department of Indigenous Affairs and relevant local indigenous people.	2.3
13-3	The proponent shall implement the Vibration Monitoring and Management Plan referred to in condition 13-1, until such time as the CEO determines that the objective of the plan has been achieved.	-
13-4	The proponent shall report the progress of conditions 13-1 to 13-3 in the compliance assessment report required by condition 4-6.	4.1
13-5	The proponent shall make the Vibration Monitoring and Management Plan required by condition 13-1 and the reports under condition 13-4 publicly available in a manner approved by the CEO.	4.1



(Strategen Environmental 2016)

Figure 1: Red Hill Quarry project area

2.3 Rationale and approach in meeting the environmental objective

The approach for managing any potential vibration impacts is to develop a comprehensive management program that identifies:

- Management risks
- Key management based targets
- Management actions
- Monitoring measures
- Review and revision requirements.

An adaptive risk based management approach has been developed in order to create a robust management system, which prioritises and manages significant risks using the mitigation hierarchy (i.e. avoid, minimise, manage, rehabilitate and offset).

This management approach allows for flexibility, to enable the management program to adapt to any changes in the project conditions, as well as to respond to the dynamic nature of the surrounding environment. The methodology for the risk-based approach is provided in Appendix A.

2.3.1 Rationale for choice of management targets

Management targets (Table 5) were selected in order to prioritise the risks identified for the project, and are based on a review of:

- Available investigations relating to vibration impacts
- The relationship between the project aspects and the environmental factors
- Industry standards and legislative requirements
- The requirements of MS 912.

3 VIBRATION MANAGEMENT

The objective of the VMMP is to identify the management provisions that Hanson proposes to implement to manage and minimise potential impacts of vibration on Aboriginal heritage sites at Red Hill, specifically potential impacts to the Owl Stone and nearby residents in order to meet the:

- EPA's objectives for amenity and heritage as described in Table 2
- Requirements of MS 912 (Table 3).

3.1 Management actions

Risk-based management actions have been identified and prioritised based on the methodology provided in Appendix A. These management actions focus on project operations that have the highest likelihood of causing environmental impact and were specifically developed to reduce potential impacts of operation activities on the Owl Stone, other Aboriginal heritage sites and nearby residents.

Table 4: Risk-based management actions

Risk and key impacts	Management actions	Risk-based priority	Timing	Responsibility
Drilling and blasting resulting in impacts to amenity of nearby residents	1. The induction will include information on: a. The potential nuisance to neighbours of vibration b. Management measures to reduce vibration levels.	Medium	Induction	Quarry manager
	2. Public complaints received relating to vibrations shall be recorded in the Public Complaints Register.	Medium	Ongoing	Person taking complaint
	3. Quarrying operations shall be restricted to between 0600 and 1800 hours Monday to Saturday, unless otherwise approved.	Medium	Ongoing	Quarry manager
	4. The appropriate stakeholders and surrounding land users shall be advised of blasting times and working schedules.	High	Prior to blasting	Quarry manager
	5. Undertake blasting to minimise noise and vibration emissions (dependent on wind and other climatic conditions etc).	Medium	Ongoing	Blasting contractor
	6. Shots shall only be permitted to be fired between the hours of 0900 and 1800 hours (unless otherwise approved) to minimise noise impacts at sensitive receptors.	High	Ongoing	Blasting contractor
Vibration caused by quarrying activities reducing the structural integrity of the Ancestral Owl Stone	1. The induction will include information on: a. The potential damage to the Ancestral Owl Stone from vibration b. Management measures to reduce vibration levels.	Medium	Induction	Quarry manager
	2. Ensure the blasting process as detailed in Appendix B is implemented for all blasts.	Very high	At all times	Blasting contractor
	3. An absolute vibration limit of 20 mm/sec will be applied at Owl Stone in accordance with Australian Standard 2187 and investigations undertaken to date.	Very high	During blasting	Blasting contractor
	4. Design blasting toward limiting vibrations to below 20 mm/sec at Ancestral Owl Stone.	Very high	Ongoing	Blasting contractor
	5. Fly-rock potential will be reduced by implementing face profiling, bore tracking and adjustments to explosive charges based on required charge containment.	High	Ongoing	Blasting contractor
	6. Undertake biannual 3D laser scan of the Ancestral Owl Stone to monitor vibration impacts.	High	Ongoing	Licensed surveyor
	7. Implement vibration control measures as required to ensure vibration limits are met, that may include: a. Reduction of MIC which may be done through a reduction in bench height and a reduction in hole diameter b. Face profiling and bore tracking (provides early management of potential hazards) c. Initiating from the closest blast hole to the structure (reduces the number of holes that can super-position or amplify vibration effects) d. Firing to free faces and free ends (reduces confinement of explosive charges) e. No choke firing of any blasts (reduces confinement of explosive charges)	Very high	Ongoing	Quarry manager / blasting contractor

Risk and key impacts	Management actions	Risk-based priority	Timing	Responsibility
	f. Reduce the number of holes firing in any eight millisecond window of time (reduces the number of charges considered to be acting as one charge) g. Reduction of burden whilst maintaining powder factor (reduces inter-row confinement) h. Reduction of spacing whilst maintaining powder factor (reduces intra-row confinement) i. Maintaining shot depth to a minimum (reduces choking thus amplification of vibration) j. Blast orientation (free face presents to the sensitive site – reduces amplification of vibration) k. General reduction of explosive charge confinement l. Use of electronic detonators, which can result in a reduction to MIC levels; only as deemed required 8. Low-density explosive products, which also reduce MIC, however they are only effective in dry hole conditions, and therefore may not be suitable for Red Hill.			

3.2 Management target

Management targets have been developed to measure and report against the proposed Hanson environmental objective (Table 5).

Table 5: Management targets

Environmental factor	EPA environmental objective	Management targets
Amenity	To ensure that impacts to amenity are reduced as low as reasonably practicable	To minimise the impact of vibration emissions from the quarry operation on nearby residents
Heritage	To ensure that historical and cultural associations, and natural heritage, are not adversely affected	To minimise the impact of vibration emissions on the nearby Ancestral Owl Stone formation

3.3 Monitoring

The purpose of the monitoring program is to inform, through the management targets, if the environmental objective is being achieved, as well as to determine if the management actions require review and revision. Table 6 outlines the monitoring program proposed to be undertaken by Hanson.

Table 6: Monitoring program to achieve management targets

Indicator	Parameter	Monitoring method	Frequency	Location
Management target: To minimise the impact of vibration emissions from the quarry operation on nearby residents				
Blasting is undertaken in accordance with the following: absolute vibration limit of 10 mm/sec at residences (only one >5 mm/sec in every ten blasts with a maximum of 10 mm/sec)	Blast vibration levels	Blasts are monitored using a data logger	All blasts (peak reading recorded during blasting)	William Street control site and other surrounding areas as required
Vibration testing equipment is in good working order.	Integrity of vibration control equipment	Test monitoring equipment in accordance with equipment specifications	Biannually	Third party premises (currently Texel)
No public complaints received relating to blasting vibration	Complaints register	Review of complaints register	Daily, during blasting activities	Project area
Management target: To minimise the impact of vibration emissions on the nearby Ancestral Owl Stone formation				
Blasting is undertaken in accordance with the following: absolute vibration limit of 20 mm/sec blasting toward limiting vibrations to below 20 mm/sec.	Blast vibration levels	Blasts are monitored using a data logger	All blasts	At the Owl Stone and Midway monitoring sites located at 412770E 6478819S and 412760E 6478690S
Overall integrity of Owl Stone remains intact.	Owl Stone	Undertake 3D laser survey of the Owl Stone	Biannually	Ancestral Owl Stone
		Monitoring of ground vibrations using a data logger	All blasts	At the Owl Stone and Midway monitoring sites located at 412770E 6478819S and 412760E 6478690S

4 REVIEW AND REVISION OF MANAGEMENT ACTIONS

In the event that management targets are not met, Hanson will investigate the potential cause and any potential impacts that may have resulted. If the management targets are not met, and it is deemed to be the result of the Project, the corrective actions detailed in Table 7 will be implemented.

Table 7: Corrective actions

Indicator	Action	Responsibility
Monitoring results indicate vibration levels exceed absolute vibration limit at nearby residences	1. Investigate to determine the cause of non-compliance. 2. Take preventative actions to prevent further non-compliance, including but not limited to things such as: a. Reduction of the mass of instantaneous charge [MIC] b. Reduced bench height or hole diameter c. Firing to free faces and free ends d. Reducing number of holes firing in any eight millisecond window of time. 3. Initiate a feedback loop to review management measures and/or further educate staff/contractors to ensure that all possible steps are taken to prevent any reoccurrence. 4. An Environment Incident Report shall be completed.	Hanson
Vibration testing equipment requires maintenance and/or is faulty	1. Investigate cause. 2. Initiate more frequent maintenance of testing equipment as required. 3. If problems persist, investigate purchase of new equipment.	Hanson
Valid public complaint received relating to blasting vibration from the quarry	4. The complaint shall be recorded in the Public Complaints Register and managed in accordance with the Public Complaint Resolution procedures (Section 5 of the overarching Red Hill Quarry EMP).	Hanson
Monitoring results indicate vibration levels exceed absolute vibration limit	1. Investigate cause. 2. Review blast monitoring data (data-logger) to identify any potential impacts to the Owl Stone 3. Cease blasting to reduce any potential further impacts. 4. Prepare a strategy to remediate impacts in consultation with DER and EPA, dependent on vibration levels. Remediation may include: a. Changes to the blasting program b. Reduction of the mic c. Reduced bench height or hole diameter d. Firing to free faces and free ends e. Reducing number of holes firing in any eight millisecond window of time. 5. Initiate a feedback loop to review management measures and/or further educate staff/contractors to ensure that all possible steps are taken to prevent any reoccurrence. 6. An Environment Incident Report shall be completed.	Hanson
Integrity of Owl Stone is compromised	1. Notify relevant stakeholder (DAA, DER, EPA, traditional owners). 2. Investigate cause. 3. Cease blasting to reduce any potential further impacts. 4. Prepare a strategy to remediate impacts in consultation with DER, EPA and DAA, dependent on the level of impacts to the Owl Stone. Remediation may include: a. Changes to the blasting program b. Reduction of the mic c. Reduced bench height or hole diameter d. Firing to free faces and free ends e. Reducing number of holes firing in any eight millisecond window of time. 5. Initiate a feedback loop to review management measures and/or further educate staff/contractors to ensure that all possible steps are taken to prevent any reoccurrence. 6. An Environment Incident Report shall be completed.	Hanson

4.1 Reporting provisions

A Compliance Assessment Report (CAR) will be prepared in accordance with condition 4 of Statement 912, addressing compliance with each condition and commitment of Statement 912, including condition 13 relating to implementation of the VMMP. The CAR will be submitted to the EPA annually in February, addressing compliance from the previous twelve month period from January to December and will be made publicly available.

The VMMP reporting template is presented in Table 8.

4.1.1 Reporting on exceedance of the management target

In the event that management targets are not met during the reporting period, a written report will be included in the CAR detailing the corrective actions that were undertaken, and the effectiveness of the corrective actions to rectify any potential impacts.

Table 8: Environmental management plan reporting table

Environmental objective and management target set in the VMMP		Reporting on the management objective and management target	Status*
EPA objective	**Management target**		
To ensure that impacts to amenity are reduced as low as reasonably practicable	To minimise the impact of vibration emissions from the quarry operation on nearby residents	Impacts to nearby residents have been prevented	Yes No
To ensure that historical and cultural associations, and natural heritage, are not adversely affected	To minimise the impact of vibration emissions on the nearby Ancestral Owl Stone formation	Impacts to the Owl Stone have been prevented	Yes No

*The status of achievement of the condition environmental objectives is indicated by the following colours:

Condition environmental objective achieved

Condition environmental objective not achieved

5 ADAPTIVE MANAGEMENT

Hanson will implement an adaptive management system to provide a robust management plan, which effectively meets the environmental objectives. To achieve this, the VMMP will be reviewed on an annual basis to ensure that the plan takes into consideration amendments to operations, monitoring results, audits, continuous improvement and changes in regulatory and corporate requirements. If revised, a copy of the revised VMMP will be provided to the OEPA as part of the CAR.

6 STAKEHOLDER CONSULTATION

To ensure stakeholder requirements are incorporated into the management of potential vibration impacts at Red Hill, consultation with key stakeholders has been undertaken throughout preparation of the VMMP. Key stakeholders consulted during the project planning and VMMP planning process include:

- Office of the EPA (OEPA)
- Department of Environment and Regulation (DER), formerly Department of Environment and Conservation
- Department of Aboriginal Affairs (DAA), formerly Department of Indigenous Affairs (DIA)
- Aboriginal traditional owners.

Consultation has been largely focussed on potential impacts to the Owl Stone and other Aboriginal heritage sites (within the boundaries of Lot 11) as a result of blasting activities at Red Hill. Hanson has incorporated outcomes of stakeholder consultation in the VMMP. Table 9 includes a summary of consultation undertaken to date including outcomes of the consultation.

Table 9: Summary of stakeholder consultation

Who	When	Subject	Outcome
Traditional owners Nyungar Elders	12 May 2014	Potential impacts to Owl Stone and other heritage sites resulting from the expansion	Traditional owners recommended a more detailed 3D laser survey to assess potential vibration impacts to the Owl Stone and to provide a record of the Owl Stone, which may be used to reconstruct the Owl Stone in the unlikely event it would fall or be damaged. Hanson committed to undertaking a 3D laser survey of the Owl Stone site (completed).
DAA James Cook	18 June 2014	Referral under s 18 of the *Aboriginal Heritage Act 1972*	No concerns raised following report submission.
DAA Tanya Butler	November 2014	Discussion regarding pending s 18 submission in relation to the eastern campsites	No concerns raised regarding s 18 submission. DAA advised they would follow up with James Cook regarding Vibration Management Plan submitted.
OEPA Tim Gentle Floyd Browne	23 February 2015	Discuss the draft VMMP including an assessment of the potential impacts to Owl Stone and other heritage sites resulting from the expansion	The meeting resulted in the following actions: • Hanson to provide OEPA with copy of the Coffey Geotechnical Report and details of the 3D laser survey. OEPA to review together with DER Noise Branch and provide feedback to Hanson • Hanson to include more information in the EMP regarding outcomes of consultation with Aboriginal groups and information on the 3D laser survey including, how often it is intended to be repeated, the surveys sensitivity to detect any movement and clarification regarding easer holes and fly rock issues • OEPA to follow up with James Cook regarding any outcomes of consultation with DAA.
DER / OEPA Floyd Browne Jingnan Guo Peter Popoff-Asotoff	16 June 2015	Discuss the draft VMMP including an assessment of the potential impacts to Owl Stone and other heritage sites resulting from the expansion	The OEPA/DER advised that there was still uncertainty around cumulative impacts of vibration on the Owl Stone and therefore additional investigations into potential displacement of the Owl Stone were recommended. Following this meeting, an Interim VMMP was developed to address comments on the VMMP to date, however noting that additional investigations were required to satisfy DER/OEPA.
Traditional owners	28 August 2015	Discussion with traditional owners regarding potential relocation of Western Power HV Transmission lines and impact on owl stone	The meeting resulted in submission of the s 18 application for sites impacted by the powerline relocation.

Who	When	Subject	Outcome
Department of Mines and Petroleum	September 2015	Discussion with Inspector of Mines regarding blasting practices at Red Hill in relation to protection of Owl Stone	The Inspector of Mines provided no further comment relating to blast practices and recommended that the OEPA and DER comments on the VMMP were addressed, including engaging a qualified peer reviewer to review the VMMP.
DER / OEPA Anthony Sutton Floyd Browne Jingnan Guo Peter Popoff-Asotoff	September 2015	Discuss the status of the VMMP including investigations undertaken to date	The OEPA and DER recommended that a peer review of the VMMP and supporting investigations was undertaken.

7 REFERENCES

Blast It Global 2016a, *Red Hill Quarry Displacement Monitoring*, report prepared for Hanson Construction Materials, April 2016.

Blast It Global 2016b, *Independent review of Red Hill VMP*, report prepared for Hanson Construction Materials, April 2016.

Coffey Mining 2010, *Stability Assessment of Heritage Listed Rock Formations*, report prepared for Hanson, July 2010.

Environmental Protection Authority 2015, *Environmental Assessment Guideline No. 17 for the preparation of management plans under Part IV of the Environmental Protection Act 1986*, August 2015.

LandSurveys 2015, *Owl Stone Monitoring – Red Hill Quarry*, unpublished report prepared for Hanson by LandSurveys, Belmont, WA.

Macintyre K & Dobson B 2009, *Report on Aboriginal Consultations and Site Investigation of the "Owl Stone: at Hanson's Red Hill Quarry, Lot 11, Toodyay Road, City of Swan*, report prepared for the combined swan river and swan coastal plains and darling ranges Nyungar elders, native title holders and traditional owners, March 2009.

Maxam 2014, *Vibration Management Report – Hanson Red Hill*, report prepared for Hanson Construction Materials, March 2014.

MAXAM Australia (MAXAM) 2015, *Blast Vibration Management Plan – Hanson Red Hill Quarry Expansion*, MAXAM Australia.

Maxam 2016, *Blast Vibration Management Plan Report – Hanson Red Hill Quarry expansion*, Revision 1, report prepared for Hanson Construction Materials, February 2016.

Narendranathan S, Sivarudrappa K & Bungard G 2010, *Stability Assessment of Heritage Listed Rock Formations*, report prepared for Clayton Utz, 21 July 2010.

Orica Pty Ltd, 2018, *Blast Vibration Management Plan Hanson - Red Hill Quarry*, report prepared for Hanson Construction Materials Pty Ltd, 7 March 2018.

Orica Pty Ltd, 2021, *Hanson Red Hill Blast Management Plan*, report prepared for Hanson Construction Materials Pty Ltd, July 2021.

Slaughter S 2014, *Vibration Management Report: Hanson Red Hill*, report prepared for Hanson Construction Materials Pty Ltd, 24 March 2014.

Strategen Environmental, 2016, *Vibration Monitoring and Management Plan*, report prepared for Hanson Construction Materials Pty Ltd, 27 May 2016.

Appendix A
Risk matrix

APPENDIX A: RISK MATRIX

Risk-based priority

A risk assessment determines whether a hazard could harm the environment. The following stages are undertaken once an environmental hazard has been identified:

- Stage 1: Risk identification to identify and document environmental risks and impacts associated with the organisation activities, goods and services
- Stage 2: Qualitatively ranking potential environmental impacts to establish relative significance
- Stage 3: Establishing and documenting control measures to mitigate potentially significant environmental impacts.

RAC shall control all environmental risks identified within the organisation to an extent that is practically possible (Table A-1), once they have been identified through the risk management and identification process.

Risk ranking is generally undertaken by assigning likelihood and consequence levels to each identified activity or issue and determining risk levels through the use of a risk matrix. After completing this process management measures are implemented and a residual risk is determined.

Table A-1: Qualitative risk rating matrix

Likelihood	Consequences			
	Critical (4)	Major (3)	Moderate (2)	Minor (1)
Almost certain (A)	Very high	Very high	High	Medium
Likely (B)	Very high	Very high	High	Medium
Unlikely (C)	Very high	High	Medium	Low
Rare (D)	High	Medium	Low	Low

Very high	Immediate action required. Task stopped
High	Senior management attention needed
Medium	Management responsibility must be specified
Low	Manage by routine procedures

Table A-2: Likelihood classification

Likelihood	Description
Almost certain (A)	Event is a common or frequent occurrence and is expected to occur daily
Likely (B)	Event is expected to occur annually.
Unlikely (C)	Event may occur. If the event has occurrence in the project area it is very infrequent. It is likely to have occurred within the industry.
Rare (D)	The event is unlikely to not occur in the project area but has been known to occur infrequently within the industry. The event may occur at a frequency of more than ten years.

Table A-3: Consequence classification

Consequence	Definition
Critical (4)	Environment: Long-term large scale damage to habitat or environment. Legal: Non-compliance having a critical financial or community profile impact. Community: Widespread community disruption with significant adverse economic impact.
Major (3)	Environment: Severe impact requiring remedial damage to environment. Legal: Non-compliance and having high financial or community profile impact. Community: Extensive community complaints extending beyond the region or adverse state level media coverage. Wider community disruption up to seven days with adverse economic impact.
Moderate (2)	Safety: Moderate impact on environment. No long term or irreversible damage. Legal: Non-compliance having moderate financial or community profile impact. Community: Widespread local complaints or adverse regional media coverage. Isolated community disruption up to three days with limited adverse economic impact.
Minor (1)	Environment: Minor breach of environmental policy. Negligible impact on environment. Legal: Technical breach with no sanction. Community: Few complaints or minor adverse media coverage. Negligible impact on reputation. Isolated community disruption up to one day with minimal economic.

When determining risk controls, the hierarchy of risk controls, summarised in Table A-4 must be considered.

Table A-4: Hierarchy of risk controls

Option	Examples
Elimination	Stop using equipment or substance or stop undertaking the procedure causing the risk.
Substitution	Use an alternative substance, equipment or process which poses less risk.
Isolation	Separate receivers from the source of the risk.
Engineering controls	Reduce exposure to the risk by making physical changes to equipment, procedures or the work environment (e.g. using dust control measures on equipment).
Change work practices	Adopt work procedures which minimise exposure to the risk (e.g. wet sweeping a dusty environment rather than dry sweeping, to minimise the amount of airborne dust.

Appendix B
Blast Management Plan (Orica 2021) and Blast Vibration Management Plan (Orica 2018)

BLAST MANAGEMENT PLAN

HANSON CONSTRUCTION MATERIALS PTY LTD

RED HILL QUARRY

Revision 2 - July 2021

DOCUMENT REVISION

Blast Management Plan

Version <2.0>, Issued <July 2021>

REVISION	AUTHOR	POSITION	DATE
Revision 1	Mat Trigwell	Blast Technician	March - 2018
Revision 2	Nathan West	Senior Blast Technician	July - 2021

CONTENTS

1. LOCATION OF PROPOSED BLASTING

Hanson Construction Materials Pty Ltd (Hanson) operates the Red Hill Quarry, located on Lot 11 Toodyay Road, Red Hill. The Red Hill Quarry is situated on the southern side of Susannah Brook, extending to Toodyay Road, on the Darling Scarp (Figure 1).

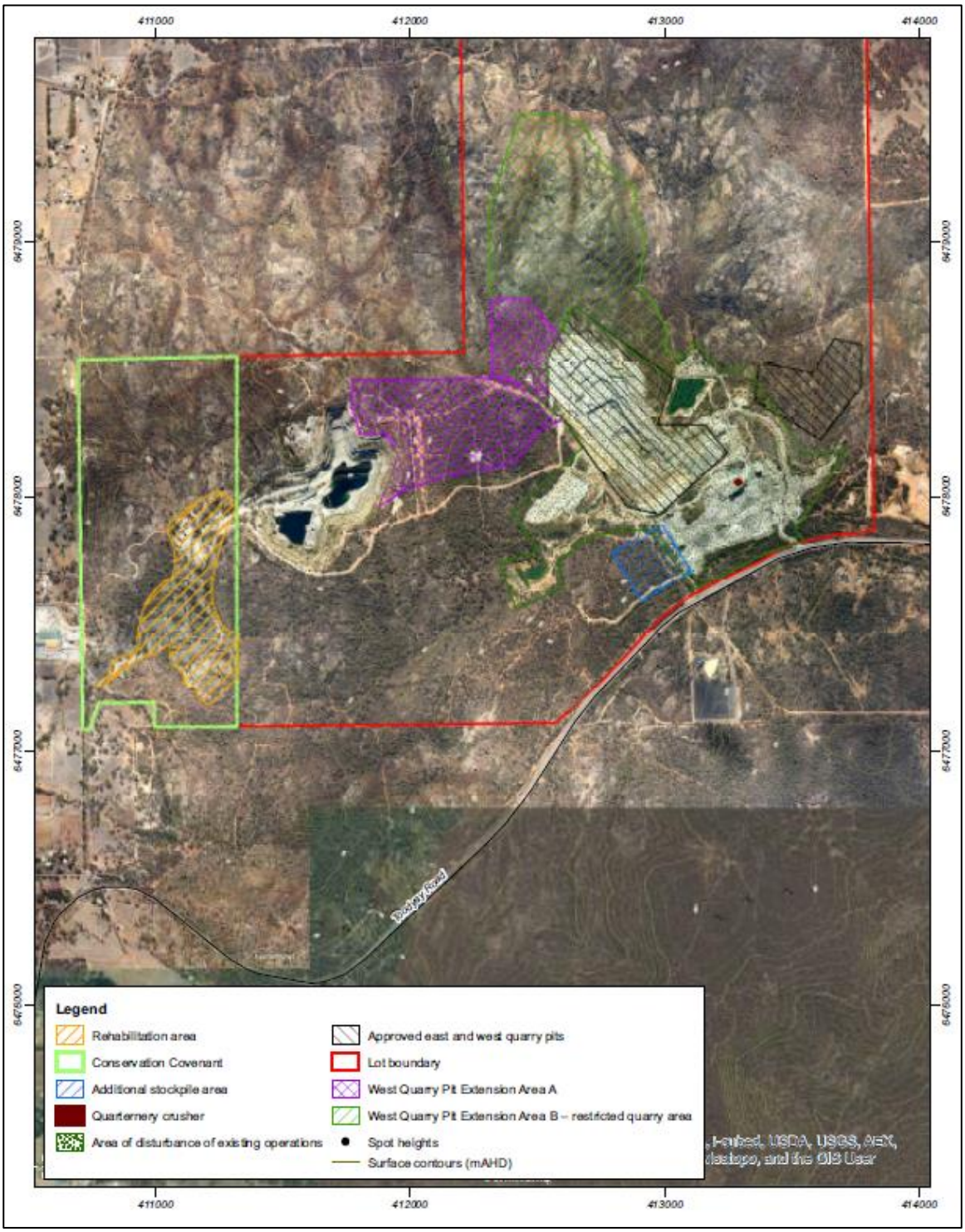


Figure 1: Red Hill Quarry geographical location.

2. DESCRIPTION OF PROPOSED BLASTING (GENERAL TYPE OF BLASTING REQUIRED)

Hanson Red Hill Quarry conducts blasting to develop the quarry (development blasting) and production blasts to supply aggregate stone to the primary and secondary crushing circuits.

The blasts must comply with environmental blasting limits of;

- Air blast – 115 dBL limit for 90 %, and 120 dBL limit for 100 % of blasts, and
- Vibration (PPV) – 5 mms^{-1} limit for 95 %, and 10 mms^{-1} limit for 100 % of blasts.

In February 2007, Hanson applied to extend the Red Hill Quarry, including an exclusion zone considering a 250 m buffer surrounding the Ancestral Owl Stone (Owl Stone).

Because of this, a Vibration Management and Monitoring Plan was established. Blasting must comply with the environmental, heritage and community requirements outlined in the management plan.

All blasts measured at the Owl Stone must meet the limits of;

- 20 mms^{-1} PPV vibration limit.

3. INTRODUCTION

The objective of the Blast Management Plan is to ensure the safety of all personnel is maintained and appropriate environmental controls are in place. A Blast Management Plan is required to conform to AS2187.2.

The process of developing the Blast Management Plan commences with a site visit by Orica personnel to record and assess the Site Safety Management Plans already in place on the customer site. Orica personnel conduct a Risk Assessment to identify risks that people may be exposed to while working on the customer site.

The Blast Management Plan comprises the following documents;

- Customer Site Risk Review – A review of safety processes already existing at the site.
- Risk Assessment – Assessment of all risks associated with blasting operations at the site. Identifies site-specific gaps in exiting procedures, including the Shotfirer's Standard Operating Procedures.
- Quarry Customer Site Procedures.
- Shotfirer's Standard Operating Procedures - a set of existing Orica Procedures that are used to manage blasting operations and control blasting risk. A copy of these is carried by the Shotfirer at all times.
- Blast Surveyor's Operating Procedures

4. CUSTOMER SITE RISK REVIEW

The attached Customer Site Risk Review specifies the following items required by AS2187.2;

- Permits/licenses required for the project.
- Identification and position of the person responsible for the project including project safety and security.
- Identification and position of person who has given approval to use explosives on the project.
- Key appointments and responsibilities.
- Shotfirer's details.

5. PERMITS/LICENCES REQUIRED

The approvals which have conditions relating to blast management on site include:

- Ministerial Statement 912 – Condition 13-1 through to 13-5
- Ministerial Statement 705 (originally MS199) Condition 6 under quarry development and operation
- Environmental Commitment 16 of MS705 (previously MS199)
- DWER Screening License L4414/1968/12
- Vibration Monitoring and Management Plan for MS912 – approved by the EPA 20/06/2016

6. IDENTIFICATION AND POSITION OF PERSON RESPONSIBLE FOR THE PROJECT INCLUDING PROJECT SAFETY AND SECURITY

NAME	POSITION	CONTACT NUMBER
Reece Naylor	Supply Chain Manager – Aggregates Hanson Construction Materials	0448 187 161
David Kraima	Quarry Manager Hanson Construction Materials	0408 602 072

7. IDENTIFICATION AND POSITION OF PERSON WHO HAS GIVEN APPROVAL TO USE EXPLOSIVES ON THE PROJECT

NAME	POSITION	CONTACT NUMBER
Reece Naylor	Supply Chain Manager – Aggregates Hanson Construction Materials	0448 187 161
David Kraima	Quarry Manager Hanson Construction Materials	0408 602 072
Abhishek Iyer	Area Business Manager Orica	0408 532 693

8. KEY APPOINTMENTS AND RESPONSIBILITIES

NAME	POSITION	CONTACT NUMBER
Reece Naylor	Supply Chain Manager – Aggregates Hanson Construction Materials	0448 187 161
David Kraima	Quarry Manager Hanson Construction Materials	0408 602 072
Abhishek Iyer	Area Business Manager Orica	0408 532 693
Laurence Goodacre	Territory Manager Orica	0436 403 991
Craig Rowe	Manager – Technical Services Orica	0409 727 217

9. SHOTFIRER'S DETAILS

NAME	LICENCE NUMBER	LICENCE EXPIRY DATES
Shane Kimberley	ESF005326	15/01/2022
Ernie Dekker	ESF006308	12/08/2024
Peter Money	ESF016693	23/05/2026
Steven Thumwood	ESF008162	20/11/2024
Nathan West	ESF084445	28/09/2022
Adam Fowler	ESF012311	17/12/2025
Darren Smith	ESF089326	28/08/2023

10. SITE RISK ASSESSMENT

The attached Risk Assessment (See Appendix C) specifies the following information required by AS2187.2;

- Details of adjacent structures or services that influence the blast design.
- Details of reports, drawings and records consulted.
- Environmental considerations for air blast overpressure, ground vibration.
- Testing for Reactive Ground and or Evidence of Elevated Temperature.
- Details of communication systems.
- Warning procedures.
- Traffic management plan.
- Details of the exclusion zone.
- Influence of weather.
- Loading in poor light conditions or reduced visibility.
- Calibration of vibration measurement systems.

11. RED HILL QUARRY PROCEDURES

Hanson is responsible for procedures relating to the following aspects of the Blast Management Plan;

i) Drilling procedures.

- Xcel Drilling Procedures

ii) Method of notification to owners and occupiers of structures, and providers of services adjacent to the blast.

- Department of Fire and Emergency Services (DFES) – Email sao@dfes.wa.gov.au
- City of Swan – Chief Bush Fire Control, Officer: Rik Mills – Email rik.mills@dfes.wa.gov.au, Phone 0418 926 785 or (08) 9267 9267
- Parks and Wildlife Service (DPAW) – District Duty Officer, Phone 9290 6100

12. DETAILS OF ADJACENT STRUCTURES OR SERVICES THAT INFLUENCE BLAST DESIGN

The most significant adjacent structure that will influence blast design is the Owl Stone. The details of each sensitive receiver are listed below in Table 1**.**

Table 1: Identified sensitive receivers at Hanson Red Hill Quarry.

SENSITIVE RECEIVER	EASTING	NORTHING	ELEVATION (M)
Owl Stone	412770	6478819	184.08
Toodyay Rd	412760	6478690	

In April 2016, a Vibration Monitoring and Management Plan was developed on behalf of Hanson for the Red Hill Quarry. The purpose of the plan was to manage all the potential blasting impacts on Owl Stone.

Included in the plan, is the Site Law established and maintained by the previous blasting contractor - MAXAM. An analysis of historical blast data was conducted to determine the K and b site constants. These have been used to predict the expected vibration at the Owl Stone monitor prior to each blast.

Hanson requested that Orica develop a site-specific Vibration Management Plan, which was to include a Site Law calculated using more recent blast vibration data and incorporate the Orica procedures in which blast vibration will be managed.

13. ORICA VIBRATION MANAGEMENT PLAN

Prior to conducting blasting at the Hanson Red Hill Quarry, Orica conducted a review of Hanson's Vibration Management Plan previously implemented onsite. This included a review of the historical vibration data measured and recorded by the previous blasting contractor MAXAM.

A Site Law was established using the most recent data collected by MAXAM so that each blast carried out by Orica could be designed and fired to comply with the vibration limits imposed on Owl Stone.

Regression analysis of the complete data set identified the strongest correlation by splitting the data into two subsets, split by proximity of the blast to the vibration monitor. A regression analysis of the two subsets was used to determine the site vibration constants K and b, for blasts greater than and less than 480 m from Owl Stone.

To ensure compliance with the 20 mm/s limit at Owl Stone, the expected vibration must be predicted using the 95 % confidence level.

The Scaled Distance relationship to vibration, at a distance less than 480 m, using the 95 % confidence level can be described by the following equation;

$$PPV = 886 \times \left(\frac{D}{\sqrt{W}}\right)^{-1.01}$$

The Scaled Distance relationship to vibration, at a distance greater than 480 m, using the 95 % confidence level can be described by the following equation;

$$PPV = 2917 \times \left(\frac{D}{\sqrt{W}}\right)^{-1.67}$$

The data analysis suggests that the K and b from the first subset should be used to determine the expected vibration at Owl Stone for blasts closer than 480 m, and the K and b from the second subset used to determine the expected vibration for blasts greater than 480 m from Owl Stone.

Although splitting the data into two subsets identified the strongest correlation, they do not show a strong correlation. The first subset showing a variation of 25 % and the second subset showing a variation of 32 %. This was the strongest correlation identified without detailed information to clarify outliers to further refine the dataset.

It is expected that with each blast added to the site law, information such as blast orientation and pit location can be used to determine the potential effects of vibration screening to identify outliers within the data to further increase the correlation. It is important that this type of information is used to account for the effects of vibration screening to verify both new and existing data validity so that the correlation can be increased to provide more reliable vibration predictions at the Red Hill Quarry.

On completion of the vibration analysis, an Orica Vibration Management Plan was established. The blast design, review and approval process has been detailed in the site-specific plan. Blast vibration will be managed utilising the control measures adopted from the Hanson Vibration Monitoring and Vibration Plan and Orica's existing procedures. Blast vibration data is collected and collated on a blast-by-blast basis to continue to refine site constant values to ensure vibration prediction relevance and accuracy.

14. DETAILS OF REPORTS, DRAWINGS AND RECORDS CONSULTED

This section details other Orica documents that form an integral part of the Blast Management Plan. The objective of the Blast Management Plan is to ensure the safety of all personnel is maintained and appropriate environmental controls are in place. A Blast Management Plan is required to conform to AS2187.2 Appendix A.

The Blast Management Plan comprises the following documents;

14.1 RISK ASSESSMENT

Assessment of all risks associated with blasting operations at the site. Identifies site-specific gaps in existing procedures, including the Shotfirers Standard Operating Procedures (SSOP's). Updated and reviewed as the task, conditions or method of work changes. See Appendix C - Risk Assessment Blasting Operations.

14.2 ORICA STANDARD SHOTFIRING OPERATING PROCEDURES (SSOP)

The SSOPs are a standard set of existing Orica procedures that are used to manage everyday blasting operations and control blasting risk. A copy of these is carried by the shotfirer always. A list of the SSOPs can be seen below in Figure 2.

DOCUMENT NUMBER	TITLE
SSOP-OC-1	Tools for managing the blasting process
SSOP-OC-2	Blass class definitions
SSOP-OC-3	Blast class responsibilities
SSOP-OC-4	Blast loading design
SSOP-OC-5	Initiation design
SSOP-OC-6	Magazines
SSOP-OC-7	Transporting explosives to and from the magazines
SSOP-OC-8	Resolving and reporting of stock discrepancies
SSOP-OC-9	Identifying and managing hazards
SSOP-OC-10	On bench hazards
SSOP-OC-11	Manoeuvring vehicles around the blast
SSOP-OC-12	Working near faces
SSOP-OC-14	Lightning
SSOP-OC-16	Order stemming
SSOP-OC-17	Managing the blast site
SSOP-OC-18	Blast preparation
SSOP-OC-19	Hole dewatering
SSOP-OC-20	Preparation of re-load site
SSOP-OC-21	Check blast loading design
SSOP-OC-22	Check initiation design
SSOP-OC-23	Shotfirer's blast planning meeting
SSOP-OC-24	Priming blast holes
SSOP-OC-25	Loading bulk explosives
SSOP-OC-26	Loading packaged explosives excluding pre, mid and post split applications
SSOP-OC-27	Decking blast holes
SSOP-OC-28	Loading packaged explosives into pre and post split blast holes
SSOP-OC-29	Loading packaged explosives – PCF cartridges
SSOP-OC-30	Problems when loading
SSOP-OC-31	Stemming blast holes
SSOP-OC-32	Disposal of explosives
SSOP-OC-33	Tie in
SSOP-OC-34	Blast monitoring
SSOP-OC-35	Shotfirer's pre-firing planning meeting
SSOP-OC-36	Blast guard duties
SSOP-OC-37	Connect blast initiation system
SSOP-OC-38	Firing the blast
SSOP-OC-40	Post blast inspection
SSOP-OC-41	Handling misfires
SSOP-OC-42	Misfire investigation and documenting responsibilities
SSOP-OC-43	Generic after blast documentation

Figure 2: Orica SSOPs List

The other important documents referred to by the SSOPs are the Job Pack and the Site Information Sheet (SIS).

14.3 ORICA JOB PACK

The blast designs and blast records will be contained in the standard Orica “Job Pack”, which is prepared for each blast and is kept on file by the local Orica plant office. The Job Pack contains all standard records of the blast as specified in section A3 of Appendix A, AS2187.2 including but not limited to:

- Pre-blast survey data
- As-drilled depths and locations of all blast holes
- Record of short or blocked blast holes
- As-loaded record of all short or blocked blast holes
- Types and quantities of initiating explosives and packaged explosives used
- Types and quantities of bulk explosives used
- Initiation plan including charge mass per delay (MIC) and method of initiation
- Vibration and Air blast records

14.4 ORICA SITE INFORMATION SHEET (SIS)

Under normal Orica Quarry Blasting procedures, the blast design parameters to be used for a specific site will be contained in the “Site Information Sheet” (SIS). The SIS will be updated if blast design parameters change. The SIS is an integral part of the blast management plan and is kept in the Orica Job Pack for each blast.

Together the SSOP, SIS and Job Pack documents address the following items of the Blast Management Plan specified by AS2187.2;

- Layout plan of the blast including drilling pattern and hole depths
- Detonation sequence/effective charge mass per delay (MIC/powder factor)
- Type of explosive to be used and quantity required
- Method of initiation
- Type of firing equipment and procedures
- Explosive loading and charging procedures
- Explosive storage and handling procedures
- Security procedures for the site and the blast, including explosives
- Environmental considerations for air blast overpressure, ground vibration
- Details of communication systems
- Warning Procedures
- Traffic management plans
- Misfire management systems
- Dates of firing and times of blasting
- Influence of weather
- Post blast inspection and assessment/comments

14.5 HIGH WALL / LOW WALL RISK ASSESSMENT

A high wall / low wall risk assessment must be conducted for personnel to work within the Danger Zone of a high or low wall.

The Danger Zone is within ½ the height of the face measured from the toe of any rill. A face is anything steeper than 45 degrees. Height is measured to the first functioning catch berm. This has been depicted in Figure 3.

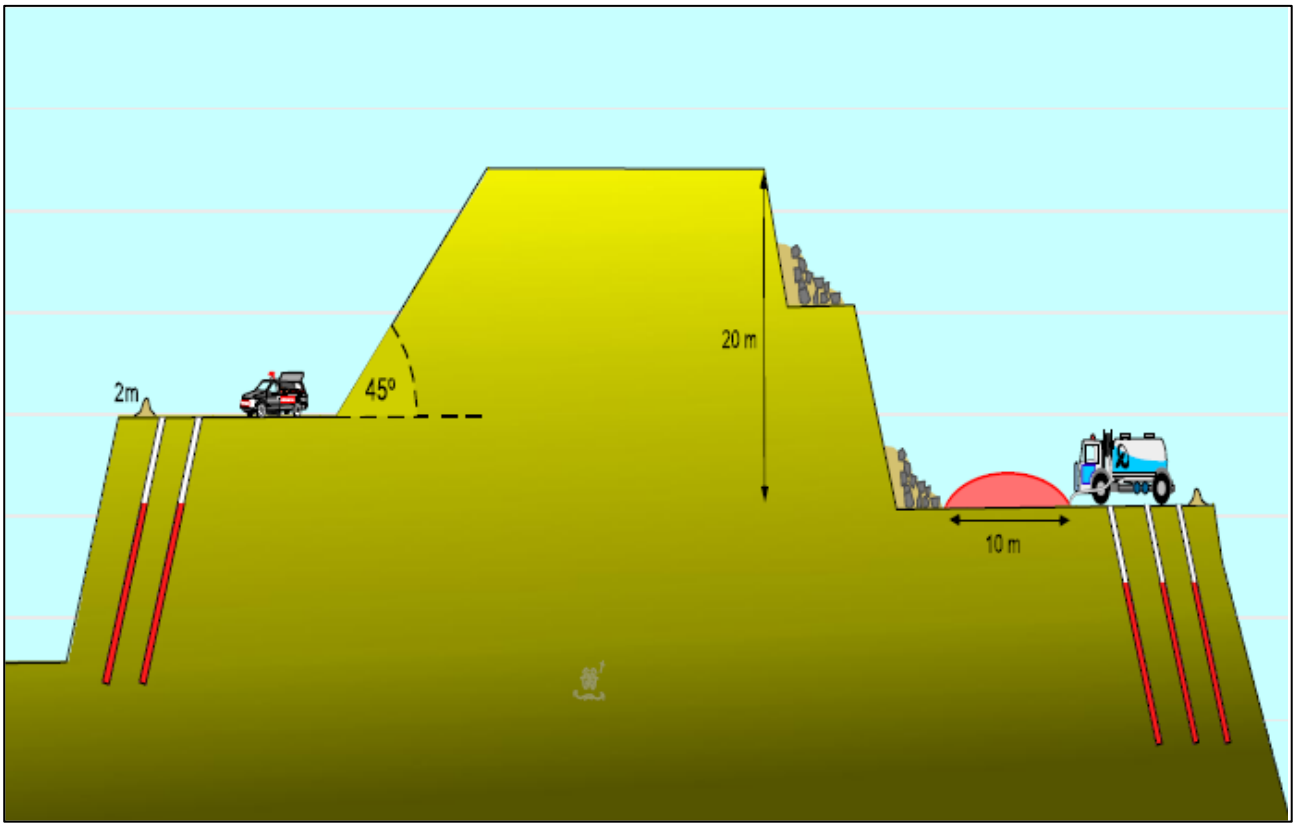


Figure 3: Highwall definition diagram.

14.6 MISFIRE PROCEDURE (SSOP – OC – 41 HANDLING MISFIRES)

In the event of a misfire the shotfirer must refer to the SSOP 41 – Handling Misfires. A detailed risk assessment to control the significant hazards associated with the recovery or refiring of the misfire must be completed. All quarries and construction misfires must be referred to the Orica Technical Services Representative.

To risk assess and manage a misfire, misfires are classified on the following basis:

- Category 1: (Minor) Can be resolved by the shotfirer with the blast guards in place. Investigation managed by shotfirer.
- Category 2: (Significant) Results in blast being delayed e.g. major surface shutdown, unsafe to fire, product found during excavation. Investigation managed by Technical Service Engineer.
- Category 3: (Serious) Results in a major disruption to the mining cycle. Investigation managed by the nominated Technical Service Engineer. Resolution process may be managed by Territory Manager.
- Category 4: Unrecoverable misfire situation. Investigation managed by nominated Technical Services Engineer and reviewed by Technical Service Superintendent. Resolution process may be managed by a higher level of Orica management.

A misfire classified as a Category 2 or higher, is not likely to be refired by the shotfirer immediately following the incident. The shotfirer must consult the Orica Technical Service Representative to ensure that the risks associated with firing the misfire are identified, this will typically result in a delay prior to refiring the blast.

14.7 DRILLING PROCEDURES

The Quarry Manager or the nominated Drilling and Blasting Manager shall ensure compliance with the following procedures:

14.7.1 PLANNING

- Pattern designs and blasting procedures shall be adopted to minimise fly rock, blast vibration, pit wall failures and safety hazards to public health.
- The drill pattern area shall be cordoned off to prevent unauthorised traffic flow in and around the area.
- Drill patterns shall be accurately surveyed to minimise the danger of under burdening holes (potential for fly rock) or overburdening holes (excessive toe and subsequent secondary firing).
- Drill hole locations shall be clearly marked out at the face by the drilling and blasting Supervisor and a drilling pattern plan shall be provided to the Driller indicating depths, diameters, angles and any other relevant information.

14.7.2 OPERATIONS

- Drill operators shall wear full protective equipment (hard hats, safety boots, safety glasses, gloves, ear protection and dust masks). Loose clothing should be avoided. Industrial deafness is a major recognised hazard associated with drilling and particular attention shall be paid to ear protection.
- Either wet drilling shall be used, or an adequate dust collection system installed to ensure dust is kept to a safe limit. Drilling operators shall wear dust masks when working in exposed conditions.
- Drill rig air hoses shall not be dragged along the bench or pit floor and shall be kept away from the tracks of the drill rig and pit traffic.
- Hose fittings shall be secured with safety clips and chains. Air hoses shall be regularly inspected and any doubts concerning their condition should be reported to the Supervisor.
- Care must be exercised in using high pressure air and hydraulic systems.
- Drills must not be positioned parallel to the face for the purpose of drilling the front row unless written permission is obtained from the Supervisor.
- Drilling must not be carried out within 6 metres of a charged blast hole nor in any hole or butt which could have been used or charged or in which a charge could have exploded or misfired.
- Drill holes shall be thoroughly cleaned of all loose material and all loose rock shall be removed from around the collars to prevent any rock fragments falling into the holes before or during charging.
- The blast hole shall be plugged as required or protected to prevent debris entering the hole.
- At the completion of drilling the pattern the Driller shall sign the drilling pattern plan to confirm that the drilling has been completed in accordance with the design and inform the Supervisor accordingly. All holes shall be checked to ensure drilling design depth has been achieved.

14.7.3 MAINTENANCE AND TRAVEL

- Carousels must be locked with a mechanical support when work is being carried out on a lowered tower. The drill shall only be moved with the tower in the drilling position if ground conditions permit and with the tower locking pin in place. The mast/tower shall be lowered when relocating to or travelling from a drill area.
- Hydraulic drill rigs shall travel/relocate with the mast lowered to horizontal position.
- When it is necessary to undertake maintenance work with the mast/tower in a raised position the mast shall be blocked.

15. DETAILS DOCUMENTS CONSULTED IN CONSTRUCTION OF THIS BMP

The following have been identified as specifically relevant to the activities to be undertaken.

- Australian Standard 2187.2 – 2006 Use of Explosives
- Australian Standard 2187.1 – 1998 Storage, transport and use – Transport
- Australian Explosives Code (AEC) (6th Edition)
- Dangerous Goods Safety (Explosives) Regulations 2007

16. APPENDICIES

Appendix A: PERSONNEL LIST.

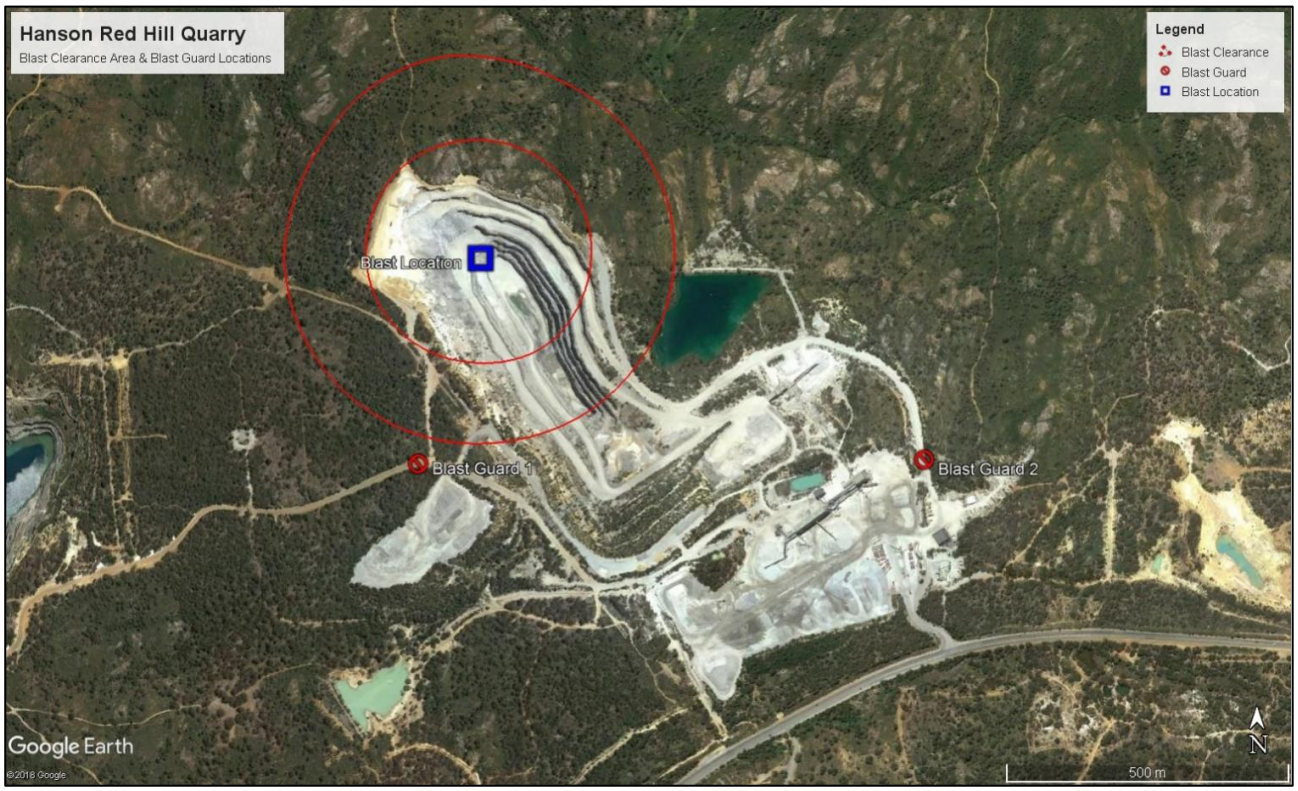
Contact details of people involved in this project:

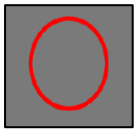
NAME	POSITION	PHONE
Reece Naylor	*Supply Chain Manager - Aggregates	0448 187 161
David Kraima	*Quarry Manager	0408 602 072
Andrew Antenucci	Shift Supervisor	0429 217 112
Russell Hughes	**Xcel Drilling**	0417 934 586
Laurence Goodacre	*Territory Manager	0436 403 991
Peter Money	*Plant Supervisor	0412 474 901
Craig Rowe	Technical Services Manager	0409 727 217
Nathan West	Blast Technician	0437 945 858
	Orica Emergency Response	**1800 011 333**

* Nominated contacts to be called immediately in the event of an incident.

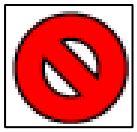
Appendix B: BLAST CLEARANCE AREA AND BLAST GUARD LOCATIONS.

A sample blast guard location map has been provided below, showing an exclusion zone around the perimeter of the blast. Due to its size and the potential to blast in varying parts of the quarry, the exclusion zone should be reviewed prior to firing each blast. The review will consider all associated blast risks to determine a safe distance to clear both personnel and equipment. Changes made to the blast clearance map will be approved by the Quarry Manager before blasting.





Blast Clearance Area – To be risk assessed and approved by QM



Blast Guard Location

Appendix C: BLASTING OPERATIONS RISK ASSESSMENT.

Risk Assessment - Blasting Operations

Hanson Red Hill Quarry

Attendees and Positions:

Hanson:

Dave Kraima – Quarry Manager - Red Hill

Orica:

Daniel Hepburn – Technical Services Superintendent

Mat Trigwell – Blast Technician

15/02/2018

Principal Risk Assessor – Mat Trigwell

Assessment designed to comply with AS / NZS ISO 31000:2009 “Risk Management”

Main elements: (from AS / NZS ISO 31000:2009)

a) Communicate & Consult

b) Establish Context

c) Identify Risks

d) Analyse Risks

e) Evaluate Risks

f) Treat Risks

g) Monitor & Review

Communicate & Consultation Steps:

- ❑ Consider costs, payment and liability for Orica conducting risk assessment.
- ❑ Physically visit and “walk” the area of any blasting proposal.
- ❑ Convene a meeting in a location with whiteboard / write-up capability.
- ❑ Gather a team of persons familiar with the site and blasting objectives.
- ❑ Review the objectives of any blasting proposal.
- ❑ Specify a “typical” blast design that might be anticipated.
- ❑ List potential hazards associated with setting up, charging and firing such a blast.
- ❑ Describe the expected environmental and other potential effects of such a blast.
- ❑ Locate site plans covering the full potential range of vibrations, air blast and flyrock.
- ❑ Highlight circles of radius around blast site (e.g. 50 m, 250m, 500m etc.)
- ❑ Identify all equipment, services, and facilities within target ranges.
- ❑ Use the assessment sheets provided to identify the hazards, determine the risk and identify the controls associated with each potential target or hazard.
- ❑ Document these on the risk management forms.
- ❑ Determine whether each hazard can be safely reduced and managed.
- ❑ Arrange to draft site-specific operational procedures covering all aspects of the blasting process.
- ❑ After completion, have qualified persons review the draft and when completed produce the final operational procedure documentation.
- ❑ Ensure every appropriate person on site is familiar with the assessments and the procedures in place to ensure safety.
- ❑ Measure and record blast outcomes and effects.
- ❑ Complete summary report after blasting as required by law and site procedures.

Context of Risk Assessment

When identifying blast-related hazards, we consider:

- ❑ Regulation requirements
- ❑ Other activities in area
- ❑ Associated tasks
- ❑ Site layout
- ❑ Property in non-safety zone
- ❑ Internal property damage
- ❑ Power lines, underground services
- ❑ All weather conditions
- ❑ Timing of activity
- ❑ Safety equipment needed
- ❑ Visitors and contractors
- ❑ Uneven surfaces
- ❑ Off-spec drilling, lost holes
- ❑ Vehicle suitability
- ❑ Operator competence
- ❑ Delays in charging / firing
- ❑ Neighbours
- ❑ Traffic/ Speed limits
- ❑ Restricted areas / Signs
- ❑ Face / ground conditions
- ❑ Geology, Hydro geology
- ❑ Oversize
- ❑ Toe
- ❑ Backbreak
- ❑ Air blast, Vibration
- ❑ Evacuation areas, Roadblocks

BLASTING RISK ASSESSMENT TABLE (Acknowledgement to Orica Explosives SHE team)

L (Likelihood) X C (Consequence) = R (Risk)

Likelihood of Occurrence (L)	Potential Consequences (C)					
	5 Notable	10 Significant	15 Highly Significant	20 Serious	25 Very Serious	30 Catastrophic
Probable **(5)**	25	50	75	100	125	150
Possible **(4)**	20	40	60	80	100	120
Unlikely **(3)**	15	30	45	60	75	90
Very Unlikely **(2)**	10	20	30	40	50	60
Extremely Rare (1)	5	10	15	20	25	30

Potential Likelihood (L)

5	**Probable**	**A common occurrence. The event is expected to occur in most circumstances.**
4	**Possible**	**Event will probably mostly occur - known to have happened in similar situations.**
3	**Unlikely**	**The event could occur but not expected.**
2	**Very Unlikely**	**The event may occasionally occur at some time but rarely**
1	**Extremely Unlikely**	**The event may occur only in exceptional circumstances.**

Note that the risk estimations and “weightings” are subjective and based on the experience and interpretation of those persons contributing to the study. For matters relating to blasting technology and design this is mostly provided by the writer of this report.

Orica Internal Hazard Management Table

Risk	Who Signs Off	Type of Investigation
1-10	Shotfirer / Supervisor	Site visit, sign off note in job pack
11-20	TS Blasting Engineer	Site visit, report in job pack
21-50	Snr TS Engineer / Project / Business Manger	Site visit, Risk report in job pack
Over 50	Must be reduced	Unlikely to Risk

Potential Consequence Examples

	Notable	Significant	Highly Significant	Serious	Extremely Serious	Catastrophic
Safety & Health	1 Minor Injury	Single MTI	Single LWC or Multiple MTI	Permanent disability or Multiple LWC	Single Fatality	Multiple Fatality
Environment	Very Minor pollution	Minor Local pollution	Evident Pollution local concern	Significant Local pollution	Major Local pollution	Extremely Severe pollution
Reputation and Image	Minor issue 1 complaint	Local issue 10 complaints	Local media 100 complaints	Regional or state media	National media coverage	Headlines, corporate damage
Services / Business Interruption	Minor re-connection required	Minor temporary loss of resource	Short-term supply loss of major resource	Medium term supply loss for major resource	Long term loss of production and/or major resource	Permanent loss of production and/or major resource
Business Liability	>$5000	>$50,000	>$200,000	>$1m	>$15m	>$50m

BLASTING RISK EVALUATION GUIDE (ISEE)

CONCERN	PRIMARY IMPACTS	CONTROLS
Flyrock	Damage and Injury	Pre-qualification requirements, blasting controls (blast mats-burden requirements) stemming requirement blast plan reviews, and inspection work.
Structural damage to buildings	Damage claims, work delays or suspension	Pre-qualification requirements, blasting controls, blast plan submittals and reviews, careful inspection of work, public education, effects monitoring and pre, blast condition surveys.
Damage to rock slopes and final excavation walls	Rock fall, remedial slope repairs, work disruption	Evaluate in situ condition of slopes and install additional support is needed. Develop blasting controls and carefully monitor the work.
Damage to buried pipes and utilities	Unrealistic restrictions or total ban on blasting	Pre-qualification requirements, blasting (controls, blast plan submittals and reviews, careful inspection of work, effects monitoring and blasting effects evaluation study by expert.
Startled people	Complaints	Inform neighbours before each blast through agreed communication medium (Newspaper Advertisements, email circulars, online). Blast information Notice board to be displayed a Quarry entrance.
Damaged water wells or aquifers	Blasting prohibition or project delays	Blasting controls, pre-blast / post blast inspections, effects monitoring and blasting effects evaluation study by expert
Environmental Impacts or other Animal Effects	Disapproved EIS, blasting prohibition or delays	Blasting controls, pre-blast and/or post. blast inspections and blasting impacts and mitigation study by expert.

Work or business disruption	Financial damage claims and/or organised opposition to the work	Public education, blasting controls, monitoring and schedule blasting during non-working hours.
Contractual Claims and Legal Actions	Financial damages	*Owners and Engineers:* Have appropriate experts review contract documents and specifications. Prepare pre-qualification requirements to ensure personnel are capable of performing the work, and carefully inspect and document all non-conforming work. *Contractors:* Carefully evaluate all available documents-including all geotechnical information, attend pre-construction meetings, document all efforts to conform and barriers to conformance

Blasting Job Safety & Risk Assessment Form - **Hanson Red Hill Quarry**						Date: 15/02/2018			
Event or Activity	**Potential Hazards & Effects**	L	C	R	**Possible Elimination Measures**	**Residual Hazard**	L	C	**R**
Flyrock blasting at 5 to 25m	Damage to in pit mobile and fixed plant.	5	10	50	Unessential equipment should be removed from in pit location. Control stemming heights Ensure correct design and blast loading, experienced supervision. Ensure Drill & Blast procedure includes the driller completing a Drill Log Sheet, which details ground conditions and cavities.	Design to “No significant flyrock” beyond 50m Expect equipment closer than 40m to be damaged.	2	10	20
Flyrock – blasting to 100m	Damage to in pit mobile and fixed plant.	4	25	100	Unessential equipment should be removed from in pit location. Control stemming heights Ensure correct design and blast loading, experienced supervision. Ensure Drill & Blast procedure includes the driller completing a Drill Log Sheet, which details ground conditions and cavities.	Design to “No significant flyrock” beyond 50m. Expect equipment closer than 50m to be potentially damaged.	1	25	25
Flyrock beyond blast clearance area	Personnel Injury, Possible fatality	4	25	100	Blast management plan enforced Blast Guard training and assessment of understanding. Ensure correct design techniques (survey and bore tracking) and blast loading, experienced operators and supervision Ensure that any exploration hole coordinates are supplied to blasting contractor to be used when designing shots. Ensure Drill & Blast procedure includes the driller completing a Drill Log Sheet, which details ground conditions and cavities Use Flyrock Risk Assessment report blast clearances for establishing blast guard positions.	Whole quarry site shut down during blasting process. Non-essential personnel to remain behind blast guards.	1	25	25

Air blast damage from normal blast	Break residential windows (133 dBL) Shed panels buckle (>133 dBL)	4	15	60	Control stemming heights Reduce charge mass per hole Ensure correct design techniques (survey and bore tracking) and blast loading, experienced operators and supervision Inform neighbours of blast times.	Air blast from unusual or unknown geological condition. Weather conditions (overcast low cloud cover)	1	15	15
Air blast – Neighbours Surprise, Excess	Neighbour complaints @ 1000 m plus.	4	10	40	Minimum stemming lengths to be applied as detailed in SIS. Face holes to be bore tracked and loading design adjusted in areas with minimal face burden.	Weather conditions (overcast low cloud cover)	2	10	20
Vibration	Owl Stone is located within 250m of pit boundary.	2	30	60	Vibration measurement and management plan to be implemented. Each blast to be review by Orica Technical Services engineer and vibration prediction submitted to the Quarry Manager.	Potential for damage or movement of the Owl Stone. Blast to be designed as per SIS to ensure MIC is managed and vibration minimised to acceptable level at the Owl Stone.	1	30	30
Blast Dust Clouds	Dust generation	4	10	40	Wind direction is to be reviewed prior to blasting. If there is a risk of dust blowing onto the property of local residents or nearby roads, the blast is to be postponed.	Dust blows over neighbouring properties or Toodyay Road.	2	10	20
Overcharged holes	Flyrock, air blast and vibration	4	25	100	Ensure that all blasts are designed to meet all vibration limits referred to in AS2187.2. Ensure blast designs maintain MIC calculated from site law at the Owl Stone monitor location. Maintain recommendations as detailed in the vibration measurement and management plan.	Design to “No significant flyrock” beyond 50m	1	25	25
Poor Rock breakage	Un diggable, non-productive results	4	5	20	Quality control procedures are to be implemented. SIS parameters are to be followed, blast designs outside of the SIS are to be reviewed by Orica TSR and approved by QM.	Secondary breakage, mechanical or blasting, additional cost associated with managing poor blast outcome.	3	5	15

Refire toe and oversized rock	Re-entry and non-productive practices Air blast and or flyrock outside blast clearance area.	3	25	75	Blast Management Plan communicated to all site personnel and neighbours. Blast exclusion area is to be reviewed and increased if required.	Non-productive blasting. Additional cost of rock breaking	1	25	25
Blast Guarding & Blast Clearances	Personnel not cleared from blast clearance zone. Blast guard position breached.	4	25	100	Blast are not currently slept over night	Local resident intentionally avoiding Shotfirer and Blast Guard so that they can view blast.	1	25	25
Sleeping Loaded Shots	Attempt to steal explosives out of charged holes. Attempt to unlawfully initiate charge blast holes. Bush fire encroaches on blast prematurely initiating blast.	4	25	100	If blast is to be slept a secure person will be in place to guard the area until the Quarry Manager or Shotfirer returns. Quarrying activities are not carried out during night shift.	Problem loading blast due to loading unit (MMU) breaking down.	1	25	25

Blasting Job Safety & Risk Assessment Form - **Hanson Red Quarry**						Date: 15/02/2018			
Event or Activity	**Potential Hazards & Effects**	L	C	R	**Possible Elimination Measures**	**Residual Hazard**	L	C	**R**
Muddy Slippery Conditions	Blast personnel slip and injured in muddy bench conditions	4	15	60	Ensure that potentially muddy benches are sheeted with adequate quarry sand or road base. In rainy weather conditions Shotfirer and Quarry Manager assess bench conditions to ensure that blasting procedures can be performed without threat of slip injury. If potential slip injury postpone loading to another day or rectify bench conditions.	Production loss as blast cannot be blasted on correct day, no broken stocks for crushing.	2	15	30
Flight Paths	Aeroplanes or helicopters flying over blast during blasting	1	30	30	No known commercial flight paths over quarry. Shotfirer to conduct visual inspection and listen for aircraft around firing time, postpone blast until certain that noise is not a low flying plane or helicopter.	Blast delays, poor visibility due to weather or cloud cover.	1	30	30
Working under high walls	Rock dislodging out of wall and landing on blast personnel working in proximity of the high wall	3	25	75	Do not design blast holes any closer than half the wall height from the toe of the high wall. E.g. If wall height is 10m height closest hole will be marked in 5m from the toe of the wall if a functioning catch berm is in position. Blast designer/surveyor to use Orica SSOP High wall risk assessment. Mining activities are not to be carried out on the bench above whilst personnel are conducting charging/blasting below.	Entire wall falling onto bench.	1	25	25
Working in close proximity to open faces	Blast personnel falling over face marking in blast pattern or loading blast holes.	2	25	50	Windrow half the height of the largest wheel to be used on bench.		1	25	25
Lone and isolated workers	Surveyor marking out shot in isolated area of the quarry falling over and injuring self. No one aware of injury	4	15	60	Follow lone and isolated procedure. Sign in and out of quarry sign in book, inform quarry supervisor when arriving and leaving site.		1	15	15

Climatic Heat	Extreme heat days + 38° conditions personnel; working on bench may experience heat stroke.	4	15	60	All personnel on bench are aware of the effects of heat stress and all personnel monitor others on bench. Ensure regular breaks for rest and water. Closely monitor new employees or personnel not used to working in hot climatic conditions.		1	15	15
Magazines	Theft of explosive from onsite magazines	2	25	50	All explosives are stored at the McLarty Explosive reserve, which has 24hr security.		1	25	25
Transport of Explosives	Accident involving explosive due to fatigue.	3	25	75	Orica Operators to follow SSOP and fatigue management policy. Stopping for breaks every two hours and limiting workday to 10 hours	3rd party influence	1	25	25
Mobile Manufacturing Unit (MMU) moving on shot	MMU running over loaded blast holes, damaging down lines or causing premature detonation.	3	25	75	Follow Orica procedure for moving MMU on shot. Spotter required at all times.	MMU operator that does not follow procedures.	1	25	25
Non-blasting personnel on blast during loading and tie up processes.	Misfire caused through untrained people conducting blasting duties. Premature initiation caused by untrained personnel mishandling explosives.	3	25	75	All visitors to be supervised while on the blast and to only observe if not completed correct on bench training.		1	25	25
Faulting IE/PE or bulk explosives	Misfired blast causing potential detonation when excavation or air blast/flyrock issue when re-firing.	3	25	75	Orica Shotfirer to follow SSOP misfire procedure. Inform Engineer/Territory Manager/Supervisor of situation and discuss any actions that are going to be taken to rectify problem. Any exposed misfired blast holes must have adequate false burden placed in front of the blast hole prior to firing to prevent flyrock or air blast.		1	25	25
Machinery excavating in close proximity of face blast holes	Exposed blast holes cause air blast flyrock. Equipment digs into charged blast hole causing premature detonation.	3	25	75	Face to be profiled prior to blast being loaded. Face cannot be mined after profiling has been completed. Blast loading not to commence until face has been profile. No excavation within 10m of a face that is being loaded, unless discussed with Shotfirer and agreed upon.		1	25	25

BLAST VIBRATION MANAGEMENT PLAN

HANSON – RED HILL QUARRY

March 2018

REVIEWED BY:

7/03/2018

X 

Daniel Hepburn
Technical Services Superintendent
Signed by: dlh4

SUMMARY

Prior to conducting blasting at the Hanson Red Hill Quarry, Orica conducted a review of Hanson's Vibration Management Plan previously implemented onsite. This included a review of the historical vibration data measured and recorded by the incumbent blasting contractor MAXAM.

A Site Law was established using the most recent data collected by MAXAM so that each blast carried out by Orica could be designed and fired to comply with the vibration limits imposed on Owl Stone. All blasts measured at the Owl Stone must meet the limits of;

- 20mms^{-1} PPV vibration limit.

Regression analysis of the complete data set identified the strongest correlation by splitting the data into two subsets, split by proximity of the blast to the vibration monitor. A regression analysis of the two subsets was used to determine the site vibration constants K and b, for blasts greater than and less than 480 m.

To ensure compliance with the 20 mm/s limit at Owl Stone, the expected vibration must be predicted using the 95% confidence level.

The Scaled Distance relationship to vibration, at a distance less than 480m, using the 95% confidence level can be described by the following equation;

$$PPV = 886 * \left(\frac{D}{\sqrt{W}}\right)^{-1.01}$$

The Scaled Distance relationship to vibration, at a distance greater than 480m, using the 95% confidence level can be described by the following equation;

$$PPV = 2917 * \left(\frac{D}{\sqrt{W}}\right)^{-1.67}$$

The data analysis suggests that the K and b from the first subset should be used to determine the expected vibration at Owl Stone for blasts closer than 480 m, and the K and b from the second subset used to determine the expected vibration for blasts greater than 480 m from Owl Stone.

Although splitting the data into two subsets identified the strongest correlation, they do not show a strong correlation. The first subset showing a variation of 25% and the second subset showing a variation of 32%. This was the strongest correlation identified without detailed information to clarify outliers to further refine the dataset.

It is expected that with each blast added to the site law, information such as blast orientation and pit location can be used to determine the potential effects of vibration screening to identify outliers within the data to further increase the correlation. It is important that this type of information is used to account for the effects of vibration screening to verify both new and existing data validity so that the correlation can be increased to provide more reliable vibration predictions at the Red Hill Quarry.

VIBRATION DATA ANALYSIS

Vibration has been shown to follow the general form of the following equation;

$$PPV = K * \left(\frac{D}{\sqrt{W}}\right)^{b}$$

Where;

K and b are site constants

D = Distance to the Monitor

W = Charge Weight of the Explosives

The term Scaled Distance is frequently used to refer to the general relationship between distance from the charge, and charge mass, where;

$$SD = \left(\frac{D}{\sqrt{W}}\right)$$

Australian Standard 2187.7 suggests that for sites where no other information is available, values of K a b equal to 1400 and -1.6 provide a reasonable initial estimate.

To determine the site constants, the scaled distance and resulting peak particle velocity (ppV) is plotted on a log-log graph. A best fit line is applied to the data using least squares regression, from this the K constant and b constant can be measured.

Red Hill Data Analysis

Beginning in 2016, up to November 2017, vibration data was collected from blast reports at the Red Hill Quarry. A data set totalling 105 data points was obtained from the 64 blasts fired in 2016 and 2017.

Regression analysis of the data set identified that the strongest correlation was obtained by splitting the data into two subsets, split by blast proximity to the vibration monitor. The regression analysis of the two subsets, (greater than and less than 480m proximity), was used to identify the site vibration constants K and b.

Subset 1 – Less than 480m proximity

Regression analysis of the 91 data points, measured at a distance less than 480 m, indicates a relationship between Scaled Distance and vibration as shown in the following Figure 1.

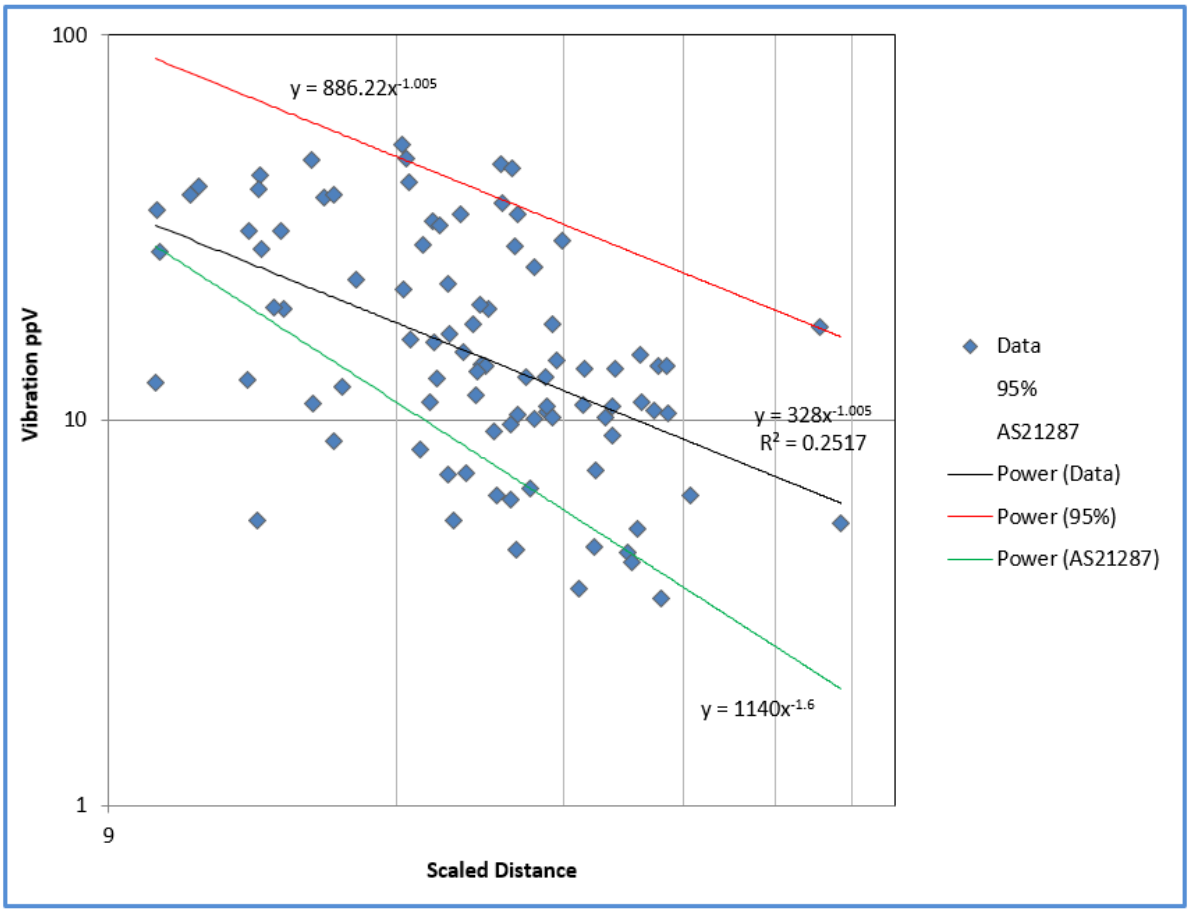


Figure 1: ppV vs Scaled Distance at monitors less than 480m from the blast.

The less than 480m data subset does not show a strong correlation with a variance of 25%, however this is the strongest correlation that was identified without further information to clarify outliers and refine the data set further.

It is expected that with each additional blast added to the site law, information such as blast orientation and pit location can be used to account for the effects of vibration screening and 'clean up' the data to increase the correlation further.

The Scale Distance relationship to vibration at a distance less than 480m can be described by the following equation;

$$PPV = 328 * \left(\frac{D}{\sqrt{W}}\right)^{-1.01}$$

Equation 1: ppV prediction using Scaled Distance at 50% confidence level.

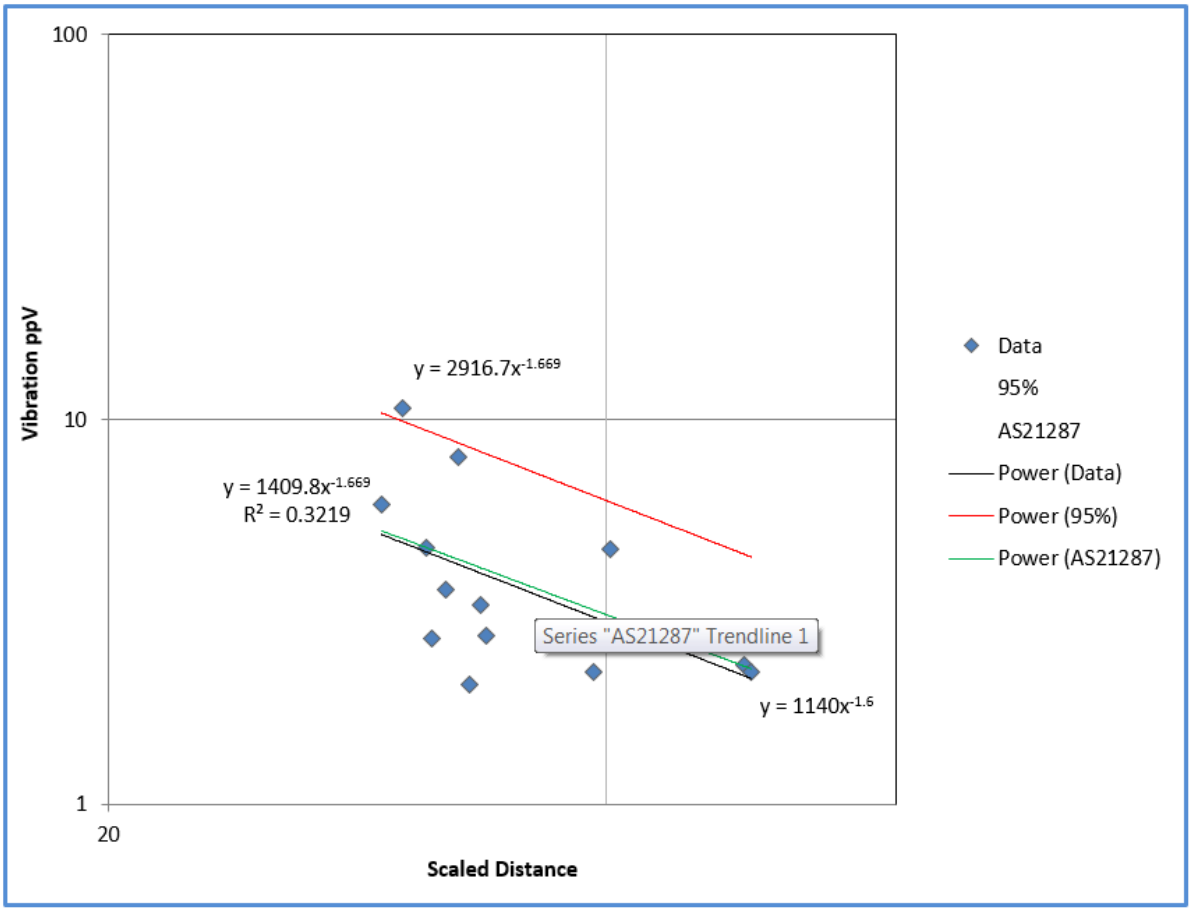
However as this will only provide a 50% confidence level, and the blasts need to be designed to ensure compliance with the 20 mm/s limit at the ancestral Owl Stone, a 95% confidence level will be used to predict vibration using the following equation

$$PPV = 886 * \left(\frac{D}{\sqrt{W}}\right)^{-1.01}$$

Equation 2: ppV prediction using Scaled Distance at 95% confidence level.

Subset 2 – Greater than 480m proximity

Regression analysis of the 14 data points, measured at a distance greater than 480 m, indicates a relationship between Scaled Distance and vibration as shown in Figure 2.



The greater than 480m data subset does not show a strong correlation with a variance of 32%, however again splitting the data by proximity at this distance produced the strongest correlation that was identified without further information to clarify outliers and refine the data set further.

As the data set is small, each additional blast added to the site law will have a much greater impact on the site constants. It is therefore important that information such as blast orientation and pit location is used to account for the effects of vibration screening and verify both new and existing data validity so that the correlation can be increased further.

The Scale Distance relationship to vibration at a distance greater than 480m can be described by the following equation;

$$PPV = 1410 * \left(\frac{D}{\sqrt{W}}\right)^{-1.67}$$

Equation 3: ppV prediction using Scaled Distance at 50% confidence level.

However again as above, this will only provide a 50% confidence level, and the blasts need to be designed to ensure compliance with the 20 mm/s limit at the ancestral Owl Stone, a 95% confidence level will be used to predict vibration using the following equation

$$PPV = 2917 * \left(\frac{D}{\sqrt{W}}\right)^{-1.67}$$

Equation 4: ppV prediction using Scaled Distance at 95% confidence level.

Maximum Instantaneous Charge (MIC)

Using the site constants obtained from data in each of the subsets, the MIC and resulting ppV can be calculated using a known distance between the blast and vibration monitor.

The data analysis suggests that the K and b from the first subset should be used to determine the expected vibration at Owl Stone for blasts closer than 480 m, and the K and b from the second subset used to determine the expected vibration for blasts greater than 480 m from Owl Stone.

BLAST DESIGN AND REVIEW PROCESS

As detailed in the Red Hill Blast Management Plan, all blasting operations conducted by Orica are managed using a standard set of Orica procedures. The Shotfirers Standard Operating Procedures (SSOP's) form a detailed process in which Orica conducts blasting activities. All the associated risks during blasting are carefully managed according to the SSOP's.

Orica does not propose significant changes to the design process previously implemented onsite, the process will be similar with adjustments made to ensure the Orica SSOP's are maintained.

Identify blast area and design parameters

The Orica surveyor will be informed of the proposed blast location by Hanson. Design parameters detailed in the applicable Site Information Sheet (SIS) are to be used to develop the drilling design. Each blast will be classified using the risk matrix detailed in the SSOP's. A blast assigned as a Class 4 or higher must be reviewed by an Orica Technical Representative (TSR).

A vibration prediction will be completed to determine the expected ppV at Owl Stone for all blasts at the Red Hill Quarry.

Drilling design approval

Once the blast has been marked out, the approving TSR, Surveyor or Shotfirer will submit the complying blast plan and predicted PPV values at Owl Stone to the Quarry Manager or quarry representative for approval.

Initiation design and approval

Blast initiation will be developed by the Orica shotfirer, a Class 4 blast or higher will be reviewed by an Orica TSR. Orica will ensure that the MIC achieved for the blast is within the limit of the MIC used to predict the PPV values at the Owl Stone. Blasts in which the MIC cannot be achieved using a non-electric initiation system, will require the use of an electronic initiation system, as specified in Hanson's Vibration Management Plan. All Orica personnel will be trained in the use of electronic blasting systems.

The initiation design will be made available to the Quarry Manager in the Blast IQ™ database.

Loading design approval

The Orica shotfirer will be responsible for the loading design, the loading design for a Class 4 blast or higher will be reviewed by an Orica TSR. The loading design must achieve an MIC equal to, or less than the MIC used to predict the PPV expected at the Owl Stone.

An Orica job pack will be maintained throughout the design process, the MIC requirement and predicted PPV at Owl Stone is to be provided to the Quarry Manager for approval prior to the blast.

Changes made to the loading design during charging, must be reviewed and approved by the Orica TSR and Quarry Manager if the design MIC cannot be maintained.

Blast Monitoring

Orica will conduct blast monitoring at each point detailed in the Hanson Blast Management Plan. This will include William Street, Owl Stone and an appropriate decay position between the Owl Stone monitor and the blast location.

If required, the decay position must be adjusted to ensure that the location is between the blast and Owl Stone monitor. Each monitor location must be recorded using GPS.

Maintaining Site Law

Following each blast, the database in which the Site Law has been developed will be updated. It will be the responsibility of the Orica TSR to periodically review changes made to the database. The site constants will be re-calculated, and the Site Law managed to provide reliable vibration predictions.

All blasts that exceed the 20 mm/s ppV limit at Owl Stone, will be investigated by Orica and conclusions provided to Hanson.

VIBRATION CONTROL

The key management and mitigation measures at the Red Hill Quarry have been detailed in the Hanson Vibration Management Plan. Orica are committed to implementing the following vibration controls;

- Minimise MIC through a reduction in bench height, reduction in hole diameter, and advanced initiation design.
- Conduct face profiling and bore tracking to identify areas with insufficient burden and manage all associated risks.
- Apply best practice during initiation design, firing the closest hole to the Owl Stone first reducing the potential for holes to amplify vibration effects.
- Always fire to free faces and free ends to reduce confinement of each explosive charge.
- No choke firing of blasts, no firing of holes with excessive subdrill.
- Reduce the number of holes firing within the 8 millisecond window of time, further reducing or maintaining the MIC.
- Blasts are not to be designed with excessive burdens or spacing to reduce confinement of explosives.

- Manage blast size and shape to reduce the depth of each blast to minimise confinement.
- Reduce the overall confinement of explosives through advanced blast design and a comprehensive review process.
- Utilise electronic blasting systems to control MIC and implement advanced blast design techniques to manage vibration that cannot be achieved with non-electric initiation systems.
- Maintain and calibrate all vibration measurement tools so that blasting impacts can be accurately measured and recorded.