BGC Voyager Quarry
Blast and Vibration
Management Plan 2006
REVISION 5

Report Prepared for

Report Prepared by

April 2007
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Blast and Vibration
Management Plan 2006
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BGC Quarries

SRK Project Number URS002
SRK Consulting, Level 6, Suite 7-9,
141 Queen Street, Brisbane, QLD, 4000

Contact: Kevin Holley
kholley@srk.com.au
www.srk.com.au

April 2007

Compiled by:
Kevin Holley
Principal Consultant
Executive Summary

BGC operates a quarry at The Lakes. The quarry site is approximately 16 kilometres east of the Town of Mundaring and 47 kilometres southwest of the Town of Northam on the Great Southern Highway, Western Australia.

The BGC Voyager Quarry has been operating since 1990 to provide crushed granite for a variety of uses, including concrete, road base and building products. The current quarry comprises an open pit, a crushing plant, noise attenuation bunds, product stockpiles, a water supply dam, a workshop, fuel storage facilities, office facilities, amenities and a weighbridge. The operation has a nominal rated throughput of approximately 900,000 tonnes per annum (tpa).

BGC have planned to extend the Voyager Quarry operation to maintain supplies of the resource. The planned expansion will involve development and operation of a quarry incorporating excavation of approximately 16 million tonnes of hard rock, approximately 2 million tonnes of gravel and approximately 12 million tonnes of clay from the quarry footprint. This will allow for approximately 60 million tonnes of granite to be excavated from the site over a 50 year period. The quarry footprint itself will cover an area of approximately 59 hectares.

Conventional drilling and blasting, loading and hauling, crushing and screening methods will be employed.

It is expected that the projects development will occur in six (6) stages over the life of the mine, with stage 1 and 2 being initially developed to provide room for the new below-ground level facilities and infrastructure. Subsequent stages will then be developed as the need to access granite resources arises. The staged approach will ensure that excavation of the topsoil and subsoil (gravel and clay) will only occur on five occasions during the life of the mine, thereby minimising the impacts of clearing at any one time. All infrastructure, crushing and screening plants and stockpiles will be housed below ground level, and the site will be surrounded by a buffer of trees and vegetation.

In April 2005 the Environmental Protection Authority submitted a report including recommendations to the Minister for the Environment on the environmental factors relevant to the proposal by BGC (Australia) Pty Ltd for the future development of the Voyager Quarry at The Lakes, in the Shire of Northam. This report identified two overarching environmental factors of relevance to blasting operations at the proposed BGC Voyager Quarry extension, namely Operational Noise and Vibration.

This document presents the BGC Voyager Quarry Blast and Vibration Management Plan as required under Condition 18 of the Minister for the Environment Statement Number 706, (Condition 706:M18) dated 16 December 2005. It has been prepared in accordance with the guidelines published by the Government of Western Australia Department of Environment. A key objective of this Blast and Vibration Management Plan is to present the framework under which BGC Quarries intend to manage blasting activities to meet the environmental permitting requirements.
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Disclaimer

The information and opinions provided in this report have been based on the information supplied to Steffen Robertson & Kirsten (Australasia) Pty Ltd trading as SRK Consulting (SRK) by BGC Quarries (BGC). The information in this report is provided in response to a specific request from BGC to do so. SRK have exercised all due care in reviewing the supplied information. Whilst SRK has compared key supplied data with expected values, the accuracy of the results and conclusions from the review are entirely reliant on the accuracy and completeness of the supplied data. SRK does not accept responsibility for any errors or omissions in the supplied information and does not accept any consequential liability arising from commercial decisions or actions resulting from them.
1 Element/issue

**Department of Environment Guideline:** Detail the aspect of the project or component of the environment to be managed such as groundwater abstraction, waste, noise or surface water. The EPA bulletin refers to environmental factors, which relate to aspects. The title of the EMP should reflect the factor to be managed, eg Noise Management Plan. This section should also include the legal framework for the management of this factor eg the Condition or Commitment, and any legislation that is applicable eg Wildlife Conservation Act, and any Government Policy/Strategy that is applicable.

1.1 Introduction

This document presents the BGC Voyager Quarry Blast and Vibration Management Plan as required under Condition 18 of the Minister for the Environment Statement Number 706, (Condition 706:M18) dated 16 December 2005. It has been prepared in accordance with the guidelines published by the Government of Western Australia Department of Environment1. A key objective of this Blast and Vibration Management Plan is to present the framework under which BGC Quarries intend to manage blasting activities to meet the environmental permitting requirements.

The existing Voyager Quarry is located within the Shire of Northam on the Great Southern Highway in The Lakes (Figure 1), and the proposed location for the new quarry is Lot 14 Horton Road, The Lakes (Avon Location 1881). Figure 1 shows that the BGC Voyager Quarry has been zoned as a “Extraction Area” that is located within an area designated as “Agricultural”.

1.2 Report of the Environmental Protection Authority (Bulletin 1169)

In April 2005 the Environmental Protection Authority submitted a report2 including recommendations to the Minister for the Environment on the environmental factors relevant to the proposal by BGC (Australia) Pty Ltd for the future development of the Voyager Quarry at The Lakes, in the Shire of Northam. This report identified two overarching environmental factors of relevance to blasting operations at the proposed BGC Voyager Quarry extension, namely Operational Noise and Vibration as summarised in Table 1.

<table>
<thead>
<tr>
<th>Environmental Factor</th>
<th>EPA Objective</th>
</tr>
</thead>
<tbody>
<tr>
<td>Operational noise</td>
<td>To protect the amenity of nearby residents from noise impacts resulting from activities associated with the proposal by ensuring the noise levels meet statutory requirements.</td>
</tr>
<tr>
<td>Vibration</td>
<td>To protect the amenity of nearby residents from vibration impacts resulting from activities associated with the proposal by ensuring the vibration levels meet statutory requirements and acceptable standards.</td>
</tr>
</tbody>
</table>


Figure 1: Location of Voyager Quarry (from Government of Western Australia³)

Operational Noise and Vibration are addressed in Chapter 3.9 of the Environmental Protection Authority report. In this Chapter the Environmental Protection Authority identify that the nearest resident to the Project Area is approximately 560m to the west of the site, whilst a residence to the north is 1km away and that noise issues are currently managed through the provisions of the Environmental Protection (Noise) Regulations 1997 (Noise Regulations). Ground vibration limits were, until recently, detailed within Condition of Licence set by the Department of Environment.

The Environmental Protection Authority states that BGC Quarries has recognised the importance of blast vibration and air overpressure, and has commissioned a number of studies to assess their impact. These studies (which included an array of modelling exercises) support BGC assertions that airblast overpressure and ground vibration associated with blasting at the proposed new quarry will not exceed the relevant statutory limits and will not cause damage to adjacent residences. The studies also provide information on appropriate management measures which should be implemented prior to, and during each blast, to ensure that all statutory limits are adhered to.

The Department of Environment identify that ground vibration impacts are not directly related to a Prescribed Activity as defined within the Environmental Protection Regulations 1987. As such they cannot be regulated through the imposition of Conditions of License.

The EPA is mindful of the concerns raised within submissions about noise and vibration. Whilst the EPA recognises that the proponent has proposed a large number of management actions to minimise the risks posed by operational noise and blasting, the EPA considers that there is a need for full confidence that the impacts of operational noise and blasting will be managed in a way that protects the amenity of the surrounding community.

The EPA considers that the management requirements should be addressed by the requirement for preparation and implementation by the proponent of an “Operational Noise Measurement Programme” as a condition on the Minister’s approval of the proposal. In addition, the EPA considers that the management of ground vibration should be addressed by the requirement for a condition relating to “Vibration” which stipulates limits to be met and monitoring requirements. The EPA’s recommended environmental conditions to achieve the objectives of these recommendations are provided as condition 13 and condition 14 in the Environmental Protection Authority report.

The EPA concludes that the BGC Voyager Quarry can be managed to meet its objectives for Operational Noise and Ground Vibration environmental factors providing that:

- a condition is imposed requiring the proponent to prepare and implement an Operational Noise Measurement Programme; and that
- a condition is imposed requiring the proponent to meet specific ground-vibration levels associated with blasting and incorporating monitoring requirements for vibration.

### 1.3 Ministerial Statement 706

On 16 December 2005 the Minister for the Environment published a “Statement That a Proposal May Be Implemented (Pursuant to the Provisions of the Environmental Protection Act 1986)”. (Ministerial Statement 706). Conditions 16, 17 and 18 of this document are relevant to the Blast and Vibration Measurement Plan.

Condition 16 refers to operational noise and states:

16-1 Prior to any excavation works below five metres depth from the surface, the proponent shall prepare an Operational Noise Management Programme to ensure that all noise from the quarry is measured in accordance with Part 3 of the Environmental Protection (Noise) Regulations 1997.
16-2 The proponent shall implement the Operational Noise Measurement Programme required by condition 16-1 and any subsequent updates as required by condition 16-3.

16-3 The proponent shall review and update the Operational Noise Programme required by condition 16-1 annually.

16-4 The proponent shall utilise that form of safety alarm on items of equipment which produces the least noise whilst complying with all statutory requirements, particularly safety requirements.

16-5 The proponent shall report any exceedances of the Environmental Protection (Noise) Regulations 1997, aside from those that meet the requirements of condition 15-6, to the Department of Environment within 24 hours of exceedances being recorded.

16-6 Upon identifying any exceedances of the Environmental Protection (Noise) Regulations 1997, aside from those that meet the requirements of condition 15-6, the proponent shall provide a report, within seven days of exceedances being recorded, to the Department of Environment on the source/reason for the exceedance, remedial actions undertaken or intended to prevent further such exceedances.

16-7 The proponent shall make the Noise Measurement Programme required by condition 16-1 publicly available.

Condition 17 refers to ground vibration and states:

17-1 The proponent shall measure for each blast, the peak particle velocity (in millimetres per second) in the ground at a measurement point on two or more “Sensitive Sites”, to the requirements of the Minister for the Environment (See Note 1 below).

Measurement of Ground Vibration Levels shall be undertaken at points which are at a distance of at least the longest dimension of the foundation of a building or structure away from the building or structure, and between that building or structure and the blasting site.

17-2 The proponent shall ensure that the ground vibration generated by any blast does not exceed 10 millimetres per second peak particle velocity at any sensitive premises.

17-3 The proponent shall ensure that not more than one blast in any ten consecutive blasts (regardless of the interval between each blast) does not exceed 5 millimetres per second peak particle velocity at any sensitive premises.

17-4 In the event that ground vibration levels in excess of the levels referred to in conditions 17-2 or 17-3 are recorded, the proponent shall notify the Department of Environment within six hours of the exceedance being recorded.

17-5 Within seven days following the levels referred to in conditions 17-2 or 17-3 being recorded, the proponent shall submit a report to the Department of Environment outlining the reasons for the levels being exceeded, and what steps are proposed to prevent recurrence.

Notes:

1. A “Sensitive Site” is defined as including any land within 10 metres of a residence, hospital, school or other premises in which people could reasonably be expected to be free from undue annoyance and nuisance caused by blasting.

2. The transducer is to be attached to the surface in accordance with AS2187.2.

3. “Peak Particle Velocity” is the instantaneous sum of the velocity vectors (measured in millimetres per second) of the ground movement caused by the passage of vibration from blasting.
Condition 18 requires that BGC Quarries develop a Blast and Vibration Management Plan, and states:

18-1 Prior to clearing the vegetation or excavation of soil or rock, whichever is the sooner, the proponent shall prepare a Blast and Vibration Management Plan to the requirements of the Minister for the Environment.

The objective of this Plan is to manage blasting activities to prevent unacceptable impacts on the amenity of nearby residents.

The Plan shall:

1. detail blast management and monitoring procedures at the quarry; and
2. identify communication procedures with local residents with respect to blasting

18-2 The proponent shall implement the Blast and Vibration Management Plan required by condition 18-1 and any subsequent updates as required by condition 18-3.

18-3 The proponent shall review and update the Blast and Vibration Management Plan required by condition 18-1 annually to include the outcomes of consultation with the owners and residents of land surrounding the project area.

18-4 The proponent shall make the Blast and Vibration Management Plan required by condition 18-1 publicly available.

1.4 Legal Framework

The proposal for the relocation of the Voyager Quarry was assessed under Part IV of the Environmental Protection Act 1986. In addition to Ministerial approval of the proposal (Statement 706), BGC Quarries is required to comply with a range of statutory requirements. Legislation that relates to the aspects of Condition 17 and 18 is summarised in Table 2. Local legislation and other documents that are of relevance to blasting at the proposed BGC Voyager Quarry extension are summarised in Table 3 and Table 4.
<table>
<thead>
<tr>
<th>Title</th>
<th>Applicability</th>
</tr>
</thead>
</table>
| Explosives and Dangerous Goods (Explosives) Regulations 1963        | Part VI — Storage and keeping of explosives  
Part X — Use of explosives                                                                                                                  |
| Explosives and Dangerous Goods Act 1961                               | Division 6 — Use of explosives  
Section 34 Use of explosives restricted  
Section 35 Conditions under which use prohibited                             |
| Mines Safety and Inspection Act 1994                                 | Part 2 — General duties relating to occupational safety and health  
Division 2 — General duties  
Section 11 Reporting of dangerous situations or occurrences  
Part 3 — Administration of Act  
Division 2 — Inspections  
Section 21 Powers of inspectors  
Part 10 — Final provisions  
Section 104 Power to make regulations                                    |
| Mines Safety and Inspection Regulations 1995                         | Part 8 — Explosives  
Regulation 8.12. Users of explosives or blasting agents must be Competent  
Regulation 8.26. Firing warnings — surface mining operations  
Regulation 8.28. Firing times — surface mining operations  
Regulation 8.30. Fly rock surface mining operations                      |
| Mining Act 1978                                                      | Part 1 - Preliminary  
Section 6. Operation of this Act: To be be read and construed subject to the Environmental Protection Act 1986.  
Part IV — Mining tenements  
Division 3 — Mining lease  
Section 78. Term of leases, options and renewals  
Section 79. Approval of application  
Section 82. Covenants and conditions of lease                            |
| Mining Regulations 1981                                              | Part IIA — Permits under section 20A  
Regulation 4F. Permit conditions                                         |
| Environmental Protection Act 1986                                    | Ministerial Statement 706 was issued under Part IV of the Act. Section 44 of the Environmental Protection Act 1986 requires the EPA to report to the Minister for the Environment on the environmental factors relevant to the project and on the conditions and procedures to which the proposal should be subject, if implemented. In addition, the EPA may make recommendations as it sees fit. BGC is required to apply for a Works Approval and Licence. |
| Environmental Protection (Noise) Regulations 1997                   | Part 2 — Allowable noise emissions: Regulation 11 Airblast levels due to blasting  
Part 2 — Allowable noise emissions: Regulation 17 Where standard can not be reasonably met.  
Part 3 – Noise measurement: Regulation 21 Measurement of airblast levels  
Schedule 4 Rules for Sound Measuring Equipment. 5 Instrument used for measurement of airblast levels |
Table 3: Local Legislation - Requirements

<table>
<thead>
<tr>
<th>Aspect</th>
<th>Title</th>
<th>Applicability</th>
</tr>
</thead>
<tbody>
<tr>
<td>Local Legislation</td>
<td>Local Government Act 1995</td>
<td>Gives a local government the authority to develop local planning schemes under the Planning and Development Act 2005.</td>
</tr>
</tbody>
</table>

Table 4: Other Relevant Documents

<table>
<thead>
<tr>
<th>Aspect</th>
<th>Title</th>
<th>Applicability</th>
</tr>
</thead>
<tbody>
<tr>
<td>Department of Environment &amp; Conservation (DEC)</td>
<td>Draft Guideline: Preparing Environmental Management Plans</td>
<td>This document has been prepared in compliance with the draft document.</td>
</tr>
<tr>
<td>Explosives—Storage and use</td>
<td>AS 2187.2—2006 Explosives—Storage and use Part 2: Use of explosives</td>
<td>Provides information with respect to blasting and blast monitoring.</td>
</tr>
<tr>
<td>Geotechnical</td>
<td>Geotechnical Considerations In Open Pit Mines Guideline, Department of Minerals and Energy</td>
<td>Provides some guidance with respect to the implementation of Mines Safety and Inspection Regulations 1995 in the context of blasting.</td>
</tr>
<tr>
<td>Local Planning</td>
<td>Shire Of Northam Town Planning Scheme No.3 District Zoning Scheme Version 1, O’Brien Planning Consultants, M J Lundstrom Pty Ltd &amp; Planning Enterprises. Original Town Planning Scheme Gazetted Date: 20 May 2005</td>
<td>Describes Local Planning Strategy and requires Environmental conditions to be incorporated into a Scheme or an amendment to a Scheme following assessment under the Environmental Protection Act 1986.</td>
</tr>
</tbody>
</table>

1.5 BGC Quarries Consolidated Commitments

BGC Quarries commitments with respect to blasting issues are stated in the PER document. The commitments applicable to the Blast and Vibration Management Plan are summarised as bullet points below:

- BGC will undertake building surveys of the nearest residences prior to the commencement of the proposed operations to provide a baseline against which claims of damage due to ground vibration can be evaluated. A copy of the results will be provided to the relevant residents.

- The Airblast and Ground Vibration Management Plan will be finalised with consideration of comments received during the public review period of the PER and in consultation with relevant stakeholders. The Proponent will implement the Airblast and Ground Vibration Management Plan during the construction and operational phases of the Project.

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BGC will monitor every blast over a 12-month period by videotaping each blast. The tapes will be reviewed to determine if flyrock is being contained within the site boundaries.

2 Current Status

**Department of Environment Guideline:** A brief description of the project, the nature of the receiving environment as relevant to the issue to be managed (eg. regional and specific conservation values of natural areas such as wetlands or remnant bush land; existing water quality; existing noise levels) and other relevant information, for example, references to relevant legislation, policies, approvals and their implications for the project.

2.1 Description of the Project

BGC currently operates a quarry at The Lakes. This site is approximately 16 kilometres east of the Town of Mundaring and 47 kilometres southwest of the Town of Northam on the Great Southern Highway, Western Australia.

The Voyager Quarry has been operating since 1990 to provide crushed granite for a variety of uses, including concrete, road base and building products. The current quarry comprises an open pit, a crushing plant, noise attenuation bunds, product stockpiles, a water supply dam, a workshop, fuel storage facilities, office facilities, amenities and a weighbridge. The operation has a nominal rated throughput of approximately 900,000 tonnes per annum (tpa). The existing quarry has less than 5 years of commercially winnable resources remaining, and in order to maintain supplies of the resource, needs to expand or relocate. An extensive review of possible locations for the relocated quarry was undertaken by the BGC, which determined that the nearest and most viable resource is situated on land located immediately to the west of the existing quarry in uncleared land on Lot 14 Horton Road.

The proposal is to undertake the development and operation of the Voyages Quarry in The Lakes, covering an area of approximately 85 hectares in the Shire of Northam (see Figure 2). This proposal is also essentially a relocation to the west of the proponent's quarry at The Lakes, located on Great Southern Highway, to Lot 14 Horton Road (Avon Location 1881).

The proposal will involve development and operation of a quarry incorporating excavation of approximately 16 million tonnes of hard rock, approximately 2 million tonnes of gravel and approximately 12 million tonnes of clay from the quarry footprint. This will allow for approximately 60 million tonnes of granite to be excavated from the site over a 50 year period. The quarry footprint itself covers an area of approximately 59 hectares.

Conventional drilling and blasting, loading and hauling, crushing and screening methods will be employed.

It is expected that the projects development will occur in six (6) stages over the life of the mine, with stage 1 and 2 being initially developed to provide room for the new below-ground level facilities and infrastructure. Subsequent stages will then be developed as the need to access granite resources arises. The staged approach will ensure that excavation of the topsoil and subsoil (gravel and clay) will only occur on five occasions during the life of the mine, thereby minimising the impacts of clearing at any one time. All infrastructure, crushing and screening plants and stockpiles will be housed below ground level, and the site will be surrounded by a buffer of trees and vegetation.
The key characteristics of the proposal are listed in Table 5.

Table 5: Key Proposed Characteristics (Assessment No. 1413)

<table>
<thead>
<tr>
<th>Element</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type of Project</td>
<td>Hard rock quarry</td>
</tr>
<tr>
<td>Project Life</td>
<td>Approximately 50 years</td>
</tr>
<tr>
<td>Rate of Extraction</td>
<td>6,000 to 10,000 tonnes per day</td>
</tr>
<tr>
<td>Extraction Method</td>
<td>Conventional drilling, blasting, loading and hauling techniques</td>
</tr>
<tr>
<td>Location of Crushing and Screening Operations</td>
<td>Within the quarry pit, approximately 30m below the ground surface</td>
</tr>
<tr>
<td>Crushing and Screening Equipment</td>
<td>New equipment to be utilised on site, incorporating improved pollution controls. Primary crusher will be housed within a noise reduction structure.</td>
</tr>
<tr>
<td>Final Quarry Dimensions</td>
<td>Length approximately 900m, Width approximately 450m, Depth approximately 50m</td>
</tr>
<tr>
<td>Footprint of Quarry pit</td>
<td>Approximately 59 hectares</td>
</tr>
<tr>
<td>Footprint of all Disturbances</td>
<td>Approximately 85 hectares</td>
</tr>
<tr>
<td>Quarry Operating Hours</td>
<td>0700 hours to 1900 hours during land clearing and excavation activities on any day which is not a Saturday, Sunday or Public Holiday</td>
</tr>
<tr>
<td></td>
<td>Normal Operating times</td>
</tr>
<tr>
<td></td>
<td>0700 hours to 1900 hours Monday to Friday</td>
</tr>
<tr>
<td></td>
<td>0700 hours to 1330 hours Saturday</td>
</tr>
<tr>
<td></td>
<td>Note no quarrying activities will be carried out on Sundays, public holidays or outside the permitted hours of operation as outlined above.</td>
</tr>
<tr>
<td>Major Components</td>
<td>Quarry, Product Stockpiles, Water Storage Dam, Infrastructure (including processing plant, administration buildings, workshop and roads)</td>
</tr>
<tr>
<td>Water Storage Dam Capacity</td>
<td>150,000 kilolitres (kL)</td>
</tr>
<tr>
<td>Water Supply Source</td>
<td>Surface runoff and groundwater seepage</td>
</tr>
<tr>
<td>Average Daily Water Requirements</td>
<td>Summer – Approximately 780 kilolitres</td>
</tr>
<tr>
<td></td>
<td>Winter – Approximately 380 kilolitres</td>
</tr>
<tr>
<td>Maximum Annual Water Requirements</td>
<td>Approximately 95,000 kL</td>
</tr>
<tr>
<td>Anticipated Quarry Yield</td>
<td>Gravel 1 to 2 million tonnes, Clay 12 million tonnes approximately, Hard rock 60 million tonnes approximately</td>
</tr>
<tr>
<td>Offsets Package</td>
<td>The covenanting of approximately 120 hectares of native vegetation in good condition, held as freehold by the proponent, including rehabilitation of the areas of native vegetation on the freehold land outside the proposed operational footprint, previously cleared by the proponent.</td>
</tr>
<tr>
<td></td>
<td>Provision of not less than 15 kilometres of fencing to protect remnant vegetation on land managed by the Department of Justice.</td>
</tr>
<tr>
<td></td>
<td>Rehabilitation of approximately 60 hectares of gravel pits and other degraded lands.</td>
</tr>
</tbody>
</table>
Figure 2: Layout of Existing and Proposed Operations (after URS\(^5\))

2.2 Receiving environment

The BGC Voyager Quarry is situated within an area zoned as “Extractive” by the Shire of Northam. Land surrounding the Voyager Quarry is zoned as “Agricultural”. The closest structure outside of the property owned by BGC Quarries is a residential structure on Lot 5 Horton Road. This is a 2 storey rammed earth structure, and it is approximately 560m from the proposed quarry extension.

2.3 Current Blast Practices

The BGC Voyager Quarry has a drill and blast manual that is periodically updated to take account of legislation, Codes of Practice, site conditions, contractual requirements and site specific experience. This manual provides a set of procedures for the safe handling of explosives at the site, and also guidance with respect to blast designs that have been proven appropriate to meet the quarry objectives.

To effectively manage the drill and blast process, BGC Quarries utilises separate specialist and experienced contractors to:

1. Carryout blast design, implement blast designs and monitor blasts, and;
2. Drill blast holes to a designed pattern.

These contractors are appointed under a formal contract to optimise the drill and blast operations and to ensure that compliance criteria are met. Under the contractual arrangements the Quarry Manager has approved a designated individual as the shotfirer. The shotfirer is appropriately trained and certified, and is responsible for the drill and blast processes.

Typical blast design parameters that are currently (as at August 2006) used at the BGC Voyager Quarry are summarised in Table 6.

<table>
<thead>
<tr>
<th>Property</th>
<th>Typical Parameter</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bench Height (m)</td>
<td>15</td>
</tr>
<tr>
<td>Typical Number of Rows</td>
<td>5</td>
</tr>
<tr>
<td>Total number blastholes</td>
<td>65</td>
</tr>
<tr>
<td>Burden (m)</td>
<td>3 to 3.3 Currently 3.4 Front row min 2.3</td>
</tr>
<tr>
<td>Spacing (m)</td>
<td>3.6</td>
</tr>
<tr>
<td>Front Row Burden (m)</td>
<td>3.4</td>
</tr>
<tr>
<td>Production Hole Diameter (mm)</td>
<td>102</td>
</tr>
<tr>
<td>Back Row Hole Diameter (mm)</td>
<td>89</td>
</tr>
<tr>
<td>Stemming Length (m)</td>
<td>2.5</td>
</tr>
<tr>
<td>Sub-drill (m)</td>
<td>1</td>
</tr>
<tr>
<td>Explosive Type</td>
<td>Most commonly Supawet Emulsion Density 1.2</td>
</tr>
<tr>
<td></td>
<td>ANFO used in exceptional circumstances 65mm Buster</td>
</tr>
<tr>
<td>Maximum Instantaneous Charge Weight (kg)</td>
<td>130 to 150</td>
</tr>
<tr>
<td>Initiation</td>
<td>Most commonly (95%) Ikon™ Excel when conditions warrant.</td>
</tr>
</tbody>
</table>
Specially prepared stemming material is used by BGC Voyager Quarry. Site specific blast trials and past experience has shown that a blended crusher run comprised of a 10/7mm aggregate mix (50:50) is optimum to contain the energy of the blast and minimise the potential for flyrock.

As a part of the blasting procedures quarry personnel are required to advise local residents prior to a blast to confirm the intended blast schedule. Residents and other interested parties are advised either by telephone or email, and the preferred method of communication is defined by the party in question.

BGC Voyager Quarry generally plans to fire shots at 15h00 on Mondays, and only one shot per week is normally planned. The planned time for blasts has been adopted following consultation with the local residents in order to minimise inconvenience and also to optimise safety aspects. Blasts are only fired at other times when unforeseen circumstances, usually issues to do with safety or weather conditions, dictate that this is required.

Where weather conditions are determined to be unfavourable a blast may be delayed to the next day. Unfavourable weather conditions may include low cloud cover, temperature inversion or wind direction towards sensitive structure of concern. Where a shot is allowed to sleep the blast area is secured. Blast patterns may sleep from Monday through to Friday to allow for weather conditions not being optimum to minimise disturbance. For safety reasons BGC have adopted a practice whereby shots may not sleep over a weekend on account of only weather conditions.

2.3.1 Current Permit Requirements

The EPA have an objective to “Protect the amenity of nearby residence from noise, airblast overpressure and vibration impacts resulting from activities associated with the quarry by ensuring that noise and vibration levels meet statutory requirements and acceptable standards”. To conform with the objective stated above there is a requirement for the BGC Voyager Quarry to comply with the DoE Works Approval and Licence Conditions.

The current DoE Licence requires that ground vibration Peak Particle Velocity (PPV) does not exceed 10mm/sec for any single blast. The nominated ground vibration limits at affected residences are:

- PPV of 5mm/sec for a single blast, and;
- Not more than one blast in ten consecutive blasts may cause a disturbance with a PPV of greater than 5mm/sec.

In the case of air overpressure, the Voyager Quarry is required to comply with the Environment Protection (Noise) Regulations 1997. This regulation specifies that for blasts between 07h00 and 18h00 on any day other than a Sunday or Public Holiday the airblast must not exceed:

- 125 dBL for any blast, and;
- 120 dBL for nine in any ten consecutive blasts regardless of the interval between them.

Historical blast practices have resulted in compliance with respect to both blast induced vibration and air overpressure. The maximum ground vibration (from available records since 1999) that has been recorded adjacent to the nearest residential structure (Lot 5, Horton Road, The Lakes) is 4.6mm/sec (blast number 473, 9 July 2003, recorded MIC 300 kg). The maximum recorded air overpressure at the same location is 121.6 dBL (Blast Number 489, 23 December 2003, recorded MIC 385 kg). The maximum recorded air over pressure over the life of the quarry is 126 dBL (December 1998), and this was attributed to extenuating circumstances (external training course).
2.4 Current Blast Monitoring

A condition survey of residential properties was carried out by McDowall Affleck Pty Ltd between 23 and 25 January 2003 (McDowall Affleck Pty Ltd, January 2003). A summary of the interpreted results of the inspections is given in Table 7. From this summary it can be seen that cracking, that is not attributed to blasting, was observed at all residences.

Table 7: Interpreted Condition Survey Results

<table>
<thead>
<tr>
<th>Address</th>
<th>Date of Inspection</th>
<th>Type of Structure</th>
<th>Cracking Observed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lot 3 Cable St.</td>
<td>23/01/2003</td>
<td>Steel and timber framed structure with concrete slab and external concrete structures. Extensions observed.</td>
<td>Yes in old structure and external concrete structures.</td>
</tr>
<tr>
<td>Lot 6 Gt Eastern Hwy.</td>
<td>23/01/2003</td>
<td>Double brick.</td>
<td>Yes</td>
</tr>
<tr>
<td>Wariin Rd</td>
<td>23/01/2003</td>
<td>Brick veneer.</td>
<td>Yes</td>
</tr>
<tr>
<td>200 Carter Rd</td>
<td>23/01/2003</td>
<td>Double brick with framed second storey.</td>
<td>Yes</td>
</tr>
<tr>
<td>Carter Rd</td>
<td>23/01/2003</td>
<td>Double brick.</td>
<td>Yes</td>
</tr>
<tr>
<td>Lot 5 Horton Rd</td>
<td>23/01/2003</td>
<td>Rammed earth. 2 storey.</td>
<td>Yes</td>
</tr>
<tr>
<td>C/O Cable St &amp; Gt Eastern Hwy.</td>
<td>24/01/2003</td>
<td>Masonry residence and ancillary structures.</td>
<td>Yes</td>
</tr>
<tr>
<td>Lot 5 Gt Eastern Hwy.</td>
<td>24/01/2003</td>
<td>Brick with sheet metal roof, water tanks and shed.</td>
<td>Yes</td>
</tr>
<tr>
<td>Gt. Eastern Hwy.</td>
<td>24/01/2003</td>
<td>Not known.</td>
<td>Yes</td>
</tr>
<tr>
<td>Lot 4 Horton Rd.</td>
<td>24/01/2003</td>
<td>Framed Construction, and concrete tank.</td>
<td>Yes</td>
</tr>
<tr>
<td>Lot 1 Cable St.</td>
<td>24/01/2003</td>
<td>Not known.</td>
<td>Yes</td>
</tr>
<tr>
<td>Lot 6 Cable St.</td>
<td>24/01/2003</td>
<td>Timber framed house on stumps.</td>
<td>Yes</td>
</tr>
<tr>
<td>284 Wariin Rd.</td>
<td>24/01/2003</td>
<td>Brick/tile.</td>
<td>Yes</td>
</tr>
<tr>
<td>Chinganning Rd.</td>
<td>24/01/2003</td>
<td>2 houses and water tanks.</td>
<td>Yes</td>
</tr>
<tr>
<td>Lot 7 Cable St.</td>
<td>25/01/2003</td>
<td>Brick</td>
<td>Yes</td>
</tr>
</tbody>
</table>

Vibration and air overpressure are monitored for all blasts that are fired at the Voyager Quarry. Prior to December 2003 vibration and air overpressure monitoring was carried out by an independent consulting firm (ABT Engineering Pty Ltd) that was appointed by BGC Voyager Quarry. Post December 2003, blast vibration monitoring has been carried out by a specialist blasting contractor appointed and managed by BGC Quarries.

As a part of the blasting procedures quarry personnel notify local residents prior to a blast, to advise them that a blast has been scheduled. BGC Voyager Quarry has modified their practice in so far as is practical to conform to the request of the local residents. Currently, interested parties are notified either by email or telephone in accordance with the interested parties preferred method of communication. BGC maintains a register of people to contact prior to a blast.
2.4.1 Monitor Location

Vibration and air overpressure monitoring has been carried out at a site near to the residence at Lot 5 Horton Road (closest residence) and also at a site closer to the quarry as a control measure and at the initiative of BGC Voyager Quarry management. The monitoring positions have been permanently established at both locations. Monitoring locations may be outside of the boundary of the Voyager Quarry. For this reason, the monitors are set up immediately prior to a blast and removed immediately after the blast.

At both of the monitoring stations described above a triaxial vibration sensor is mounted by way of two bolts on top of a concrete pad that is between about 200 and 400mm diameter, and extends into the ground for up to about 1 metre. The surface of the concrete pad is flush with the ground surface. The concrete column was formed using a rapid set concrete and it has an estimated strength of about 15 MPa. Typically, the concrete column to which the triaxial vibration monitoring transducer is attached can be expected have a mass of approximately 170kg. A typical vibration transducer mounting pad is shown in Figure 3. The orientation of the axis of individual geophones that make up the triaxial sensor are constant for all blast measurements.

![Figure 3: Vibration Monitoring Pad Near Lot 5 Horton Road](image)

Blast induced air overpressure is monitored at the same locations as vibration. The sensor used to monitor airblast is tripod mounted, and located at approximately 1.2m above the ground.

2.4.2 Monitoring Equipment

Blast vibration and air overpressure are monitored using instrumentation that is in compliance with the specifications listed in Australian Standard, *AS 2187.2—2006 Explosives—Storage and use Part 2: Use of explosives*. This instrumentation is owned and operated by the specialist experienced blast contractor under contract to BGC Quarries. It is calibrated annually.

The vibration monitor is triggered by a preset vibration threshold. Trigger thresholds are selected on a blast by blast basis to take account of the location of the monitor relative to the blast, background noise and the blast design. Monitor sampling frequency is set at 500Hz, and the sample duration may be adjusted to account for the location of the blast relative to that of the monitor (in order to capture the entire blast induced vibration waveform).

Monitoring results are saved to instrument memory at the time that the monitor is triggered. Immediately after the blast the monitored data is used to generate a report of the blast. An example report is shown in Figure 4.
Figure 4: Typical Blast Monitoring Report for BGC Voyager Quarry
3 Potential Impacts

*Department of Environment Guideline:*
Provide an outline of project components that are the source of the potential environmental impact, and the nature of the flowpath and potential impact on the receiving environment. This section should also identify any circumstances where the predicted impacts are significantly different from those identified in the environmental review documents assessed by the EPA.

During 2004 BGC commissioned an assessment of blast impact\(^6\). This document reviewed available monitoring records and presented a discussion on the potential for blast induced (vibration and air overpressure) damage to structures. A summary of these discussions is given below.

### 3.1 Blast Vibration

Ministerial Condition 706:M17 requires that:

- Ground vibration generated by any blast does not exceed 10 millimetres per second peak particle velocity at any sensitive premises.
- Not more than one blast in any ten consecutive blasts (regardless of the interval between each blast does not exceed 5 millimetres per second peak particle velocity at any sensitive premises.

Vibration limits are commonly imposed on blasting operations conducted in proximity to structures, including residential housing, historical sites, etc., based on the condition of the structure. Vibration limits imposed on structures attempt to account for personal comfort, cosmetic damage, and structural damage. If the human response factor is removed, then substantially higher vibration limits can be imposed while still providing a high factor of safety over the integrity of a structure.

There is, as recognised by Head and Jardine\(^7\), a considerable difference in opinion as to what constitutes blast vibration damage thresholds as is illustrated in Figure 5 (after Theissen and Wood\(^8\)). Figure 5 shows that the lowest blast induced vibration that has been attributed to damage (in common residential type structures) is about 100mm/sec to induce cracking. At the Voyager Quarry the objective is to limit vibration to 5mm/sec (i.e. only 5% of the minimum that is attributed to damage).

It is important to note that the units of vibration are in terms of velocity and not displacement. PPV can be converted to a displacement by integration of the vibration waveform that approximates a sinusoidal wave. For a blast event with a frequency that is typical of a quarry blast, a PPV of 5mm/sec could be expected to equate to a displacement of approximately 3.9 μm (0.0039mm). This is very small, and judged as highly unlikely to cause damage to a residential type structure.

Blast vibration will induce strain. To understand the potential impact of blast induced vibration it is useful to compare the equivalent stresses induced in a structure by everyday environmental changes to those induced by blast vibration, as shown in Figure 6 (modified after Stagg et al\(^9\)).

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Figure 5: Observed and Anticipated Blast Vibration Damage Thresholds

Figure 6: Environmental Stresses and Equivalent Peak Particle Velocity

From Figure 6 it can be seen that environmental changes that are quite acceptable, and expected to occur within daily (or even more frequent) cycles, induce greater stress in a structure than does blast induced vibration at commonly accepted limits or the limits to which the Voyager Quarry is striving to achieve.

The recommended *Australian Standard AS2187.2-2006* blast vibration limits to prevent cosmetic damage to structures is summarized in Table 8. The expected maximum blast induced vibration levels at residential properties adjacent to the BGC Voyager Quarry are substantially lower than the recommended maximum limits to prevent damage to a structure given in Table 8.
### Table 8: AS2187.2-2006 Ground Vibration Limits for Cosmetic Damage

<table>
<thead>
<tr>
<th>Category</th>
<th>Type of blasting operations</th>
<th>Peak component particle velocity (mm/s)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>4-15Hz</td>
</tr>
<tr>
<td>Other structures or architectural elements that include masonry, plaster and plasterboard in their construction</td>
<td>All blasting</td>
<td>Type of Building</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Unreinforced or light framed structure. Residential or light commercial type buildings</td>
</tr>
<tr>
<td>Unoccupied structures of reinforced concrete or steel construction</td>
<td>All blasting</td>
<td>100 mm/s maximum unless agreement is reached with the owner that a higher limit may apply</td>
</tr>
<tr>
<td>Service structures, such as pipelines, powerlines and cables</td>
<td>All blasting</td>
<td>Limit to be determined by structural design methodology</td>
</tr>
</tbody>
</table>

Compliance with legislative limits or Standards does not necessarily ensure residents will not perceive the vibration from quarry activities. Humans are very sensitive to vibration. They are, however, poorly equipped to distinguish between different intensity or disturbance. Human perception, and hence personal amenity, is difficult to precisely define in view of the fact that a person's perception and response will vary according to the nature of vibration (duration, amplitude, frequency, and frequency of occurrence), health, state of mind, temperament, and physical attitude of individuals. Consequently, vibration or overpressure on one occasion may be acceptable to a nearby person, although a disturbance at a similar level on another day may be classified as offensive by the same individual. Experience gained from the environmental monitoring of blasting activities has shown that when ground vibration routinely exceeds the threshold of perception (around 1 mm/s), the possibility of complaints arises. Given that short duration vibrations of less than 1 mm/s are generally considered imperceptible, complaints under these circumstances are more commonly related to alternative sources of annoyance, such as overpressure or noise.

The recommended Australian Standard AS2187.2-2006 blast vibration limits for human comfort are presented in Table 9. Blast induced vibration limits given in Table 9 are consistent with the limits that are required by Condition 706:M17.
<table>
<thead>
<tr>
<th>Category</th>
<th>Type of blasting operations</th>
<th>Peak component particle velocity (mm/s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sensitive site*</td>
<td>Operations lasting longer than 12 months or more than 20 blasts</td>
<td>5 mm/s for 95% blasts per year 10 mm/s maximum unless agreement is reached with the occupier that a higher limit may apply</td>
</tr>
<tr>
<td>Sensitive site*</td>
<td>Operations lasting for less than 12 months or less than 20 blasts</td>
<td>10 mm/s maximum unless agreement is reached with occupier that a higher limit may apply</td>
</tr>
<tr>
<td>Occupied non-sensitive sites,</td>
<td>All blasting</td>
<td>25 mm/s maximum unless agreement is reached with occupier that a higher limit may apply. For sites containing equipment sensitive to vibration, the vibration should be kept below manufacturer’s specifications or levels that can be shown to adversely affect the equipment operation</td>
</tr>
<tr>
<td>such as factories and commercial premises</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*A sensitive site includes houses and low rise residential buildings, theatres, schools, and other similar buildings occupied by people.

NOTE: The recommendations are intended to be informative and do not override statutory requirements with respect to human comfort limits set by various authorities. They should be read in conjunction with any such statutory requirements and with regard to their respective jurisdictions.

### 3.1.1 Management of Blast Vibration

The principal design method for managing blast induced vibration at the Voyager Quarry is by controlling the maximum instantaneous charge weight (MIC).

During 2004 and 2005 BGC Voyager Quarry monitored a series of blasts to establish site specific vibration attenuation characteristics. The site specific vibration attenuation equation derived from interpretation and analysis of the results of monitoring\(^{10}\) is:

\[
PPV = 473 \times \left[ \frac{D}{\sqrt{Wt}} \right]^{1.367}
\]

Where,

- \(PPV\) = instantaneous resultant of the three orthogonal components of peak particle velocity of ground motion (mm/s)
- \(Wt\) = weight of the explosive per delay (kg)
- \(D\) = distance between blast holes and the locality of receiver (m)
- \(K, n\) = site specific parameters relating to local conditions and strength

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The calculated attenuation of vibration, using the site specific equation given above, is shown graphically in Figure 7. This Figure also shows the attenuation that is predicted using the average attenuation relationship quoted in AS2187.2 (2006). Consideration of this Figure shows that for scaled distances of greater than about 41 (equivalent to a distance of about 500m with a charge weight of 150kg) the site specific vibration equation will predict a slightly greater level of vibration than the equation given in AS2187.2 (2006). The site specific vibration attenuation equation is therefore slightly more conservative (i.e. predicts a greater level of vibration), under the anticipated circumstances, than the average attenuation equation given in AS2187.2 (2006). The closest sensitive structure to blasting will be approximately 560m.

Blast designs are assessed against the site specific vibration attenuation equation (at design stage) to minimise the potential for generating non-compliant blast induced vibration at sensitive sites.

Other issues that are taken into consideration by BGC Voyager Quarry to manage blast induced vibration include:

1. Advising neighbours of the intended blast schedule.
2. Use of appropriate delay intervals.
3. Giving careful consideration to the initiation sequence.
4. Selection of appropriate blast pattern dimensions for the insitu rock mass to be broken.
5. Use of an appropriate explosive and initiation system.
7. Maintaining a complaints register and investigating complaints.

8. Maintaining Blast records.

## 3.2 Blast Overpressure

Regulation 11 of the *Environmental Protection (Noise) Regulations 1997* requires that:

(3) **No airblast level resulting from blasting on any premises or public place, when received at any other premises, may exceed** —

(a) 125 dB L Linear peak between 0700 hours and 1800 hours on Monday to Saturday inclusive; or

(b) 120 dB L Linear peak between 0700 hours and 1800 hours on a Sunday or public holiday.

(4) **Notwithstanding subregulation (3), airblast levels for 9 in any 10 consecutive blasts (regardless of the interval between each blast), when received at any other premises, must not exceed** —

(a) 120 dB L Linear peak between 0700 hours and 1800 hours on Monday to Saturday inclusive; or

(b) 115 dB L Linear peak between 0700 hours and 1800 hours on a Sunday or public holiday.

(5) **No airblast level resulting from blasting on any premises or public place, when received at any other premises, may exceed** —

(a) 90 dB L Linear peak outside the periods between 0700 hours and 1800 hours on any day except where that blasting is carried out in accordance with regulation 8.28(4) of the Mines Safety and Inspection Regulations 1995; or

(b) the levels specified in sub-regulations (3) and (4) outside the periods between 0700 hours and 1800 hours, as appropriate for the time when it was intended that the blast be fired, if the exception in paragraph (a) applies.

At the BGC Voyager Quarry, blasting is carried out only on weekdays between 0700 hours and 1800 hours. Regulations 3a and 4a of the *Environmental Protection (Noise) Regulations 1997* are therefore applicable, and the maximum allowable airblast is limited to 125dBL.

Air overpressure is generated when an explosive is detonated. Air overpressure is made up of energy within a wide range of frequencies both above and below the audible range (±20 Hz). The very low frequency (±5 Hz) component of overpressure can induce vibration in a building. Various researchers, for example Anch\(^\text{11}\), have noted that it is possible for air overpressure to generate higher levels of structural vibration than that caused by ground vibration.

Studies in the USA have addressed the level of overpressure generated by wind. These studies are supported by measured data and indicate that an overpressure level of 115 dBL is generated by a wind with a velocity in the range 11 to 16 km per hour (6 to 9 knots). Overpressure levels in excess of 115 dBL are, therefore, easily and frequently exceeded on a daily basis by natural wind occurrences. This is clearly seen in the results of a study by Holley et. al.\(^\text{12}\) (2001), where air

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overpressure was measured over a 14 day period in an upmarket residential area that was not in the vicinity of any blasting activities or excessive traffic disturbance. In this study (Figure 8) 11% of 6,800 measurements made by the authors exceeded the commonly imposed air overpressure limit of 115dBL for blast generated disturbances. Light winds were observed to be the cause of the overpressure fluctuations.

![Figure 8: Background Air Overpressure (after Holley et.al., 2001)](image)

The USBM (Siskind et.al.\textsuperscript{13}) have carried out extensive studies into the impact of air overpressure, and concluded that a level of 133dBL (measured with a microphone with 2 Hz cut-off) can be regarded as incapable of causing damage (<1% probability of even superficial damage) to the typical residential structures studied. The USBM add that the safe air overpressure levels are still high enough to produce secondary vibration effects (rattling of windows etc.). Complaints about rattling are observed to become more common when air overpressure levels exceed approximately 120dBL. Siskind et al have observed that up to 10% of homes will exhibit rattling once overpressure levels reach 134dBL.

Reasons for limiting air overpressure can be related to concern for structural integrity, concern over human safety, or a concern over human annoyance. It is generally recognised that the potential for overpressure from normal rock blasting activities to inflict structural damage is very limited. It can be stated that the onset of structural damage from air overpressure is the cracking of glass windows. If windows have not cracked, the likelihood of structural damage is extremely remote.

Air overpressure levels less than 115dBL rarely invoke complaints given that these levels are commonly exceeded by naturally occurring events such as wind. The perception of high overpressure levels is generally through the rattling of loosely fitting windows, often giving the misconception to the resident that the building has been subjected to very high levels of ground vibration.

The levels of air overpressure, that are expected to be generated by blast activities at the BGC Voyager Quarry, are extremely unlikely to cause structural damage to adjacent residences that are approximately 560m from the quarry.

### 3.2.1 Management of Blast Induced Air Overpressure

BGC Voyager Quarry manages blast induced air overpressure by:

1. Advising neighbours of the intended blast schedule.

2. Maintaining indigenous vegetation between the Quarry and surrounding areas.

3. Adopting an appropriate stemming design (both material type and stemming height).

4. Adopting an appropriate front row burden.

5. Where possible taking weather conditions (cloud cover, temperature inversions, and wind direction) into account before firing a shot.

6. Monitoring air overpressure at sensitive sites and reviewing the results of monitoring to assess the need for blast design modification.

7. Maintaining a complaints register and investigating complaints.


### 3.3 Flyrock

The EPA Bulletin 1169 has provided advice in relation to flyrock. In Section 3.10.1 the EPA comment that:

> Operations at the current quarry site have raised a number of queries and concerns regarding the management of flyrock from blasting practices. Submissions on the PER suggest that blasting practices at the existing quarry have caused large pieces of flyrock to land more than 100m from the pit, with associated risks to people and animals.

The Department of Industry and Resources has reviewed the PER document, and has suggested that the issues associated with flyrock appear to have been adequately addressed by the proponent and that blasting practices have been substantially modified, with blasts being video-taped to monitor the distances rock is thrown from the blast site. The EPA understands that management of flyrock will be addressed through the provisions of the mine safety legislation, administered by the Department of Industry and Resources, as well as the Local Government Authority’s Extractive Industries Licence.

Extreme flyrock is usually considered to emanate from the collars of blastholes that had received inadequate stemming. Flyrock from this source is considered likely to travel in any direction from the hole. Other sources of potential flyrock include loose debris at the surface of the blast and also debris from the free face. It should be noted that flyrock originating as loose debris or from the free face would have a very low potential of travelling distances as far as 100m from the source.

BGC Quarries incorporate a number of procedures to minimise the risks of flyrock, and to manage the potential for flyrock. These include:

1. **Stemming Material:** Specially prepared crusher run material is used as stemming material. Site specific blast trials and past experience has shown that a blended crusher run comprised of a 10/7 mm aggregate mix (50:50) is optimum for the site conditions. This stemming material has been determined to be effective in containing the gas pressure and energy within the blast.

2. **Stemming Height:** Current blast design practice at the Voyager Quarry aims for a stemming height of 2.5 m (with a minimum of 2.3 m). For the blasthole diameters used at the Voyager Quarry this represents a stemming height that is consistent with a stemming height appropriate for a site that is sensitive to flyrock (Sterner14).

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3. **Blast site preparation:** Prior to implementing the blast design the blast site is properly prepared to minimise the potential for flyrock originating as surface debris.

4. **Survey:** Prior to charging blastholes the free face is profiled and the front row blastholes are surveyed using BoreTrac. This is done to confirm that there is adequate front row burden. If survey identifies an inappropriate front row burden then holes are either re-drilled or the loading schedule is modified to reduce the potential for front row break-out.

5. **Monitoring:** A video record of each blast is made. This record allows the performance of the shot to be analysed. If excessive flyrock is identified then design changes would be made to reduce flyrock potential.

6. **Blast records:** Detailed blast records are made and retained by BGC Voyager Quarry. This will help to keep the blasting experience on site and allow new personnel to access the “corporate memory”.

With the blast design measures (stemming height and material) that are used at the BGC Voyager Quarry there is a extremely low probability that debris could be thrown the maximum theoretical extreme range as shown in Table 10.

<table>
<thead>
<tr>
<th>Hole Diameter (mm)</th>
<th>Theoretical Extreme Flyrock Range (m)</th>
<th>Explanation</th>
</tr>
</thead>
<tbody>
<tr>
<td>102</td>
<td>655</td>
<td>Extreme flyrock is usually considered to originate from the collars of blastholes that had received inadequate stemming. Flyrock from this source could travel in any direction from the hole, and the range estimated from the relationship is considered to represent the maximum flyrock range under worst-case conditions. Basis is statistical.</td>
</tr>
<tr>
<td>89</td>
<td>598</td>
<td></td>
</tr>
</tbody>
</table>

### 4 Environmental Objectives

*Department of Environment Guideline:* A summary of the principal environmental objectives, as described in the Ministerial Statement.

The principal environmental objectives, relevant to blasting activities at the BGC Voyager Quarry, of the Environmental Protection Authority are:

- To protect the amenity of nearby residents from noise impacts resulting from activities associated with the proposal by ensuring the noise levels meet statutory requirements.
- To protect the amenity of nearby residents from vibration impacts resulting from activities associated with the proposal by ensuring the vibration levels meet statutory requirements and acceptable standards.

To ensure that the objectives listed above are achieved the EPA has specified:

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1. Allowable blast induced air overpressure limits.
2. Allowable blast induced vibration threshold limits.
3. That a detailed Blast and Vibration Management Plan is prepared, adopted, and periodically reviewed and updated.
4. That blast monitoring is carried out in a prescribed manner at a minimum of two sensitive locations to demonstrate compliance at sensitive sites.
5. That the Blast and Vibration Monitoring Plan and the results of annual reviews of compliance are made available to the Public.
6. Reporting of monitoring results that are out of compliance.

5 Performance Indicators/Criteria

**Department of Environment Guideline:** The indicators and/or Criteria that will be used to track progress in achieving objectives and targets. These indicators should be specific, objective, achievable, relevant and time-framed, and therefore verifiable and reproducible. Possible indicators and criteria may include ANZECC water quality criteria, site-specific criteria, regulatory standards (eg Noise Regulations), plant density/diversity measures and Australian Standards. Measurable performance criteria are crucial elements of a management plan, allowing the proponent and regulatory bodies, to confirm the effectiveness of management strategies and for proponents to demonstrate compliance with environmental regulation. They are also an important tool for monitoring continuous improvement.

The performance indicators and criteria that will be used to track progress in achieving objectives and targets are summarised in Table 11 and Table 12.

<table>
<thead>
<tr>
<th>Target</th>
<th>Performance Indicator</th>
<th>Criteria</th>
<th>Requirement</th>
<th>Means of Verification</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. PPV&lt;10mm/s at Sensitive Sites</td>
<td>Notification of Blast Schedule</td>
<td>BGC Voyager Quarry Documented Drill and Blast Procedures</td>
<td>All interested parties to be notified prior to each blast. Notification register to be maintained.</td>
<td>Blast Record. Annual Audit conducted by QA/QC Specialist appointed by BGC.</td>
</tr>
<tr>
<td>2. PPV&lt;5mm/s for at least 9 out of 10 blasts at Sensitive Sites</td>
<td>Monitoring</td>
<td>AS2187.2-2006</td>
<td>Record results of monitoring at a minimum of 2 locations for each blast.</td>
<td>Blast monitoring record. Annual Reporting of the monitoring outcomes to EPA. Annual Audit conducted by QA/QC Specialist appointed by BGC.</td>
</tr>
<tr>
<td>3. PPV&lt;10mm/s at Sensitive Sites</td>
<td>Blast Record</td>
<td>BGC Voyager Quarry Documented Drill and Blast Procedures and AS2187.2-2006</td>
<td>Complete blast record to be maintained for each blast. Record to be stored to allow easy access</td>
<td>Annual Audit conducted by QA/QC Specialist appointed by BGC.</td>
</tr>
<tr>
<td>4. PPV&lt;5mm/s for at least 9 out of 10 blasts at Sensitive Sites</td>
<td>Non-compliance</td>
<td>Minister for the Environment Statement Number 000706</td>
<td>Notify the Department of Environment within six hours and submit a report on the incident within 7 days.</td>
<td>Blast monitoring record. Annual Reporting of the monitoring outcomes to EPA. Annual Audit conducted by QA/QC Specialist appointed by BGC.</td>
</tr>
<tr>
<td>5. Complaints register</td>
<td>Complaints register</td>
<td>BGC Voyager Quarry Documented Drill and Blast Procedures</td>
<td>Maintain a register and address complaints in a timely manner.</td>
<td>Blast monitoring record. Annual Reporting of the monitoring outcomes to EPA. Annual Audit conducted by QA/QC Specialist appointed by BGC.</td>
</tr>
</tbody>
</table>
### Table 12: Used To Track Progress In Achieving Blast Overpressure Threshold Limits

<table>
<thead>
<tr>
<th>Target</th>
<th>Performance Indicator</th>
<th>Criteria</th>
<th>Requirement</th>
<th>Means of Verification</th>
</tr>
</thead>
<tbody>
<tr>
<td>Overpressure &lt; 125 dB L at Sensitive Sites</td>
<td>Notification of Blast Schedule</td>
<td>BGC Voyager Quarry Documented Drill and Blast Procedures</td>
<td>All interested parties to be notified prior to each blast. Notification register to be maintained.</td>
<td>Blast Record. Annual Audit conducted by QA/QC Specialist appointed by BGC.</td>
</tr>
<tr>
<td>Overpressure &lt; 120 dB L at Sensitive Sites</td>
<td>Monitoring</td>
<td>Environmental Protection (Noise) Regulations 1997</td>
<td>Record results of monitoring at a minimum of 2 locations for each blast.</td>
<td>Blast monitoring record. Annual Audit conducted by QA/QC Specialist appointed by BGC.</td>
</tr>
<tr>
<td></td>
<td>Blast Record</td>
<td>BGC Voyager Quarry Documented Drill and Blast Procedures and AS2187.2-2006</td>
<td>Complete blast record to be maintained for each blast. Record to be stored to allow easy access</td>
<td>Annual Audit conducted by QA/QC Specialist appointed by BGC.</td>
</tr>
<tr>
<td>Non-compliance</td>
<td>Non-compliance</td>
<td>Minister for the Environment Statement Number 000706</td>
<td>Notify the Department of Environment within six hours and submit a report on the incident within 7 days.</td>
<td>Blast monitoring record. Annual Reporting of the monitoring outcomes to EPA. Annual Audit conducted by QA/QC Specialist appointed by BGC.</td>
</tr>
<tr>
<td>Complaints register</td>
<td>Complaints register</td>
<td>BGC Voyager Quarry Documented Drill and Blast Procedures</td>
<td>Maintain a register and address complaints in a timely manner.</td>
<td>Blast monitoring record. Annual Reporting of the monitoring outcomes to EPA. Annual Audit conducted by QA/QC Specialist appointed by BGC.</td>
</tr>
</tbody>
</table>

### 6 Implementation strategy

**Department of Environment Guideline:** Detail the strategies, tasks or action program that will be implemented to achieve the agreed environmental objectives, as they apply to implementation stages of the project. This section should address roles, responsibilities, processes, resources, timeframes and priorities, and provide details on how they relate to the objective. Responsibilities for environmental management roles should be clearly indicated preferably using an organisational chart.

Details of the drill and blast management requirements, responsibilities and procedures are given in Appendix A.

A simplified and schematic organisation chart showing the lines of responsibility for drill and blast at the BGC Voyager Quarry is shown in Figure 9, and the responsibilities as they relate to achieving the environmental objectives are detailed in Table 13. They are also shown schematically (in the context of the cyclical nature of drill and blast) in Figure 10.
**Figure 9: Drill and Blast Organisation Chart**

**Table 13: Drill and Blast Responsibilities to Meet Environmental Objectives**

<table>
<thead>
<tr>
<th>Entity</th>
<th>Environmental Objective</th>
<th>Responsibility to Meet Environmental Objectives</th>
</tr>
</thead>
</table>
| Quarry Manager          | Minimise Blast induced Overpressure and Vibration to as a minimum comply with the stated limits | o Overall Quarry Planning and Scheduling.  
   |                                                                         | o Overall Management of Drill and Blast Processes.  
   |                                                                         | o Appointment of shotfirer with appropriate experience and qualifications.  
   |                                                                         | o Appointment of Specialist Drilling and Blasting Contractors.  
   |                                                                         | o Developing and Maintaining the Blast and Vibration Management Plan.  
   |                                                                         | o Developing and maintaining Voyager Quarry drill and blast procedures.  
   |                                                                         | o Advising interested parties of blast schedule.  
   |                                                                         | o Review of the blast and blast monitoring results.  
   |                                                                         | o Responding to complaints.  
   |                                                                         | o Reporting non compliance to EPA.  |
| Shotfirer               |                                                                                         | o Implementation of drill and blast procedures.  
   |                                                                         | o Implementation of specific blast design.  
   |                                                                         | o Co-ordination of blasthole and free face survey.  
   |                                                                         | o Co-ordination of drilling and blasting contractors.  
   |                                                                         | o Co-ordination of monitoring at a minimum of 2 sensitive sites.  
   |                                                                         | o Maintaining blast records.  
   |                                                                         | o Reporting of monitoring results to Quarry Manager.  
   |                                                                         | o Reporting unsafe or unusual practices to Quarry Manager.  |
| Specialist Blast Contractor |                                                                                       | o Blast design.  
   |                                                                         | o Preparation of blast design records.  
   |                                                                         | o Implementation of blast design.  
   |                                                                         | o Blast survey (face and down-hole).  
   |                                                                         | o QA/QC of blast.  
   |                                                                         | o Supply of appropriate explosives and accessories.  
   |                                                                         | o Loading of blastholes.  
   |                                                                         | o Monitoring (vibration, overpressure, video).  
   |                                                                         | o Maintain and report explosive and accessory usage.  
   |                                                                         | o Provide specialist advice at request of Quarry Manager.  |
| Drilling Contractor     |                                                                                         | o Drill blastholes in accordance with design requirements, and within the required tolerances.  |
7 Monitoring

Department of Environment Guideline: Provide details of the monitoring program that will be used to monitor progress towards the achievement of the objectives or targets. This section should include details on how/when monitoring will be undertaken i.e. relevant equipment, location of monitors, parameters measured, baseline monitoring, frequency of monitoring/inspections, recording of complaints, reporting of results (format/frequency). This section should also detail how monitoring results will be analysed and used to identify both successes and areas requiring correction or improvement. Reference should be made to legislation, guidelines and Australian standards where possible.

7.1 Relevant Equipment

To monitor environmental compliance ground vibration and air overpressure are measured as millimetres per second (mm/s) and dBL respectively.

Blast induced ground vibration and air overpressure monitoring equipment that complies with the recommendations given in AS2187.2 - 2006 will be used by BGC Voyager Quarry to monitor blasts. Blast induced vibration (Peak Particle Velocity in mm/s) will be measured using a standard triaxial
geophone with a frequency bandwidth of 4.5Hz to 500Hz. Blast overpressure will be measured using a linear weighted microphone with a frequency bandwidth of 2 Hz to 500 Hz.

The results of monitoring, including full waveforms generated with a sample frequency of up to 500 Hz, will be stored on the monitor at the time that the event is recorded. Processing of results to produce a monitoring record will be done as soon as practical after the blast.

The triaxial geophone used to monitor ground vibration will be mounted, at ground level, on a preformed concrete pad (formed in the ground) of minimum 30kg.

7.2 Monitoring Frequency

Blast monitoring will be carried out for all blasts. Compliance monitoring will include:

1. Vibration monitoring at a minimum of 2 locations near to sensitive sites.
2. Air overpressure monitoring at a minimum of 2 locations near to sensitive sites (the same sites that vibration is monitored at).
3. A video of the blast.

In addition to the monitoring described above, BGC Voyager Quarry use down-hole survey tools to record the orientation of blastholes, and a laser profiler to record the free face profile of the shot. This monitoring is done as a QA/QC measure and the results of the monitoring may be used to modify the blast design that is currently being implemented.

7.3 Monitoring Locations

Blast vibration and air overpressure will be measured at a minimum of two locations for each blast. Vibration and air overpressure will be measured concurrently using a purpose designed monitor designed to log disturbances generated by a blast.

The approximate intended routine monitoring locations are shown in Figure 11 (Locations D and E). These locations have been selected to monitor potential disturbances near the closest Residence (Residence D) and also to ensure compliance at Residence E (from which there is a history of complaints). Monitor locations are a minimum of the longest foundation length from any structure. They are also located in areas that BGC Quarry personnel have unrestricted access to, and sited between the blast and structure of interest.

An alternative monitoring location (Location C) is also shown in Figure 11. It is intended that monitoring will be carried out at this location (near to Residence C) when blasting is in progress within the northern most area of the proposed pit.

Air overpressure and vibration monitoring stations will be set up in accordance with the requirements of Environmental Protection (Noise) Regulations 1997 and recommendations of AS2187.2 – 2006 for air overpressure and vibration respectively.

A video of each blast will be recorded by the Specialist Blasting Contractor. The purpose of the video will be to allow an assessment of potential flyrock to be made. The video record will be made from a video recorder set up at a location considered to be safe. This will vary from blast to blast.
7.4 Monitoring Results

A vibration and air overpressure monitoring record in the format shown in Figure 4 will be generated for each recorded blast. This format of reporting is consistent with the recommendations given in AS2187.2 – 2006. The following information will be recorded on each monitoring record:

- Time
- Date
- Monitor Location
- Blast No/Id
- Pattern Type
- Pattern Size (m)
- Designed Tonnage
- Bench Height (m)
- Number of Rows
- Number of Holes
- Blasthole Dia. (mm)
- Stemming (m)
- Sub Drill
- Max. Inst. Charge
- Explosive (Type & Weight)
- Delay Type
- Average Interval
- Duration (ms)
- Comments and Observations, including weather conditions [temp, cloud cover %, and wind direction/speed]
- Monitoring conducted by
- Checked by
Monitor Serial Number
Monitor Calibration Date
Peak Vector Sum Velocity (mm/s)
Peak Overpressure (dBL)
Vibration and overpressure traces.

Should the monitor fail to record information (for example if the vibration is insufficient to trigger the instrument) then an explanation will be given on the monitoring record. This would include a statement of trigger levels.

Vibration and air overpressure monitoring results will be communicated to the quarry manager as soon as the report has been prepared (immediately after retrieval of the monitor from the monitoring location). The monitoring results will be actioned as follows:

- **Monitor fails to record:** Quarry Manager notified of result. Specialist Blast Contractor to determine reason for no record, and take this into consideration for subsequent blasts.

- **Recorded Vibration less than 4mm/s and Recorded Blast Overpressure less than 120dBL:** Quarry Manager notified of result. Report is stored with blast record. No further action required.

- **Recorded vibration greater than 4mm/s and less than 5mm/s:** Quarry Manager notified of result. Blast design to be reviewed by Specialist Blast Contractor to determine reason for higher than expected vibration. Results of review to be taken into account, as appropriate, in future designs.

- **Recorded vibration greater than 5mm/s:** Quarry Manager notified of result. Quarry manager to advise EPA of breach of condition within 6 hours. Blast design to be reviewed by Specialist Blast Contractor to determine reason for higher than expected vibration. Quarry Manager to submit report to EPA within 7 days. Results of review to be taken into account, as appropriate, in future designs.

- **Recorded Blast Overpressure greater than 120dBL:** Quarry Manager notified of result. Quarry manager to advise EPA of breach of condition within 24 hours. Blast design to be reviewed by Specialist Blast Contractor to determine reason for higher than expected blast overpressure. Quarry Manager to submit report to EPA within 7 days. Results of review to be taken into account, as appropriate, in future designs.

The video for each blast is to be reviewed by the Specialist Blasting Contractor. If the video shows that there was flyrock then this is to be brought to the attention of the Quarry Manager. A detailed review of the blast design will then be carried out to determine the causes of flyrock. The results of this review will then be incorporated into future blast design and quarry drill and/or blast procedures, as appropriate.

The results of monitoring will form a part of the blast record. The blast record shall be maintained for a minimum of 7 years. Each blast record should include the following information:

- Monitoring results;
- Check form showing BGC Requirements for Post Blast Reports;
- Orica Product Delivery Docket;
- IS Issues Log (Record Issues of Initiating and Packaged Explosives);
- Blast Loading Sheet (with design and actual);
- Blast Summary Data Sheet (plan includes blast layout and initiation design);
- Blast Summary Data Sheet (plan includes hole numbers and tie-in);
7.5 Complaints

Complaints associated with blasting are to be referred to the Quarry Manager. The complaint shall be entered into the complaints register that is maintained by the BGC Voyager Quarry. The quarry Manager will in the first instance refer to the blast record to determine the blast details and monitoring results. If monitoring results indicate that there was a breach of Licensing Condition then the quarry manager will detail the results of the investigation into the cause of the non-conformance, and measures taken to minimise the disturbance, to the complainant. If the monitoring results were in compliance with the licence requirements the Quarry Manager shall advise the complainant of the results of monitoring. In addition, the Quarry Manager shall endeavour to work with the complainant to better understand the cause and reaction. The outcome of the interaction with the complainant will be made known to the Specialist Blasting Contractor and Shotfirer, and where practical and appropriate future blast designs will take the outcomes into consideration.

A record of complaints, including actions taken, will be incorporated into the annual report that is submitted to the EPA.
8 Contingencies

**Department of Environment Guideline:** Describe the triggers and resulting management actions that will be implemented when monitoring indicates actual and/or apparent non-conformance with the EMP.

The triggers and resulting management actions that will be implemented when monitoring indicates actual and/or apparent non-conformance with the EMP are detailed in Table 14.

### Table 14: Triggers and Management Actions

<table>
<thead>
<tr>
<th>Element</th>
<th>Trigger</th>
<th>Management Action</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vibration</td>
<td>Monitoring: 5mm/s&lt;PPV&gt;4mm/s</td>
<td>Quarry Manager to instruct Specialist Blast Contractor to assess causes. Future blast designs to take account as appropriate.</td>
</tr>
<tr>
<td>Vibration</td>
<td>Monitoring: PPV&gt;5mm/s</td>
<td>Quarry Manager to advise EPA within 6 hours. Quarry Manager to instruct Specialist Blast Contractor to assess causes. Quarry Manager to submit report to EPA within 7 days. Future blast designs to take account as appropriate.</td>
</tr>
<tr>
<td>Overpressure</td>
<td>Monitoring: &gt;120dBL</td>
<td>Quarry manager to advise EPA within 24 hours. Blast design to be reviewed by Specialist Blast Contractor to determine reason for higher than expected blast overpressure. Quarry Manager to submit report to EPA within 7 days. Results of review to be taken into account, as appropriate, in future designs.</td>
</tr>
<tr>
<td>Flyrock</td>
<td>Video record shows</td>
<td>A detailed review of the blast design will be carried out to determine the causes of flyrock. The results of this review will then be incorporated into future blast design and quarry drill and/or blast procedures, as appropriate.</td>
</tr>
<tr>
<td>Complaint</td>
<td>Quarry Manager notified of a perceived disturbance</td>
<td>Quarry Manager to enter into Complaints Register, refer to blast design and outcome, respond to complainant, work with complainant to resolve where practical and appropriate.</td>
</tr>
<tr>
<td>Internal Records</td>
<td>Incomplete or No Records</td>
<td>Quarry Manager to review procedures and identify cause for non-compliance. Relevant personnel to be given instruction by the Quarry Manager. For repeated non-conformance personnel are to be disciplined as appropriate by the Quarry Manager.</td>
</tr>
</tbody>
</table>
9 Stakeholder consultation

**Department of Environment Guideline:** Include a list of the major stakeholders (including government agencies) and the evidence that input has been incorporated into the EMP, and describe any on-going liaison that is required with stakeholders during implementation of the EMP.

A list of major stakeholders is included in Table 15.

<table>
<thead>
<tr>
<th>Stakeholder</th>
<th>Type of Input</th>
<th>Date of Input</th>
<th>On-going Liaison</th>
</tr>
</thead>
<tbody>
<tr>
<td>Environmental Protection Authority (EPA)</td>
<td>Review and approval of Management Plans</td>
<td>Annual monitoring Report Report non-compliances.</td>
<td></td>
</tr>
<tr>
<td>Department of Environment &amp; Conservation: Env Regulation Div.</td>
<td></td>
<td>Periodic reporting as required by Operating License (Pt V of EP Act)</td>
<td></td>
</tr>
<tr>
<td>Department of Consumer and Employment Protection</td>
<td>Review of Management Plans</td>
<td>Compliance with occupational safety and health requirements; Dangerous Goods.</td>
<td></td>
</tr>
<tr>
<td>Department of Industry and Resources</td>
<td>As above</td>
<td>Administration of Mines Act.</td>
<td></td>
</tr>
<tr>
<td>Shire of Northam</td>
<td>As Above</td>
<td>As required by Extractive Industry License. As representative of Shire of Northam residents.</td>
<td></td>
</tr>
<tr>
<td>Shire of Mundaring</td>
<td></td>
<td>As representative of Shire of Mundaring residents.</td>
<td></td>
</tr>
<tr>
<td>Community Liaison Group (to include Lakes Action Group representation)</td>
<td>Consultation pursuant to 706:M19 prior to EPA approval of Management Plans</td>
<td>TBC</td>
<td>Ongoing liaison regarding review and revision of management plans</td>
</tr>
</tbody>
</table>
10 Auditing

**Department of Environment Guideline:** Describe how implementation of the EMP will be audited. This should include details on the format, timing and responsibility for auditing (internal and external).

The Voyager Quarry Blast and Vibration Management Plan will be subject to audit as detailed in Table 16

<table>
<thead>
<tr>
<th>Type of Audit</th>
<th>Frequency</th>
<th>Responsibility</th>
</tr>
</thead>
<tbody>
<tr>
<td>Blast</td>
<td>Each Blast</td>
<td>Shotfirer to audit Specialist Blast Contractor – collation of blast information into a blast record that will be retained for 7 years.</td>
</tr>
<tr>
<td>Internal</td>
<td>6 Monthly</td>
<td>Quarry Manager. Audit to be done under instruction of Quarry Manager by a nominated individual. Nominated individual is to be from a department other than drill and blast.</td>
</tr>
<tr>
<td>External</td>
<td>12 Monthly</td>
<td>SAI Global Limited or other nominated specialist audit company. Audit is to be coordinated by the Quarry Manager.</td>
</tr>
</tbody>
</table>
11 Review and Revision

**Department of Environment Guideline:** Detail how the plan will be reviewed to assess its suitability, adequacy and effectiveness in meeting the set objectives? This should include details on the review process, review frequencies and the revision processes. A revision status record should form part of each EMP.

The Voyager Quarry Blast and Vibration Management Plan is a “live” document. As such it is anticipated that from time to time it will be reviewed and updated to incorporate changes to procedures and systems that are implemented in response to lessons learned. It is anticipated that review and registration will be required as outlined below:

1. The Blast and Vibration Management Plan will be reviewed annually, by the Quarry Manager or under the supervision of the Quarry Manager. This review will be undertaken prior to submission of the annual report to the EPD. The annual report to EPD will include comment on the applicability of the current Blast and Vibration Management Plan. If it has been considered necessary to amend the plan a summary of amendments will be provided. The revised Blast and Vibration Management Plan will be made publicly available on the BGC WWW site (http://www.bgc.com.au/).

2. Where significant changes to Blast Practices are implemented at Voyager Quarry, the Blast and Vibration Management Plan will be updated. A copy of the updated plan will be circulated to the key stakeholders for their input, and the approved final version will be made publicly available on the BGC WWW site (http://www.bgc.com.au/). The frequency and timing of changes of this nature can not be defined.

The original approved Blast and Vibration Management Plan is designated REVISION 1. The final page of the Blast and Vibration Management Plan incorporates a revision status that is required to be updated when amendments are made to this document. The format of this status is shown in Table 17. The revision number is also required to be updated on the cover pages, and in the header.

<table>
<thead>
<tr>
<th>Rev No.</th>
<th>Date</th>
<th>Revised By</th>
<th>Revision Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>04/09/2006</td>
<td>SRK Consulting</td>
<td>Original Document</td>
</tr>
<tr>
<td>2</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
12 Reporting

Department of Environment Guideline: The format, timing and responsibility for reporting implementation of the EMP, and any necessary corrective actions: internally, to DoE and other stakeholders. It is expected that performance against EMPs will be reported to DoE in the annual Performance and Compliance Reports. This section must include a reference to the Key Management Actions Table (see below).

The implementation of the Blast and Vibration Management Plan will be reported on annually to the EPA in accordance with the Management Actions Table that is presented in Chapter 13. The report will be submitted as a “Hard Copy” and also electronically as a PDF document. An outline of the Blast and Vibration Management Report is given in Table 18.

<table>
<thead>
<tr>
<th>Chapter</th>
<th>Heading</th>
<th>Typical Content</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Introduction</td>
<td>Description of Project. Description of the current report.</td>
</tr>
<tr>
<td>2</td>
<td>Progress in Reporting Period</td>
<td>Volume of material moved. Number of blasts fired. Type of Monitoring carried out.</td>
</tr>
<tr>
<td>3</td>
<td>Compliance with Licence</td>
<td>Statement of Licence Requirements Number of blasts monitored. Number of blasts recorded. Statement of compliance record to address vibration, overpressure and flyrock. Comparison of status with previous years.</td>
</tr>
<tr>
<td>4</td>
<td>Non-Compliance Reports</td>
<td>State number of reports submitted to EPD. Summary of actions taken as a result.</td>
</tr>
<tr>
<td>5</td>
<td>Complaints</td>
<td>Summary of blast related complaints. Summary of actions</td>
</tr>
<tr>
<td>6</td>
<td>Revision to Blast and Vibration Management Plan</td>
<td>A statement as to the need for revision. Summary of proposed changes if these are proposed.</td>
</tr>
</tbody>
</table>

A copy of the Blast and Vibration Management Plan will be made publicly available. This will be achieved by posting the plan on the BGC Quarries WWW site at http://www.bgc.com.au/.

13 Key Management Actions Table

Department of Environment Guideline: This table should form the basis of annual compliance reporting and all environmental compliance monitoring and/or auditing undertaken by the proponent. The table should summarise the key management actions that will be carried out for the purpose of achieving the environmental objectives, and give an indication of the evidence that will be provided to DoE to demonstrate implementation. Key management actions should include implementation strategies, monitoring programs and contingency actions.

A summary of Key Management Actions is given in Table 19.
### Table 19: Key Management Action Table

<table>
<thead>
<tr>
<th>Ref #</th>
<th>Key Management Action</th>
<th>Target/Objective</th>
<th>DoE Reporting/Evidence</th>
<th>Status</th>
</tr>
</thead>
<tbody>
<tr>
<td>16-1</td>
<td>Ensure that all noise from the quarry is measured</td>
<td>Part 3 of the Environmental Protection (Noise) Regulations 1997. All blasts.</td>
<td>Annual Reporting to EPA. Result of internal and external audits.</td>
<td>Active</td>
</tr>
<tr>
<td>16-2</td>
<td>Implement the Operational Noise Measurement Programme</td>
<td>Environmental Protection (Noise) Regulations 1997</td>
<td>Annual Reporting to EPA. Result of internal and external audits.</td>
<td>Draft</td>
</tr>
<tr>
<td>16-3</td>
<td>Review and update the Operational Noise Programme</td>
<td>Ministerial Statement 706 Condition 16-1</td>
<td>Annual Reporting to EPA.</td>
<td>Draft</td>
</tr>
<tr>
<td>16-5</td>
<td>Report any exceedances of the Environmental Protection (Noise) Regulations 1997</td>
<td>Maximum allowable blast air overpressure 125dBL. Maximum allowable blast air overpressure 120dBL for 9 in any 10 consecutive blasts.</td>
<td>Annual Reporting to EPA. Result of internal and external audits.</td>
<td>N/A</td>
</tr>
<tr>
<td>16-6</td>
<td>Provide a report, within seven days of exceedances being recorded, to the Department of Environment</td>
<td>Ministerial Statement 706 Condition 16-5</td>
<td>Annual Reporting to EPA. Result of internal and external audits.</td>
<td>N/A</td>
</tr>
<tr>
<td>17-1</td>
<td>Measure for each blast, the peak particle velocity (in millimetres per second) in the ground at a measurement point on two or more “Sensitive Sites”</td>
<td>Comply with AS2187.2 - 2006</td>
<td>Annual Reporting to EPA. Result of internal and external audits.</td>
<td>N/A</td>
</tr>
<tr>
<td>17-2</td>
<td>Ensure that the ground vibration generated by any blast does not exceed 10 millimetres per second peak particle velocity at any sensitive premises</td>
<td>Ministerial Statement 706</td>
<td>Annual Reporting to EPA. Result of internal and external audits.</td>
<td>N/A</td>
</tr>
<tr>
<td>17-3</td>
<td>Ensure that not more than one blast in any ten consecutive blasts (regardless of the interval between each blast) does not exceed 5 millimetres per second peak particle velocity at any sensitive premises</td>
<td>Ministerial Statement 706</td>
<td>Annual Reporting to EPA. Result of internal and external audits.</td>
<td>N/A</td>
</tr>
<tr>
<td>17-4</td>
<td>Notify the Department of Environment within six hours of exceedance being recorded.</td>
<td>Ministerial Statement 706</td>
<td>Annual Reporting to EPA. Result of internal and external audits.</td>
<td>N/A</td>
</tr>
<tr>
<td>17-5</td>
<td>Submit a report to the Department of Environment outlining the reasons for the levels being exceeded within 7 days</td>
<td>Ministerial Statement 706</td>
<td>Annual Reporting to EPA. Result of internal and external audits.</td>
<td>N/A</td>
</tr>
<tr>
<td>18-1</td>
<td>Prepare a Blast and Vibration Management Plan to the requirements of the Minister for the Environment</td>
<td>Ministerial Statement 706</td>
<td>Annual Reporting to EPA. Result of internal and external audits.</td>
<td>N/A</td>
</tr>
<tr>
<td>18-2</td>
<td>Implement Blast and Vibration Management Plan to the requirements of the Minister for the Environment</td>
<td>Ministerial Statement 706 Condition 18-1 and 18-3</td>
<td>Annual Reporting to EPA.</td>
<td>N/A</td>
</tr>
<tr>
<td>18-3</td>
<td>Review and update the Blast and Vibration Management Plan</td>
<td>Ministerial Statement 706</td>
<td>Annual Reporting to EPA.</td>
<td>N/A</td>
</tr>
<tr>
<td>18-4</td>
<td>Make the Blast and Vibration Management Plan publicly available</td>
<td>Ministerial Statement 706</td>
<td>WWW site</td>
<td>N/A</td>
</tr>
</tbody>
</table>
Appendices
Appendix A

Drill and blast management requirements, responsibilities and procedures
### Table AI: Drill and Blast Management

<table>
<thead>
<tr>
<th>Process Step</th>
<th>Responsible Party</th>
<th>Activity</th>
</tr>
</thead>
<tbody>
<tr>
<td>Blast Planning</td>
<td>BGC Quarries</td>
<td>Provision of Weekly Blasting requirements (size &amp; location) to Blasting Contractor.</td>
</tr>
<tr>
<td></td>
<td>Blasting Contractor</td>
<td>Blast boundaries for future and completed blasts to be updated on Site plan.</td>
</tr>
<tr>
<td>Blast Design Parameters</td>
<td>BGC Quarries</td>
<td>The following parameters and tolerances are to be stated: MIC (kg), Bench Ht (m), Sub-drill (m), Diameter (m), Burden (mm), Spacing (m), Stemming (m).</td>
</tr>
<tr>
<td></td>
<td>Blasting Contractor</td>
<td>Pattern to be marked out by laser survey where appropriate. Location of holes will be marked with painted rocks. A drilling plan detailing hole orientation, angle and depths will be provided to BGC Quarries.</td>
</tr>
<tr>
<td>Markout Drill Pattern</td>
<td>BGC Quarries</td>
<td>BGC’s surveyor will mark out the control points in the pit according to Minesite operating procedure.</td>
</tr>
<tr>
<td></td>
<td>Blasting Contractor</td>
<td>Pattern to be marked out by laser survey where appropriate. Location of holes will be marked with painted rocks. A drilling plan detailing hole orientation, angle and depths will be provided to BGC Quarries.</td>
</tr>
<tr>
<td>Drill Pattern</td>
<td>BGC Quarries</td>
<td>Blastholes shall be drilled according to standard procedures and within specified design tolerances.</td>
</tr>
<tr>
<td>Audit Drilling</td>
<td>Blasting Contractor</td>
<td>Blasting Contractor will audit drilling for accuracy. Using Boretrak where applicable. Drilled holes not within the design tolerance may be required to be redrilled.</td>
</tr>
<tr>
<td>Redrills</td>
<td>BGC Quarries</td>
<td>Redrill holes to design specification.</td>
</tr>
<tr>
<td></td>
<td>Blasting Contractor</td>
<td>Blasting Contractor to audit holes with Boretrak.</td>
</tr>
<tr>
<td>Develop Loading Chart</td>
<td>Blasting Contractor</td>
<td>Shotfirer to produce a “Loading Chart” and follow Blasting Contractor Operating Procedures to complete the chart.</td>
</tr>
<tr>
<td>Blasthole Dipping</td>
<td>Blasting Contractor</td>
<td>All blastholes shall be dipped. Blastholes outside agreed tolerances to be referred to Minesite for advice.</td>
</tr>
<tr>
<td></td>
<td>BGC Quarries</td>
<td>Under-depth holes may either be accepted or redrilled.</td>
</tr>
<tr>
<td>Explosives on site</td>
<td>Blasting Contractor</td>
<td>All necessary explosives &amp; accessories will be brought from the Baldivis magazines for the blast in an appropriately licensed vehicle.</td>
</tr>
<tr>
<td>Charge &amp; Stem Blastholes</td>
<td>Blasting Contractor</td>
<td>MMU operation – Loading of bulk product to Blasting Contractor processes - As per Blasting Contractor Quarry Services Standard Operating Procedures.</td>
</tr>
<tr>
<td></td>
<td>Blasting Contractor</td>
<td>Blastholes shall be charged according to Blasting Contractor Standard Procedures.</td>
</tr>
<tr>
<td></td>
<td>Blasting Contractor</td>
<td>During charging, exceptions to the tolerances stipulated shall be marked on the “Loading Chart” and referred to BGC Quarries for advice on how to handle.</td>
</tr>
<tr>
<td></td>
<td>BGC Quarries</td>
<td>Stemming to be provided by Rapid Screens and placed around the blastholes.</td>
</tr>
<tr>
<td>Blasthole Initiation Design</td>
<td>Blasting Contractor</td>
<td>Design initiation sequencing and timing shall be determined by Blasting Contractor in consultation with BGC Quarries.</td>
</tr>
<tr>
<td></td>
<td>Blasting Contractor</td>
<td>The Shotfirer shall produce an initiation plan for the blast.</td>
</tr>
</tbody>
</table>
## Table AI: Drill and Blast Management

<table>
<thead>
<tr>
<th>Blasthole Tie-up</th>
<th>Blasting Contractor</th>
<th>The Shotfirer shall ensure the blastholes are tied up in accordance with both Blasting Contractor Standard Operating Procedures and the design approved by BGC Quarries.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Firing the Blast</td>
<td>Blasting Contractor</td>
<td>A Firing Procedure shall be written to describe the process from “Ready” to “All Clear” (see attachment).</td>
</tr>
<tr>
<td></td>
<td>Blasting Contractor</td>
<td>The Blasting Contractor Blast Controller will control the clearing of the pit, guarding, firing of the shot and post-blast processes in accordance with Blasting Contractor Standard Operating Procedures.</td>
</tr>
<tr>
<td></td>
<td>Blasting Contractor</td>
<td>The Blasting Contractor Blast Controller will request personnel to be assigned as blast guards.</td>
</tr>
<tr>
<td></td>
<td>Blasting Contractor</td>
<td>Blasting Contractor Blast Controller will ensure guards understand their duties and have signed appropriate documentation.</td>
</tr>
<tr>
<td></td>
<td>BGC Quarries</td>
<td>Supply guards to facilitate clearing of the pit and subsequent guarding during the firing process.</td>
</tr>
<tr>
<td>All</td>
<td></td>
<td>Blasts targeted to be fired at agreed time.</td>
</tr>
<tr>
<td>Blast Evaluation Record</td>
<td>Blasting Contractor</td>
<td>A blast evaluation record shall be prepared in conjunction with BGC Quarries after the blast has been fired.</td>
</tr>
<tr>
<td></td>
<td>BGC Quarries</td>
<td>A further review shall be made during or after the blast has been fully excavated.</td>
</tr>
<tr>
<td></td>
<td>BGC Quarries</td>
<td>Review blasts in conjunction with Blasting Contractor Shotfirer to determine any changed needed.</td>
</tr>
<tr>
<td>Misfires</td>
<td>Blasting Contractor/BGC Quarries</td>
<td>Misfires to be identified ASAP and immediate “Misfire Procedure” put into place.</td>
</tr>
<tr>
<td></td>
<td>Blasting Contractor/BGC Quarries</td>
<td>Misfires may be identified immediately after blast or later during digging.</td>
</tr>
</tbody>
</table>
### Table A: Voyager Quarry Drill & Blast Responsibilities and Actions

<table>
<thead>
<tr>
<th>Activity/Description</th>
<th>Responsibility</th>
<th>Record</th>
<th>Copies To</th>
<th>Where Filed</th>
<th>How Filed</th>
<th>Minimum Retention Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ensure the Drill and Blast Manual is complied with</td>
<td>All</td>
<td>EPA Conditions of Licence</td>
<td>N/A</td>
<td>N/A</td>
<td>7 years</td>
<td></td>
</tr>
<tr>
<td>Ensure at all times we comply with our EPA Conditions of Licence</td>
<td>Quarry manager</td>
<td>Quarry Manager</td>
<td>Records</td>
<td>N/A</td>
<td>Blast Records File</td>
<td>7 years</td>
</tr>
<tr>
<td>Prepare a blast plan and obtain the Quarry Manager's/Leading Hand's approval</td>
<td>Shotfirer</td>
<td>Shot Plan</td>
<td>N/A</td>
<td>Blast Records File</td>
<td>By shot number</td>
<td>7 years</td>
</tr>
<tr>
<td>Arrange bulk explosive to be delivered on an agreed day and time</td>
<td>Shotfirer</td>
<td>Purchase Order</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mark drill hole locations with spray paint</td>
<td>Shotfirer</td>
<td>Shot Plan</td>
<td>N/A</td>
<td>Blast Records File</td>
<td>By shot number</td>
<td>7 years</td>
</tr>
<tr>
<td>Drill required holes, very depth of holes and update Shot Plan</td>
<td>Driller/ Shotfirer</td>
<td>_shot Plan</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Place &quot;Danger Blasting Area&quot; sign at the entrance to the quarry ramp, and place &quot;Danger Keep Out Blasting&quot; sign around the perimeter of the blast area</td>
<td>Shotfirer</td>
<td>Blast Notification Board</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Post intended blasting time on the blast notifications board, and verbally notify all personnel</td>
<td>Shotfirer</td>
<td>Blast Notification Board</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Coordinate the services of a Blast Monitoring Consultant to monitor the air blast disturbances and ground vibration during each blast</td>
<td>Shotfirer</td>
<td>A. Purchase Order</td>
<td>Attached to Shot Plan</td>
<td>Blast Records File</td>
<td>By shot number</td>
<td>7 years</td>
</tr>
<tr>
<td>Coordinate the services of a Blast Monitoring Consultant to monitor the air blast disturbances and ground vibration during each blast</td>
<td>Shotfirer</td>
<td>B. Blast Monitoring Consultant Report</td>
<td>Attached to Shot Plan</td>
<td>Blast Records File</td>
<td>By shot number</td>
<td>7 years</td>
</tr>
<tr>
<td>Contact listed neighbouring properties prior to 9.30 am to notify of the intended blast time</td>
<td>Quarry Manager</td>
<td>Blast Notification Register</td>
<td>Attached to Shot Plan</td>
<td>Blast Records File</td>
<td>By shot number</td>
<td>7 years</td>
</tr>
<tr>
<td>Place down the hole detonator and suitable booster (primer) down each hole prior to the explosive product</td>
<td>Shotfirer</td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Notify Quarry Manager/Foreman/Leading Hand when the bulk explosive delivery truck arrives to arrange them to be escorted to the blast site</td>
<td>Weighbridge Operator</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Explosive primers and detonators must be carted in separate vehicles or at separate times</td>
<td>Shotfirer</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Load explosive into blast holes as per section entitled &quot;Delivery Hose Handling Procedure&quot; within the Drill &amp; Blast Manual</td>
<td>Shotfirer</td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Measure to determine correct gassing of the explosive product has taken place. Where correct place a coloured paint mark at the collar of the hole to identify it as being ready to stem</td>
<td>Shotfirer</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Extract explosive material from over filled holes with a plastic extractor pipe</td>
<td>Shotfirer</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Re-measure holes which are too low and if required top up to correct height</td>
<td>Shotfirer</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Where cap rock is present on the top level of the quarry, prepare a cement mix comprising 5 mm and diorite dust mixed with 15% cement to use as stemming and place in holes using a plastic bucket, fill to the top and ensure care is taken not to damage the nonel cord</td>
<td>Shotfirer</td>
<td></td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>Where below the cap rock area 10 mm granite is to be used as stemming and placed in holes using a plastic bucket, fill to the top, and ensure care is taken not to damage the nonel cord</td>
<td>Shotfirer</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tie holes in using connectadets (this must only be done on the day of the blast)</td>
<td>Shotfirer</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Evacuate site and on receipt of an all clear to fire, move to the blasting shelter (usually a dump truck is used with the rear of the truck facing the blast)</td>
<td>Shotfirer</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Test the firing circuit and once satisfied notify Foreman/Leading Hand ready to fire</td>
<td>Shotfirer</td>
<td>Shot Plan</td>
<td>N/A</td>
<td>Blast Records File</td>
<td>By shot number</td>
<td>7 years</td>
</tr>
<tr>
<td>Give the all clear to fire</td>
<td>Foreman/ Leading Hand</td>
<td>Shot Plan</td>
<td>N/A</td>
<td>Blast Records File</td>
<td>By shot number</td>
<td>7 years</td>
</tr>
<tr>
<td>Initiate Shot, inspect the result and report to the Foreman/Leading Hand</td>
<td>Shotfirer</td>
<td>Shot Plan</td>
<td>N/A</td>
<td>Blast Records File</td>
<td>By shot number</td>
<td>7 years</td>
</tr>
<tr>
<td>Description</td>
<td>Procedure</td>
<td></td>
<td></td>
<td></td>
<td></td>
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</tr>
<tr>
<td>---------------------------</td>
<td>------------------------------------------------------------------------------------------------------------------------------------------</td>
<td></td>
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<td></td>
<td></td>
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</tr>
<tr>
<td>Identify holes</td>
<td>Mark some blastholes by painting a number and letter on ground near the hole. Obtain the blasthole plan to record the depth of any short holes. Blastholes that are too deep must be backfilled to correct depth and re-measured. Blastholes that are too short must have the depth recorded on the loading plan.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Special holes</td>
<td>Any blastholes requiring the attention of the Shotfirer whilst loading are marked with an &quot;X&quot; at the collar. Check the face Condition for: - loose rocks; - soft seams, slips, joints, etc; - water.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Report variances</td>
<td>Report any exceptions considered significant to Quarry Manager.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Plan charging</td>
<td>Plan charging sequence to avoid driving over charged blastholes. If MMU must STRADDLE the blastholes, you MUST ALWAYS use a spotter. Mark the delivery hose at the desired collar height.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Priming</td>
<td>Pull primer up to grade level after pumping 2 metres of product. Measure the blasthole collars with the measure pole. Record the collar height of any blastholes outside the sensitivity limits.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Firing Times</td>
<td>Agree firing time with the Quarry Manager.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Safe location</td>
<td>Agree on a firing position with the Quarry Manager. The firing position must be located where flyrock WILL NOT land. If required, the Shotfirer must be provided with substantial cover that can withstand an impact of a heavy rock.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Guarding</td>
<td>The Blast Controller is responsible for appointing blast guards/sentries and assigning the roadblock locations.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Blast Controller</td>
<td>Blast Controller to confirm security of the blast area by radio calling each guard in turn. Blast Controller will request the Shotfirer to proceed with the blast.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Firing sequence</td>
<td>When the Shotfirer is satisfied the Blast Area is secured, final hook up can be completed and firing sequence can commence. After a final visual check of the Blast Area and a sentry check, the agreed firing siren sequence is to be performed. Run out the firing cable to a safe firing position. Connect Lead-in-Line to initiation. Recheck with guards to ensure Blast Area is totally clear. Perform a final visual inspection of the blast site.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Firing</td>
<td>Fire the blast after all the appropriate signals have been given.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Post-blast</td>
<td>After firing when dust and fumes have cleared, the Shotfirer will make an inspection of the blast looking for signs of a misfire or anything unsafe. If the Shotfirer is satisfied that all holes have been fired and the area is safe they will call for the “All Clear” to be given.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Misfires</td>
<td>Wait 15 minutes before entering the blast site if a misfire is suspected. In the event of a misfire being identified, the area is to be cleared of all personnel and not re-entered for 15 minutes. Notify quarry personnel by radio that a misfire has been found. Blast guards must remain in position until a decision is made on the actions to be taken. Regulations shall be followed in the treatment of any misfire.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Safe to work</td>
<td>Any area considered unsafe is to be paint marked and taped off with hazard tape. Where any abnormal circumstances are found that could be unsafe, these must be communicated to the Quarry Manager immediately.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
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PROCEDURE TO SECURE AND EVACUATE MAGAZINES DURING THUNDERSTORMS AND DUST STORMS

Where there is evidence of atmospheric electrical activity or disturbance or dust storm approaching a magazine area:-

(a) promptly place explosives or detonators situated outside inside the magazine;

(b) close and lock the magazine;

(c) prior to the arrival of the storm every person shall be withdrawn to a designated safe area, and

(d) no person shall return to the magazine until a competent person determines that it is safe to do so.

NOTE: The distance, in metres, from a magazine area to an approaching thunderstorm may be estimated by the product of time, in seconds, between a lightning flash and the resulting thunder and the velocity of sound, i.e. 344 m/s.
PROCEDURE TO SECURE AND EVACUATE MAGAZINES DURING MAGAZINE FIRES OR BUSHFIRES

Due to the considerable risk to fire fighters, fires in proximity to external magazines or within magazines should not be fought, all personnel should be removed to a safe location and access to the magazine secured. When such fires are fought, the firefighters should follow the fire emergency plan and, where practicable, liaise with the person in charge of the magazine. An appropriate firefighting plan shall be developed by the person in charge of the magazine in consultation with the local firefighting authority. Such a plan shall include:-

(a) the location of the magazine record book;
(b) an up-to-date list of type and quantity of explosives stored;
(c) a plan showing access to the magazine;
(d) the contact details for the person in charge of the magazine; and
(e) Location of:-
   (i)  external fire extinguishers and on-site fire installation;
   (ii) electrical isolation board; and
   (iii) any other dangerous goods

If a bushfire threatens an area containing an external magazine then:-

(a) any explosives or detonators situated outside shall be promptly placed inside the magazine or removed to a safe location;
(b) the magazine shall be closed and locked;
(c) every person shall be withdrawn to a designated safe area prior to the arrival of the bushfire;
(d) the person in charge of the magazine shall be available to advise and assist the local firefighting authority; and
(e) no person shall return to the external magazine until a competent person determines that it is safe to do so.
PROCEDURE FOR THE DISPOSAL OF OLD OR DEFECTIVE EXPLOSIVES

Explosives which are considered unsafe for use, storage or transport shall be destroyed.

Explosives shall not be thrown away, buried, discarded or placed with garbage.

Explosives other than Detonators

(a) Burning
Explosives may be disposed of by burning under the control of a person competent in the destruction of explosives.

(b) Detonation
Explosives may be disposed of by detonation, providing that a fresh priming charge is used and no detonators are inserted into the deteriorated explosives.

NOTE: If explosives are detonated on stony ground, or in a shallow hole in such ground, or on an area where debris is likely to become missiles, missile damage may be expected within 400m when 3kg of explosives is detonated. For this reason, explosives should be detonated in sand or earth free from stones.

(c) Dissolving in water
Very small quantities of water-soluble explosives may be destroyed by immersion in buckets or drums of water.

Detonators

Small quantities of detonators or detonating relays may be disposed of by either:-

(a) Detonation
One method of destroying up to 100 detonators at a time is to ensure that the explosive filled section of each detonator is in contact with high explosives such as gelignite, emulsion or detonating cord.

The high explosive is primed with a good detonator and fired in a manner which is safe and prevents the scattering of debris.

Detonators to be destroyed may have the lead wire or signal tube cut off not less than 25 mm from the end of the detonator casing, with care being taken not to pull the lead wires or signal tube from the detonator casing.

In placing the charge, care should be taken to ensure that the detonators are as close as possible to the charge, and that the end of the detonator containing the explosive is touching the primer charge.

(b) Burning in a furnace specially constructed and approved for the purpose.
PROCEDURE FOR THE DESTRUCTION OF EXPLOSIVES BY BURNING

The following steps are suggested as necessary to ensure the safety of personnel during the burning of explosives:

CAUTION

BURNING EXPLOSIVES MAY EXPLODE

THE FUMES PRODUCED BY THE BURNING OF AMMONIUM NITRATE OR EXPLOSIVES ARE TOXIC

(a) Make a sawdust bed or “trail” adequate for the quantity of explosives to be burned, approximately 200 mm to 250 mm wide and 25 mm deep, upon which the explosives will be laid. If sawdust is not available, news paper may be used. Normal precautions should be taken against the spread of fire.

(b) The following precautions should be observed:-

(i) Check that all cartridges are free of detonators.

(ii) Place the cartridges on the saw dust (or paper) making sure they are not piled on top of each other (they can be touching).

(c) Individual trails should not be closer than 600 mm and should contain not more than 12 kg of explosive.

(d) Trails should be side-by-side, not in a line, and not more than four should be set up at one time.

(e) Remove any explosive that is not to be burnt to a distance of at least 300 m.

(f) Sufficient kerosene or diesel oil (never petrol or other highly flammable liquid) should be used to thoroughly wet the saw dust (or paper). At least 4 L per trail is recommended.

(g) Light the trail from a long paper ‘wick’ which should be placed down wind and in contact with the 1 m of trail that is not covered with explosive.

   The wind should blow so that the flame from the wick (and later from the burning explosives) will blow away from the un-burned explosives as detonation is more likely to occur if the explosives are preheated by the flame.

   If plastic igniter cord (slow) is available, its use is recommended instead of paper. One end should be coiled into the sawdust or under the paper and the other end lit from a minimum of 7 m from the trail.

(h) Retire at least 200 m or to a safe place.
(i) Do not return to the site for at least 15 min after the burning has apparently finished.

(j) If the fire goes out do not approach for at least 15 min after all trace of fire has gone. Do not add more kerosene or diesel oil unless certain that the flame is completely extinguished.

Detonating cord may be destroyed by burning. It should not be burnt on a reel or spool but cut into lengths or loosely coiled on top of sawdust or paper as for cartridge explosives, burning in lots no greater than two reels at a time. Care is to be taken to ensure that the cord is free of detonators.

There is little danger with safety fuse, provided that care is taken to ensure that it is free of detonators. It may be destroyed by burning on an open fire.

The residue from some cartridge explosives is poisonous to livestock and, if necessary to protect them, it should be buried.

CAUTION

(1) Burning of explosives should not be attempted if serious exudation of nitroglycerine is apparent.

(2) When serious exudation is a problem or in large quantities of explosives are to be destroyed, contact the appropriate regulatory authority and the supplier of the explosives.

(3) Some emulsion and water-gel explosives are difficult to burn and may require additional fuel. The manufacturer or supplier should be contacted if large quantities of these explosives are to be destroyed.

(4) If unsure of any of the requirements that need to be followed ASK your supervisor.
QUARRY APPROVED FIRING TIMES

BGC Quarries, The Lakes shall fire all blasts at 3.00pm on the predetermined blast days. This time has proven to fit in well with the quarry operations and surrounding activities.

All neighbouring properties that require notification must be notified by 9.30am on the blast day.

Alterations to the blast time can be made due to unforeseen circumstances (electrical storms etc) but only with the approval of the Quarry Manager or his representative.
PROCEDURE FOR THE CORRECT MANAGEMENT OF MISFIRES

DETERMINATION OF MISFIRES

Misfires shall be determined as follows:-

(a) If the number of shots counted is less than the number of holes or groups of holes fired, or if there is a disagreement on the count of shots fired, a misfire shall be assumed. The following precautions should be observed:

(b) If damaged detonating cord, lead wires or unfired signal tube is exposed in a portion of a hole that has been fired, that hole shall be treated as a misfire.

(c) Unless cutoffs, butts or remaining portions of holes which are suspected of containing explosives have been shown to be free of explosives, they shall be treated as misfires.

NOTE: Some regulatory authorities require that misfires be reported to them and major misfires be dealt with under their supervision.

PRECAUTIONS

The following precautions shall be followed after a misfire:-

(a) Adequate precautions shall be taken to prevent access to the misfire site by unauthorised persons

(b) Should a misfire occur with charges which are fired by means of safety fuse, or the hook up is initiated by safety fuse and detonator, no person shall approach the misfire until an interval of 30 min has elapsed. Where a safety fuse and detonator is used to fire detonating cord and the safety fuse detonator has fired, but a detonating cord or unfired signal tube remains, this interval may be reduced to 5 min.

(c) For electric firing, or non-electric firing initiated by an electric detonator or signal tube starter, the interval may be reduced to 5 min, provided that firing cables are first disconnected and short-circuited.

EXAMINATION OF SITE

The site shall be examined as follows:-

(a) Examination of the site and implementation of such work as is necessary to ascertain the location of the misfired hole or holes shall be the responsibility of a shot firer (or appointed responsible person).
(b) The shot firer shall conduct a careful examination amongst the debris for explosive, which if present shall be removed to a safe place and disposed of in accordance with the Disposal of Old or Defective Explosives.

NOTES

(1) If wires are protruding from a hole, they should be joined together and coiled into the collar of the hole.

(2) If there is doubt as to whether a signal tube has fired it may be helpful to cut a short length (about 150 mm) of tube and tap it. If aluminium powder falls out, it is unlikely that the signal tube has fired.

(3) Any detonating cord which survives a misfire must be assumed to be live. If it must be cut, it must be cut in a manner which does not risk detonation.

TREATMENT OF MISFIRES

(a) **Refiring misfired holes**
If the down lines are considered to be in good condition, an attempt can be made to refire.

(b) **Removal of stemming**
Stemming may be removed by applying water under pressure, compressed air, or a mixture of water and compressed air, through a non-ferrous blow pipe.

NOTES

(1) The use of compressed air alone is not encouraged. Where it is used, special precautions should be taken to minimise the dangers from static electricity and impact.

(2) Where water under pressure or compressed air is not available, the stemming may be sludged out by the use of a wooden or other approved implement.

(3) When removing stemming, care should be taken to ensure that any detonator or explosive which may be susceptible to detonation during the process of stemming removal is not disturbed.

(c) **After removal of stemming**
When stemming has been removed from a water-resistant charge, a fresh primer shall be inserted and the blast hole stemmed and fired.

For a misfire containing explosives rapidly destroyed by water, such explosives may be sludged out using the procedure described in Note 2 of the above clause. The hole shall then be reprimed and fired to remove the original primer.
Where necessary in surface operations, an artificial burden shall be placed around the hole to prevent fly rock.

(d) **Firing of new hole in vicinity**
Where it is not possible or practicable to remove a misfire by refiring of the explosives or removal of the stemming as described in clause 4:b, a relief hole shall be drilled as parallel as possible to the original blast hole, then charged and fired as follows:-

(i) The collar of the misfired hole shall be effectively blocked by the insertion of a wooden plug, or otherwise be clearly marked.

(ii) Where the misfired hole is 50 mm or less in diameter and 4.5 m or less in length, holes shall not be drilled closer than 450 mm to the nearest point of the misfired hole. Where such misfired holes are greater than 4.5 m in length, relieving holes shall not be drilled closer than 750 mm to such holes.

(iii) With larger and longer holes, the distance between the misfired hole and the relieving hole shall be increased as circumstances warrant.

(iv) Where an electric detonator is involved in the misfire, the detonator wires shall be short-circuited.

(e) **Restriction of use of relieving holes**
where a hole has been previously bulled, the relieving hole method described in clause (d) shall not be used.

(f) **Search for explosives**
After a further change has been exploded as set out in Clause (d), work shall not resume at that location until the shotfirer has made a careful search for any explosive from the misfired charge.

(g) **Alternative procedures**
where the procedures set out about cannot be applied, the shotfirer shall adopt such procedures which are considered necessary to meet the situation, eg. drilling by remote control.

(h) **Explosives recovered from misfire**
No person shall leave unguarded, abandon, discard or otherwise neglect to safely dispose of any explosive recovered in the treatment of misfire.
QUARRY SLEEPING BLAST PROCEDURE

All sleeping blasts carried out at BGC Quarries, shall be to the guidelines set out in this procedure.

All persons involved in blasting at the quarry must follow the following procedure.

The following blast procedure shall be followed should there be a need to delay the firing of a blast to a later day after seeking approval from the Quarry Manager or his representative.

Usual reason for a delayed firing is due to the size of the blast (if it is a large shot and cannot be ready by 1500 on the loading day).

All loading and firing shall be carried out as per the BGC Quarries, Quarry Blasting Procedure with the following alterations to the procedure.

The blast can be checked, primed and loaded with explosive product and stemmed on the first day, but is not to be tied in with surface delays until the morning of the firing day.

Under no circumstances is a blast to be left tied in during the period that the blast is left sleeping.

Under no circumstances is there to be any explosive stores left at the blast site and all blast holes must be sealed (stemmed) so that no explosive product can be removed from the blast hole.

Before leaving a blast sleeping over night, the blast must be barricaded so that the area is highlighted as a blast area.

Access to the ramp leading to the blast area must have the access blocked off so that access can not be gained to the blast area during the hours of darkness.

The site is to remain attended at all times during the sleeping period.

The nightshift operation is to be made aware of the sleeping blast and denied access to this area during the hours of darkness.

Only on the blast day can the surface delays be tied in and checked ready for firing as per the BGC Quarries, Quarry Blasting Procedure.
BLAST EVACUATION PROCEDURE

The purpose of this procedure is to ensure that all personnel and vehicles are clear of the blast area prior to blasting.

(1) The Shot Firer shall inform the Quarry Manager/Foreman of the time of firing and update the Blast Information Board.

(2) One half hour before the nominated blast time, the quarry foreman / shot firer shall nominate a responsible persons to be stationed at the entrance to the quarry site at muster point one and at the adjoining vacant property gate to stop all traffic/persons from entering the site.

(3) The Mine Manager/Quarry Foreman and Shot Firer shall evacuate everyone not involved in the blasting operation at least fifteen (15) minutes prior to the blast time. All persons not involved with the blast must gather at Evacuation Muster Point 1 located near the access road entrance to the quarry site.

(4) The Shot Firer shall carry out an inspection of the site ten (10) minutes prior to the blasting time to ensure that the quarry areas have been fully evacuated.

(5) The Shot Firer appoints a person to activate the siren for the ten (10) minutes prior to blasting. The siren shall be left running until the blast has been fired and the all clear given.

(6) The Shot Firer shall notify the Mine Manager/Foreman when the blast area is clear.

(7) After the shot has been blasted the Shot Firer shall check the blast for misfires and if it has gone according to plan, the shot firer shall notify (by two way radio) the quarry foreman/leading hand that it is safe to re enter the quarry site. Then the siren is switched off which signals the all clear.

(8) In the event of a misfire the Shot Firer shall not allow anyone to enter the blast area until the blast has been refired and is considered safe to do so. An entry of the misfire details shall be made into the Mines Record Book.
PROCEDURE FOR CEASING OF CHARGING OPERATIONS DUE TO A THREAT FROM AN APPROACHING ELECTRICAL STORM

If there is evidence of any form of atmospheric electrical activity or disturbance, surface blasting operations shall be suspended and such operations shall not be resumed until the electrical disturbance has passed.

Should the atmospheric activity or disturbance be far in the distance, approval can be given by the quarry manager to initiate the blast with safety fuse.

The use of safety fuse is to be kept to a minimum and avoided wherever possible, but can be used for extreme circumstances. Safety fuse initiation must be carried out as per the safe initiation procedure.

Should the atmospheric activity or disturbance appear during the final steps of the blasting procedure, the firing cable shall be shorted at the firing point and the detonator removed from the initiation end of the firing cable.

The blast operation shall be suspended until the atmospheric activity or disturbance has passed.

No blasting operations shall continue during atmospheric activities or disturbances.
PROCEDURE FOR ELIMINATING PREMATURE INITIATION OF DETONATORS BY STRAY OR STATIC ELECTRICITY

Due to the possibility of a blast being prematurely initiated by stray or static electricity, the following procedures will apply:-

(a) No electrically operated equipment will be allowed within 20 metres of a blast area. This includes two way radios, mobile phones, drills, grinders, etc.

(b) Signs and witch’s hats shall be positioned to show the outer limits of the blast area.

(c) Only equipment directly involved with the blast shall be allowed into the blast area.

(d) No blasting operations shall be carried out during atmospheric activities or disturbance (thunderstorms or dust storms).

(e) No electric welding operations shall be carried out within 50 metres of the blast area.

(f) No blasting is to be carried out in the vicinity of over head power cables.
PROCEDURE FOR SAFE METHODS OF INITIATION

The follow procedures shall be followed to ensure safe initiation of quarry blasts.

Safety and Health

The starter utilises a Shotshell Primer to initiate signal tube, and is designed to be placed on the ground, and foot activated.

This device must only be used by suitably qualified and trained personnel.

Appropriate PPE should be worn at all times.

Equipment Required

- Detonating cord cutters or approved cutting device.
- IES Non-Electric Starter mkII.
- Shotshell Primers (Winchester W209 are recommended)

Preparation

1. Lay out signal tube to point of safety in accordance with site firing procedure.
2. Ensure that a suitable area is cleared on the ground.
3. Ensure all required equipment is readily available.

Non-Electric Initiation Process

Following completion of site blast procedures and prior to firing:-
1. Cut the end seal from the signal tube with a sharp cutter where necessary.
2. Insert the cut end of the signal tube into the barrel in the bottom of the IES Non-Electric Starter, ensuring that it is seated firmly.
3. Clip the signal tube into the retaining slot in the side wall of the starter base. Ensure that the end of the signal tube does not pull from the firing barrel.
4. Place the base of the starter on a suitably cleared area on the ground. In uneven or muddy conditions consideration should be given to the use of the black plastic base cover provided.
5. Remove the lid of the starter, and place a Shotshell primer in the firing chamber in the top of the base of the starter.
6. When ready to fire, replace the lid.
7. To fire, give the lid a short sharp impact with the foot so that the striker pin impacts the primer. This fires the primer and initiates the signal tube which starts the blast.
8. After firing, remove the signal tube from the retaining slot in the starter base, remove the fired primer and dispose of both according to local regulations.
Non-Electric Initiation Common Problems

- Jammed primers may be dislodged by turning the base upside down, and giving it a firm tap using the lid.
- Dirt build up in the base can be removed by washing with water. Shake to remove excess water and leave to dry.
- Periodically check the firing chamber and barrel for soot build up. A 6.3mm drill bit may be used to clear any build up in the firing chamber, avoid drilling into the metal. The barrel should self clean.
- Winchester W209 Shotshell primers are recommended as they have been found to provide consistent energy output with low soot production.
- Use of a blunt cutting tool could result in ‘squashing’ the cut end of the signal and a failure to pick up.
- In the event of a failure to pick up, at least 2 metres of signal tube should be cut off the end before re-firing.
- Contamination of the exposed end of signal tube by water, dirt etc could result in a failure to pick up.

Electric Initiation

(a) Firing Cable

(i) All blasts are to be electrically initiated (unless approved by Quarry Manager or representative) by means of an exploder.

The shotfirer should maintain possession of the key to the exploder at all times. Exploders should be tested at regular intervals to ensure reliable operation and to comply with Statutory requirements / obligations.

(ii) The exploder and firing cable should always be under the control of the shotfirer.

One way to accomplish this is to have the firing cable coiled up near the blast area. When all connections have been made and all personnel safely removed, the firing cable is then uncoiled from the blast area to the point at which the exploder is to be operated.

The exploder ends of the firing cable should be kept shorted and insulated from ground until they are attached to the exploder at the time of firing. Just before connecting the shot-firing cable to the exploder, the circuit should be tested using an approved circuit tester. Resistance (ohms) on firing cable should be 5.2 ohms/100 metres maximum and 1.0 – 2.2 ohms per instantaneous electric detonator.

If a proper reading is not obtained, the circuit should be reinspected by the shotfirer and the source of trouble located. If nothing happens when the exploder is operated, the key must be removed, then the firing cable must be shorted, and a guard posted at the exploder while the source of trouble is being investigated.

This guard should not hold the key to the exploder.
(b) **Exploder**

(i) To use the exploder, connect leads to the large terminals. Screw down firmly, do not over tighten as this may damage the wire.

(ii) Insert the magnetic key to charge the capacitor. The ready light should illuminate within 5 seconds.

(iii) When the light is illuminated press the red fire button to set off the charge.

(iv) Remove the key after firing.

**NOTE:** This machine has a charge monitor and will not allow firing if the capacitor does not have sufficient charge, even if the button is pressed.
DELIVERY HOSE HANDLING PROCEDURE

Introduction

Hose handling is one of the most important area of the blasting operation.

Poor hose handling can result in:-
- Misfires (total or partial)
- Overloaded holes
- Fume
- Poor fragmentation and heave

These procedures are intended as a guide to assist the hose person to safely and efficiently handle delivery hoses to correctly charge bulk explosives into blast holes.

Personal Protective Equipment (PPE)

Always wear or use the necessary protective clothing and equipment.

As well as the minimum BGC requirements (ie safety helmet, safety glasses, safety boots, BGC issued clothing and sun screen (where appropriate), impervious gloves should also be worn when handling explosives delivery hoses.

Charging Details

Before charging begins, the hose person/operator must be made aware of the following details which the shot firer is to provide:-

(a) Product to be loaded
(b) Depth of holes and amount of water in the holes
(c) Charge weight or stemming height
(d) Any other relevant information (ie cavities, short/blocked holes etc)

Responsibilities

The shotfirer (or other nominated person) should check for depth, amount of water and estimate the charge length/weight. Wet holes should also be marked. Where any doubt may exist, the hose person/operator should check, by dipping the hole to detect water.

The hose person/operator must ensure that procedures for loading wet and dry holes are followed.
Hose Positioning (Bottom Loading Only)

It is important that the end of the hose is initially located approximately 200mm above the primer. This will avoid pumping product beneath the primer and causing it to float. The primer should be located at the bottom of the hole prior to the commencement of pumping.

During loading, the delivery hose should be maintained at approximately 300 – 500mm into the rising product column.

![Diagram of hose and primer positioning](image)

Primer Positioning

It is impossible to avoid entrapping some water with the product at the bottom of the hole. For this reason, the primer must be pulled off the bottom and into good product after the hole charging has commenced. This must only be done after the hose delivering product has been retracted at least 2 metres. **Do not** pull the primer and hose off the bottom together, as this causes water to be mixed into the product.

It is recommended that the bottom primer is located approximately 1 to 1.5m from the toe of the hole. There can however be deviations from this rule of thumb.

Product Column

Product may be loaded to either a pre-designated collar length or to a designated number of kilograms. In either case, it is important that holes are not loaded higher than an agreed height in the hole. Loading holes too close to the top has the potential to cause fly rock and air blast.

If the hole is loaded by designated kilograms, the pump operator may cease pumping product without the correct collar having been reached. This may be due to product running away into cavities or cracks in the hole walls. The shotfirer will advise the remedial action to be taken in these situations.
Hose Withdrawal Rate

Whilst pumping product, control of hose withdrawal rate is critical. When manually handling hoses, the “feel” of the hose in the product is an important concept in assessing what is actually happening during loading. The pressure on the end of the hose changes if the hose is brought up too fast or if there are cavities in the hole. In this way the “feel” can be used to gauge the retraction rate of the hose and the cavities.

Marking The Delivery Hose

Hoses are marked for loading to a target collar height. The following hose marking scheme is recommended.

Use of two (2) markings – a target collar mark and a warning mark.

Establish the desired stemming height. If delivering gassed product, allow for column rise.

**NOTE:** The tape colour should be one that is easily seen.

![Diagram of hose with markings]

Target Collar Mark  Warning

Marks
DRILLING PROCEDURES

Drilling – T-51

➢ Consists of 6.1m speed rods, 76mm 3.7 metre TAC Tube and 102mm flat face button bits.

Rods

➢ Integral coupling type, no need for extension couplings, more efficient transfer of impact through rod joints, less wear in threads, longer rod life.

Bits – Atlas Copco B.F. 102mm

➢ 8 gauge buttons – 4 face buttons.
➢ Low number of face buttons gives good rotation pressure allowing more impact pressure and penetration.
➢ Less wear on carbide inserts than previous bits.
➢ 10-12 re-sharps per bit at an average of 35 to 45 metres per grind.
➢ Less button breakage allowing bit to be run down until body wears out and buttons fall out.
➢ 89mm drill bits can be used to cushion back and side rows.

TAC Tube – 3.7 metre x 76mm Inverted

➢ Tube allows for greater drilling accuracy which allows wider drill patterns, better face profiles and more consistent drill depths.
➢ Less clearance between tube and hold gives higher flushing pressures aiding removal of all cuttings from hole.
➢ Higher flushing pressure keeps water out of hole while drilling.
➢ Straighter holes reduce wear on rod threads increasing rod life.
➢ Tube does reduce shank life. Currently shank life is about 4000-5000 metres.
➢ Rigidity of tube makes it susceptible to breakage in bad, broken ground either reduce penetration rate or remove tube and drill with speed rod.

TAC Tube Modifications

Doing trial on female/female TAC tube especially made by A/C Rocktools. The theory is to do away with the male end of the tube which does wear and break at about 4000-5000 metres. Also coupling not required at shank/string end of the tube allowing better transfer of impact (less joints).

Adaptors

Tube is currently being used upside down with a coupling to attach it to the shank and string. A male/male adaptor has been made up to go on the bottom of the tube. 90% of tube failures occur at the threaded end inside the drill bit. By inverting the tube most breakages occur with the male/male adaptor. When broken the adaptor is removed and replaced with a new one instead of replacing the whole tube.
Tub life is doubled to average of 4000-5000 metres depending on condition of ground being drilled.

**Lubrication**

TAC tube increases rotational loading of the shank driver which in turn requires better lubrication. 150w rock lube oil is now used (100w previously) ECL pump rate has between changed from 45 pulses per minute to 60 pulses per minute. Lube oil galleries in rock drill have been modified to increase oil flow to shank driver.
BLAST HOLE PATTERN DESIGNS

Top Level

Top level of pit requires different patterns to the lower levels because of the solid cap rock which needs to be broken. A square pattern is used so the stab holes (which are used to break the cap rock) can be placed in the middle of adjacent blast holes.

Burden and Spacing

Burden and spacing varies between $3.0 \times 3.0$ to $3.3 \times 3.3$. $3.3 \times 3.3$ pattern is used where the rock is good – no seams. Most areas on top level.

North eastern and south eastern corners of the pit have a clay seam ($200 \text{mm} – 400 \text{mm}$) which is located between 4-7 metres down and travels horizontally through this area. This seam causes cut off of the explosives columns resulting in incomplete breakage of rock above the seam. $3.2 \times 3.2$ pattern is used in this area.

Dual Blast Holes

With dual blast holes the rear hole is drilled to full depth. Whilst this hole is being drilled the driller must record the depth of the clay seam as the drill passes through it. The front hole is then drilled $200\text{mm}-300\text{mm}$ forward to rear hole to a depth of $1\text{m}$ above the seam. Depth of the seam for each long blast hole is recorded on a pattern plan to determine the amount of explosives for each hole. Both holes are drilled at the same angle.

- Hole angle $7.5^\circ$
- Hole diameter $102\text{mm}$
- Front row $3.0 \text{m}$ burden
- Sub-drill $1\text{m}$

Method tried to break rock above seam in N.E. and S.E. corners of quarry.

1. Top prime – with same delay detonators – no change.
2. Deck loading – $2\text{m}$ deck through seam – no change.
3. Dual blast holes – $2^{nd}$ hole to $1\text{m}$ above seam – good breakage.
4. Burden and spacing – reduced to $3.2 \times 3.2$ – good breakage.

Back-Wall Over-Break

Over-break on the back wall of the shot is almost non-existent, however intra-echelon timing does have an effect on the back wall. The less time allowed between rows, (ie $m/s$) the better the finish on the back wall using $89\text{mm}$ drill bits on the back row with the same burden and spacing as with $102\text{mm}$ bits also has a good effect.
Side Wall Over-Break – Method Used

Remove 1 echelon from side of shot and 45° wall mark out a row parallel to the side row the same burden and spacing as the rest of the shot. Initiate with 17 m/s down side row.

```
  3.2m  3.2m
         • •          • •
```

The distance between H.1 and H.2 is 4.4m which is 1.2m more than the normal spacing.

The distance between H.3 and H.4 is 3.2m, same as normal spacing leaving a good stable side wall.

Top priming of the side row can also be done for a better result. Top prime with same delay det as the bottom primer. This initiates the top of the hole first breaking the cap rock so excess energy is not confined by cap rock.

Lower Levels

With the lower levels of the pit the first metre of the benches are already blasted due to the sub-drill of previous shots from the level above. As a result stab holes are not required so a staggered blast pattern which is more efficient, can be used.

Spacing and Burden – Square Pattern

Currently a burden and spacing of 3.3m x 3.3m is being used to good effect.

Side Wall Over-Break

Currently using same methods on side walls as top level (ie. methods 3 and 4). Results not as good as top level because of staggered pattern. With a staggered pattern the relief angle is only 30° instead of 45° as with square patterns.

With 90° sidewalls a combination of 102mm and 89mm drill bits where different spacing is used. Reasonable results are achieved but shots more than 4 rows deep are still a problem. Methods 3 and 4 also used.

- Hole angle – 7.5°
- Hole diameter – 102mm
- Front row burden – 3m
- Sub-drill – 1m
Burden and Spacing

A 3.0m x 3.3m pattern has been used but not required as there are too many fines in shot.

A 3.5m x 3.7m pattern has been used but is considered on boarder line of good fragmentation, close to producing over size through middle of shot.

Blast Hole Timing and Sequence

The blast hole tie-in remains basically the same on most blasts with only slight changes made due to different conditions.

Standard tie-in for a 5 row shot is, 17 m/s across the front row (control row), 342 m/s across the next two rows and 65 m/s across the two back rows.

Square Pattern

\[ \begin{array}{cccccccc}
17 & M/S & 17 & M/S & 17 & M/S & 17 & M/S \\
42 & 42 & 42 & 42 & 42 & 42 & 25 & M/S \\
42 & M/S & 42 & 42 & 42 & 42 & 42 & 42 \\
65 & M/S & 65 & 65 & 65 & 65 & 65 & 65 \\
65 & M/S & 65 & 65 & 65 & 65 & 65 & 65 \\
65 & M/S & 65 & 65 & 65 & 65 & 65 & 65 \\
65 & M/S & 65 & 65 & 65 & 65 & 65 & 42 M/S \\
42 & M/S & & & & & & \end{array} \]

\( \leftarrow \) to stay in sequence this hole must fire before

\( \begin{array}{cccccccc}
17 & M/S & 17 & M/S & 17 & M/S & 17 & M/S \\
42 & 42 & 42 & 42 & 42 & 42 & 25 & M/S \\
42 & M/S & 42 & 42 & 42 & 42 & 42 & 42 \\
65 & M/S & 65 & 65 & 65 & 65 & 65 & 65 \\
65 & M/S & 65 & 65 & 65 & 65 & 65 & 65 \\
65 & M/S & 65 & 65 & 65 & 65 & 65 & 65 \\
65 & M/S & 65 & 65 & 65 & 65 & 65 & 42 M/S \\
42 & M/S & & & & & & \end{array} \)

\( \nabla \) to keep the sequence right with these holes a 25 m/s det is used. The tie-in moves forward 1 echelon so there is a need to gain 17 milliseconds.

\[ \begin{align*}
17 & \quad 0 \\
42 & \quad - \frac{25}{-} = 17 \\
59 & \quad 42 \\
\end{align*} \]
The same applies with the 65 m/s rows only a 42 m/s det is used.

\[
\begin{align*}
17 & \quad 0 & \quad 65 \\
82 & \quad 65 & \quad 42
\end{align*}
\]
RECEIVAL AND STORAGE OF EXPLOSIVES

All magazine rules must be adhered to, these are displayed on the inside of the magazine door.

Detonator Magazine

1. Guide the delivery truck through the gates so the detonator container doors are as close to the magazine doors as possible. Care should be taken as the roof overhangs the magazine.
2. Unload detonators 1 box at a time.
3. Store detonator boxes in the appropriate place in regards to tube length and delay times. Shot Shell Starter to be stored in detonator magazine.
4. New stock to be stored at the bottom of the appropriate stack.
5. Stacked boxes not to obstruct air vents.
6. Stacked boxes not to exceed a height of 1.5 metres.
7. Check receipt to ensure it corresponds with the amount of detonators delivered.
8. Enter contents of order into magazine records.
9. Close magazine door and check if it is locked securely.
10. Close and lock gate.
11. Escort the delivery truck back to the weighbridge.
12. Enter contents of order into office records.
13. Give receipts to the Purchasing Officer.

Explosives Magazine

1. Guide the delivery truck through the gates so the explosives container doors are as close to the magazine doors as possible. Care should be taken as the roof overhangs the magazine.
2. Unload explosives 1 box at a time, ANFO should be unloaded one (1) bag at a time.
3. Packaged explosives are to be stacked on the right hand side of the magazine.
4. Stacked boxes are not to obstruct air vents.
5. New stock to be stored at the bottom of the appropriate stack.
6. ANFO is to be stored on the left hand side of the magazine, bags are to be stacked no closer than 200mm to the wall and no higher than 1 metre.
7. Safety fuse and detonating cord are to be stored in the Explosives Magazine.
8. Under no circumstances are detonators to be brought into a stored in the Explosives Magazine.
9. Check receipt to ensure it corresponds with the amount of explosives delivered.
10. Enter contents of order into magazine records.
11. Close magazine door and check if it is locked securely.
12. Close and lock gate.
13. Escort the delivery truck back to the weighbridge.
14. Enter contents of order into office records.
15. Give receipts to the Purchasing Officer.
Revision Status

Any changes made to Plan must be noted below and EACH version of the report saved as a new Revision number.

<table>
<thead>
<tr>
<th>Rev No.</th>
<th>Date</th>
<th>Revised By</th>
<th>Revision Details</th>
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<td>1</td>
<td>5 September 2006</td>
<td>Kevin Holley</td>
<td>First Draft for Review by Rob Holmes of URS.</td>
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<td>2</td>
<td>13 September 2006</td>
<td>Kevin Holley</td>
<td>Second Draft incorporating comment from Rob Holmes. Issued to Paul Berkhout of BGC Voyager Quarry for Review.</td>
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<tr>
<td>3</td>
<td>14 September 2006</td>
<td>Kevin Holley</td>
<td>Third Draft incorporating comment from Paul Berkhout of BGC Voyager Quarry. Issued to Lloyd Acoustics for Peer Review.</td>
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<tr>
<td>4</td>
<td>25 September 2006</td>
<td>Kevin Holley</td>
<td>Fourth Draft incorporating comment from external peer reviewer – Daniel Lloyd of Lloyd Acoustics.</td>
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<td>5</td>
<td>19 April 2007</td>
<td>Kevin Holley</td>
<td>Final – includes comment from Ben Miles (DEC)</td>
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