Environmental Blast Management Procedure

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This document has been prepared based on assumptions as reported throughout and upon information and data supplied by others.

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1 Introduction

This blast management procedure has been prepared to manage blasting during the operation of the Warrawoona Gold Project (WGP), and specifically relates to ensure activities from blasting does not affect threatened species within the Klondyke Queen historic workings which is located adjacent to the planned Klondyke Open Pit and Underground.

1.1 Purpose

The purpose of this procedure is to provide guidance to all personnel associated with blasting operations on site. It is intended to be used as part of an overall framework to plan works and mitigate the environmental risks with blasting.

1.2 Scope

This procedure address blast vibration, air blast overpressure and fly rock to determine a safe set of Open Pit blast parameters that will allow blasting within 185m of the Klondyke Queen historic workings.

The Klondyke Open Pit is currently proposed to be located adjacent to the Klondyke Queen, historical gold workings that have a colony of Pilbara Leaf nosed Bat (PLNB) and Ghost Bat (GB), which are both considered by state and federal governments as a threatened species.

The scope does not include a set of underground blast parameters as the underground mine design is still conceptual in nature and subject to additional resource drilling in order to finalise the design. The underground blast design will be modelled to determine the minimum offset (buffer) from the Klondyke Queen workings in order to active a <10mms^{-1} vibration limit as explained below. This will also require confirmation of the depth of the Klondyke Queen workings which currently rely on historic records and may not be accurate.

1.3 Context

A 200m buffer has been provided for in the open pit mine design between the western edge of the proposed open pit and the Klondyke Queen workings, based on recommendations from Drew Martin (2018), a recognised expert in Drill and Blast.

The paper “Scientific Evaluation of Fauna Sensitivity to Blasting” authored by Martin (2012) documents a seismic blasting trial completed by Rio Tinto at a Pilbara Iron ore mine that monitored the blast vibration generated at a PLNB colony for a total of 6 explosives charges and correlated the data to bat monitoring data. In summary the blast events recorded between 0.58 mms^{-1} and 12.2 mms^{-1} at the monitoring located closest to the PLNB colony. No disturbance to the PLNB colony was concluded on assessment of the bat monitoring data.

The Rio Tinto mine site conducted the study to validate that using a blast vibration limit of 10 mms-1 at the PLNB colony would cause no disturbance to the bats and this threshold has been adopted as the basis for the recommendations in this procedure.

Independent Geotechnical Consultants (O'Bryan, 2019) were engaged to review the recommendations who endorsed the finding that a peak velocity of 10 mms^{-1} is unlikely to compromise the integrity or stability of the Klondyke Queen historical workings.

1.4 Definitions

Term	Definition
Air blast	The airborne shock wave or acoustic transient generated by an explosion
Blast	The action of breaking and displacing rock by means of explosives
Blast Area	The area of a blast within the influence of flying rock missiles, gases, and concussion
Blast Monitor	An instrument that measures seismic waves along three mutually perpendicular axes (x, y, z) to determine Peak Particle Velocity
Decibel (dB)	A unit of sound measurement which quantifies pressure fluctuations associated with noise and overpressure
dB (Lin Peak)	Decibel associated with the maximum excess pressure in the overpressure wave. Lin represents linear – indicating that no weighted or adjustment is made to the measurement
Fly Rock	Rocks or any other debris propelled from the blast area by the force of an explosion
Fumes	The gaseous products of an explosion. For the purpose of fume classification, only poisonous or toxic gases, such as carbon monoxide, hydrogen sulphide, and nitrogen oxides are considered
Ground vibration	Motion of ground caused by the passage of seismic waves originating from a blast. The rate of the ground vibration movement is referred to as Peak Particle Velocity (PPV) and is measured in millimetres per second (mm/s)
Maximum Instantaneous Charge	The maximum permissible charge weight allowed to ensure the radial propagation of vibration does not exceed assessment criteria at a receiver distant from the blast site
Mis-fire	A blast that fails to detonate completely after an attempt at initiation, also the explosive material itself that failed to detonate as planned
Overpressure	A pressure wave in the atmosphere which is caused by the detonation of explosives. Overpressure consists of both an audible (noise) and inaudible energy. The energy of the overpressure is measured in decibels (Lin Peak)
Sound Level Meter	An instrument that measures sound pressure levels in decibels
Stemming	Inert material used to maximise the effect of an explosion by filling the remainder of hole after they have been charged with explosives

2 Responsibilities

2.1 General Manager:

(a) Must ensure adequate resources are available to enable implementation of the Plan.

2.2 Quarry Manager (Mining Manager):

(a) Accountable for the overall environmental performance of the Project, including the outcomes of this Plan.

2.3 Drill and Blast Engineer:

(a) Design all blasts to ensure compliance with statutory and site specific conditions;
(b) Conduct and review monitoring data following each blast to ensure compliance; and
(c) Where non-compliance recorded, advise Environmental Supervisor and Mining Manager.

2.4 Shot Firer:

(a) Conduct all blasts in accordance with statutory and site safety work procedures

2.5 Site Environmental Officer:

(a) Ensure the implementation of this Plan, including reporting of non-compliances with the criteria identified in statutory and/or site specific conditions; and
(b) Ensure employees are competent through training and awareness programs.

2.6 Competence and Training:

(a) All personnel shall undergo blast management awareness training. Blast Management shall be a component of the competency based site induction program.
(b) The Site Environmental Officer shall be responsible for ensuring the appropriate Blast Management training is included in the induction.

3 Environmental Blasting Criteria

3.1 General

(a) Key Open Pit blasting environmental concerns are focused around air blast overpressure, blast vibration, fly rock, dust from blasting and post detonation fumes (CO and NOx) gases. Using the proposed distances and mining bench heights, blast parameters are assessed against conservative limits for all blasting environmental effects. The limits used, with no other limits available with reference to native fauna and specifically PLNB and GB are as follows:

(i). Air blast Overpressure < 125 dBL within 20 m of any PLNB/GB roosting habitat entry point(s);

(ii). Blast Vibration < 10 mms-1 within 20 m of any PLNB/GB roosting habitat entry point(s);

(iii). Fly rock – No fly rock to be project within 50m of the PLNB/GB roosting habitat entry point(s); and Dust and Fume – No fume (NOx) orange gas or dust to drift within 200 m of the PLNB/GB roosting habitat entry point(s).

(b) The limits imposed are the same as human comfort limits. The limits are set low as any disturbance that could make the PLNB and GB take flight during roosting hours, has the potential to consume excess energy disabling the nocturnal mammal from foraging for food away from the roost during the hours of darkness.

3.2 Regulations and Standards

(a) To evaluate the proposed blasting activities on the sensitive sites, the relevant Australian Standards and legislation were used:

(i). Australian Standards 2187.2 – 2006 Explosives – Storage and use Part 2: Use of explosives (Appendix J, Table J (4.5)A); and

(ii). Environmental Protection (Noise) Regulations 1997 (Part 2 - Section 11).

(b) No Standards or Regulations have environmental blasting limits for native fauna.

3.3 Adaptive Management

(a) Calidus will assess and manage blast related risks to ensure compliance with the Environmental Blasting Criteria.

(b) Where a non-compliance has occurred, Calidus will:

(i). take all reasonable and feasible measures to ensure the exceedance ceases and does not reoccur;

(ii). consider all reasonable and feasible options for remediation (where relevant) and prepare a report to the describing those options and any preferred remediation measures of other course of action; and

(iii). implement remediation measures as directed by the appropriate Regulatory Authority.

4 Blast Parameters

4.1 General

(a) All blast designs must be designed to comply with this 10 mms^{-1} limit unless further field work is to be conducted to establish site blast vibration constants. An increase to 20 mms-1 could be possible using an approved scientific program in consultant with Biologists and Geotechnical Engineers.

(b) A seed drill and blast programme will be completed prior to full scale production blasting to evaluate actual site blast vibration attenuation constants. The first blast will use a conservative Maximum Instantaneous Charge (MIC) weight in order to verify prevailing ground conditions. The results of monitoring data from this first blast will be used to determine future blast design. In addition to the normal overpressure and ground vibration data, monitoring of the first blast will also include the incidence of fume generation, fly-rock and rock breakage pattern. This data will then be used to refine drill depth and pattern, stemming details, charge decking requirements and MIC.

(c) The proposed blast parameters are as follows:

Table 1 - Recommended Blast Parameters

	Standard Blast Parameters	Alternate # 1	Alternate #2 Ore Mine to Mill	Alternate # 3	Alternate # 4
Bench Height (m):	5	5	5	7.5	10
Blast Hole Diameter (mm):	102	115	115	127	165
Burden (m)	2.8	3.0	2.5	3.5	4.4
Spacing (m)	3.2	3.4	2.9	4.0	5.0
Stemming Length (m):	2.0	2.3	2.0	2.3	3.3
Subdrill (m):	0.7	0.7	0.5	0.8	1.0
Explosives Type:	Emulsion	Emulsion	Emulsion	Emulsion \ HANFO	Emulsion \ HANFO
Explosives Density (gcm^{-3}):	1.1	1.1	1.1	1.1	1.1
Explosives Charge per Blast Hole (kg):	33.3	38.8	40.0	83.6	181.1
Powder Factor (kgm^{-3})	0.70	0.76	1.10	0.80	0.82
No explosive decks	1	1	1	1	1
Inert deck length	NA	NA	NA	NA	NA
Initiation System:	Non-electric	Non-electric	Non-electric	Non-electric	Non-electric
Maximum Instantaneous Charge (kg):	126.0	155.2	160.0	323.2	724.4
No of blast holes per delay	4	4	4	4	4

(d) Using standard initiation sequencing, non-electric, based on the results displayed above, blasting would not be able to occur within 200 m of the Klondyke Queen (Standard Blast Parameters). With modifications to initiation designs, blasting could occur at the closest separation distance of 185 m and be compliant with the 10 mms^{-1}. These are shown as Alternate#1 and Alternate#2.

(e) A 200 m buffer has been allowed for in the open pit mine design, so the Standard Blast Parameters are the applicable standards for blasting from the 200 m buffer to within 350 m of Klondyke Queen.

(f) Alternate#3 and Alternate#4 able to be used at distances greater than 350 m with modifications to the stemming length (3.0 m and 3.9 m for Alternate#3 and Alternate#4 respectively which will also decrease the charge weight per hole and potentially increase the maximum particle size and concentration of large rock fragments), and then from 500m as per the table above.

(g) All blasts within 1,000 m should be monitored via a permanent blast monitor location within 10 m of the Klondyke Queen and located between the Klondyke Queen and the proposed Open Pit.

(h) Only non-electric or electronic initiation systems should be used, and electronic initiation will allow blast vibration to be controlled with greater ease, although both systems can be used to control vibration.

(i) The no disturbance limit of 10 mms^{-1} is lower than the spalling blast vibration limit and therefore all blast designs must be designed to comply with this limit unless further field work is to be conducted to establish site blast vibration constants. In addition to establishing a blast vibration equation with site specific constants, a biologist consultant specialising in bats could also be engaged to monitor bat activity for disturbances, if a review of the 10mms^{-1} limit was warranted. An increase to 20 mms^{-1} could be possible using an approved scientific program.

4.2 Blast Fume and Dust

(a) A weather monitoring station is to be used to ensure the blast is fired when the prevailing winds are blowing away from the Klondyke Queen.

(b) Blasting activities have the potential to result in dust and fume emissions. Dust emissions from blasting are controlled by adequate stemming of the blast.

(c) Blast fumes are typically associated with using ANFO and wet holes. ANFO will react with water and produce fumes, however this is more prevalent for a blast design that uses straight ANFO.

(d) As shown in Table 1, the WGP's blast design includes a wet product (Emulsion) which is used to minimise blast fumes. Blast fumes are very rare when using an Emulsion product, unless a reactive ground or wet ground is present, which may produce some fume emissions.

4.3 Blast Monitoring

(a) Permanent blast monitoring stations will be established at close proximity to the Klondyke Queen (within 10m). The monitor must record both air overpressure and ground vibration for all blasts within 1000m of the Klondyke Queen.

(b) The resultant data plus blast parameters should be used to develop site prediction equations.

(c) Initial site blasting should commence a minimum of 1000m from both the Accommodation Village and the PLNB roosting habitat, until the site prediction equations are established with a high level of confidence.

(d) Blast monitoring will record the following for each blast:

(i). location of blast monitoring site;

(ii). time and date of monitoring;
(iii). blast number and location of blast;
(iv). peak vector sum (PVS - mm/s);
(v). wave form trace; and
(vi). air overpressure peak (dB [Linear Peak])

(e) Detailed climatic and atmospheric conditions including temperature and wind speed and direction at the time of blasting will be monitored at the WGM meteorological station.

4.4 Meteorological Monitoring

(a) Data from the on-site meteorological station will be used to determine whether conditions are suitable for blasting operations at the WGP. The meteorological monitoring station will be maintained for the life of the WGP to:
(i). assist in the prediction of noise, dust and blasting impacts; and
(ii). to provide data at the time of each blast as part of the blast design iterative process.

(b) Data from the on-site meteorological station will be used to establish correlations between weather conditions and blast monitoring results to establish appropriate site specific weather conditions for blasting operations at the WGP. Meteorological conditions will be recorded with each blast (Section 4.3).

5 Blast Monitoring Report

(a) Blast monitoring results will be reviewed on a monthly basis and an annual Blast Monitoring Report will be prepared by an independent specialist which includes a summary of the annual monitoring results and a review and analysis of the results against the blast impact assessment criteria.

(b) If blast monitoring results indicate an exceedance of the blast impact assessment criteria at the relevant blast monitoring locations, the incident investigation procedures will be implemented.

5.1 Annual Review

(a) An Annual Review of this Blast Management Procedure will be undertaken to refine and improve the Environmental Impact of the proposed Open Pit and underground development on the Klondyke Queen.

6 Related Documentation:

CRL-ENV-PLN-006-19 Significant Species Management Plan

7 References

Martin, D (2018). Assessment of Blasting on the Klondyke Queen. A roost site for Pilbara Leave Nosed Bat and Ghost Bat

Martin, D (2012). Scientific Evaluation of Fauna Sensitivity to Blasting, 11th International Symposium on Rock Fragmentation by Blasting, Sydney Australia

Peter O'Bryan and Associates (2019). Warrawoona Project – Geotechnical Review of Blasting Report