Before a joint hearing of the

Otago Regional Council **RM 20.024**
Waitaki District Council

IN THE MATTER OF of the Resource Management Act 1991

AND

IN THE MATTER OF applications by Oceana Gold (New Zealand) Limited for resource consents for the Deepdell North Stage III Project

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STATEMENT OF EVIDENCE BY NICHOLAS ELITH

FOR OCEANA GOLD (NEW ZEALAND) LIMITED

4 AUGUST 2020

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1. INTRODUCTION

- My name is Nicholas Elith. I am Principal Blasting Consultant and Director of TechNick Consulting Pty Limited, Consulting Mining Engineering which has undertaken a wide range of studies for public and private sector clients in Australia, New Zealand and overseas since its inception in 1982.

- I have been asked by OceanaGold (New Zealand) Limited (OceanaGold) to provide evidence in respect of its application for resource consents to establish, operate and rehabilitate its proposed Deepdell North Stage III Project (the Project) at the Macraes site. I have previously prepared technical reports , which are referred to in the "RESOURCES" section below and were attached as Appendices to the Application for consents.

Qualifications and Experience

- My areas of expertise are explosives and blasting and environmental impacts including airblast and vibration effects.

- I hold a Bachelor of Engineering (Mining). I have 50 years' experience in explosives and blasting practices. A summary of my curriculum vitae is attached as Annexure 1. More detailed listings of projects and experience are included as Appendices in my previous technical reports for OGL as listed in the "RESOURCES" section below,

- Prior to establishing TechNick Limited in 1982, I worked as a technical blasting engineer with ICI Australia from 1971 in opencut mines and quarries where blast design and environmental management was a major part of my responsibilities.

- With respect to the Resource Management Act 1991 (RMA), I have prepared evidence for clients covering a number of projects and policies including preparing evidence in relation to the obtaining of consents for previous expansions of OceanaGold's operations at its Macraes sites. A selection of these include the OGL Coronation Project in 2012 and 2015, Golden Point UG, Frasers West and on other blasting matters for South Taranaki District Council.

1. I have read the Code of Conduct for Expert Witnesses in the Environment Court Practice Note 2014. I have agreed to comply. This evidence has been prepared in accordance and I have not omitted to consider material facts known to me that might alter or detract from the opinions expressed.

2. SCOPE OF EVIDENCE

2. My evidence will address the following:

   - Summary of the proposed activity
   - The status of the houses / sites of concern that are of relevance to the blasting side-effects of vibration and airblast
   - The sources of vibration and airblast effects at the mine and the measures that OGNZL proposes to use to avoid and mitigate any undesirable effects of the proposed blasting
   - Calculations of predicted vibration and airblast levels based on history of blasting at similar OGNZL sites
   - Conclusions on the overall vibration and air blast effects of the proposed activity on the surrounding environment

3. EXECUTIVE SUMMARY

3. OGNZL is proposing to re-mine and extend the current Deepdell North Pit, backfill the existing Deepdell South Pit and construct a new waste rock stack (WRS).

4. The proposed Pit area will be mined using the same equipment and processes as are currently used in other areas of the Macraes mining operation.

5. The site is approximately 1.5 kilometres southwest of the nearest residence[1] and 7 kilometres from Macraes Village.

[1] This is the Howard residence. I understand Mr and Mrs Howard have given their written approval in relation the Deepdell North proposal and that therefore any effects on their property are not to be taken into consideration

6. I have not identified any environmental impacts of the proposed blasting program that are likely to cause adverse effects or discomfort to specified neighbouring houses or sensitive sites.

7. Issues concerning vibration, airblast and flyrock can be managed using best practice techniques to ensure that significant adverse effects do not arise. This is due to the large separation distance between the site boundary and nearest residences and the proposed control methods.

8. Calculations based on the Standard AS2187.2 (2006) indicate that vibration and air overpressure levels will be comfortably below those specified as conditions of consent and compliance.

9. The Standard AS2187.2 (2006) states that a ground vibration level of 5 mm/s is acceptable for human comfort and well below any level of damage to housing. The specified residences will experience predicted vibration levels of 3.8mm/s at Howard's residence (1.5 km) and 1.0mm/s at O'Connell residence (3.6 km).

10. An airblast level of less than 115dBL is acceptable for human comfort and well below any level of damage to housing. The two identified residences which are beyond 1km will experience acceptable airblast levels well below this.

SUMMARY OF PROPOSED ACTIVITY

11. OGNZL operates an open pit gold mine at Macraes Flat in North Otago. OGNZL is proposing to re-mine and extend the current Deepdell North Pit, backfill the existing Deepdell South Pit and construct a new waste rock stack (WRS). The project elements are to be known as Deepdell North Stage III Pit, Deepdell South Backfill and Deepdell East WRS.

12. The proposed North Stage III Pit area will be mined using the same equipment and processes as are currently used in other areas of the Macraes mining operation. The mining will use the existing fleet of diesel-powered mining equipment and will involve drilling and blasting in a new[2] proposed location. However, overall, the level of activity at the Macraes Gold Project will not increase.

[2] the proposed pit is an extension of a previously mined pit

ENVIRONMENTAL SETTING

13. The Macraes Gold Project is located in a rural area that is dominated by OGNZL's existing mining activity and low intensity pastoral farming. Macraes Village, located to the southwest of the Gold Project mining area, is a small settlement of approximately 20 houses and an historic hotel.

14. The existing Deepdell North Pit is located to the north of the main Macraes Gold Project, approximately 4.3km from the village. The Deepdell North Stage III Pit is located to the north of Deepdell Creek. Land in the vicinity of the Stage III Pit is similar in character to land around the overall Project area.

15. There are few houses in the area. The closest privately-owned houses to the Stage III Pit boundary will be:

    - the Howard residence (approximately 1.5km and 1.1 km to southwest of the Pit boundary and haul road, respectively); The owners/residents of this address have provided written approval for the proposal, so consideration of effects on this party is not required.

    - the O'Connell residence (approximately 3.6 km to the south of the Pit boundary)

    - The Vanderley residence at Deepdell Station (approximately 4.8 km to the southwest of the Pit boundary)

    - The Tisdall and Roy residences (approximately 5.5 km to the southwest of the Pit boundary).

IMPACTS OF VIBRATION AND AIRBLAST

16. In this report I have considered the predicted vibration and airblast levels at the nearest sensitive sites and particularly residential houses

17. I comment on factors that have the most effect on vibration and airblast.

18. In my previous referenced reports I have provided responses to a list of items raised by council relating to the 115 dBL limit, the frequency of blasting, the expected impact of the depth of the pit, the basis for using a 'K' value of 1450 and how the 115 dBL limit was arrived at in the Standard AS2187.2 2006.

RESOURCES, REPORTS AND REFERENCES

19. The following documents are relevant to my evidence:

- Health and Safety at Work (Hazardous Substances) Regulations 2017
- AS/New Zealand Standard 2187.2 2006
- AS/NZ Standard 2187.2 2006 Extracts: J7 ESTIMATION OF GROUND VIBRATION AND AIRBLAST LEVELS
- Report - Technical Report January 2018b Mining Vibration Assessment – Deepdell North Stage III Project by N Elith 17 January 2018
- Report – "+Deepdell blasting Enviro update 8-18 V.3" Mining Airblast Assessment – Deepdell North Stage III Project Macraes New Zealand by N Elith 17 September 2018
- Report – 'Covernote for council queries 8-18' Response to feedback & queries from council by N Elith 17 September 2018
- Report – '+Deepdell blasting Enviro update 5-19' by N Elith 24 May 2019
- Report – '+Deepdell blasting Enviro covernote 3-20' Mining Vibration Assessment – Deepdell North Stage III Project Macraes New Zealand – response to queries by N Elith 26 March 2020
- Response to queries raised from a council review of Deepdell Report by N Elith, requested in email on 14/02/2020
- Actual historical Airblast / overpressure readings at the existing Macraes goldmine operations including the Deepdell project
- Macraes Phase III Vibration and Air Blast Assessment by Orica Mining Services 30 March 2010
- 01 OGL Deepdell Stage III 42A WAITAKI DISTRICT COUNCIL Report Final 29 Jul 20
- Statement of evidence Scott Sutherland Tonkin and Taylor Geotech - 15 July 2020
- Various aerial maps, residence locations, wind rose contours and project elements

- OceanaGold resource prior consents for mining operations at Macraes gold projects
- Otago Regional Council - Section 42A Staff Recommending Report 28 July 2020

BLAST DESIGN CHARACTERISTICS

20. Blast designs for the Deepdell North Open Pit including drilling, charging, stemming, and firing procedures will be essentially the same as those used at the existing Macraes goldmine operations where historic data shows that airblast / overpressure readings have never exceeded the 115 dBL level. This will be largely because the AS2187.2 predictive formulae are based on typical hard rock, opencut, operations with substantial bench heights and free faces. This gives an inherent safety buffer on all predictions.

21. I have used these values to calculate predicted environmental effects for the Deepdell North Open Pit. The following table gives an indication of typical blast design parameters and explosives charge mass per hole, and per delay interval (MIC = Maximum Instantaneous Charge) for the types of blasting employed at OceanaGold open pits at Macraes gold project.

	Ore	Waste
Diameter (mm)	102mm	229mm
Explos/hole (kg)	50 kg	450 kg
Explos MIC (kg) to 3 holes / delay	200 kg	1350 kg

22. It has been demonstrated that there is a substantial factor of safety in the planned designs. More significantly it is a simple matter to make design changes to the degree of confinement, mainly through adjustments to stemming lengths, which have the most dramatic effect on airblast reductions, and this will be done on a blast by blast basis according to actual airblast recordings.

FACTORS TO REDUCE VIBRATION AND AIRBLAST

23. The following management measures can be employed to reduce effects:

- Designing the blast initiation sequence to avoid excessive timing overlaps

- Accurate survey and layout of drill hole positions
- Checking depths and angles of holes after drilling
- Rechecking hole depths immediately before charging
- Suitable priming practices including the location of primer
- Continuous monitoring of explosives charging
- Checking explosives, column rise
- Ensuring stemming quality and quantity are as per design
- On-bench attention to initiation delay detonators
- Style of blast (OCG employs Paddock blasts rather than free face blasts) (Airblast)
- Considering the effect of topography, bunds, deep pits (Airblast)
- Protective shielding such as the now-existing dump giving added buffering (Airblast)
- Control maximum explosives charge per delay (by cube root scaling)
- Charge confinement - Depth of burial / Stemming length (Airblast)
- Confinement of energy - Front row burdens, hole spacings (Airblast)
- Accurate survey and layout of drill hole positions
- Checking depths and angles of holes after drilling
- Rechecking hold depths immediately before charging
- Suitable priming practices including the location of primer
- Continuous monitoring of explosives charging

- Checking explosives, column rise
- Ensuring stemming quality and quantity are as per design (Airblast)
- On-bench attention to initiation delay detonators
- Managing delay intervals and designing the blast initiation sequence to avoid excessive timing overlaps
- Minimise exposed detonating cord initiation system (Airblast)
- Adapt to atmospheric conditions – inversions or strong, unfavourable wind direction and choice of blast time (Airblast)

24. It is also relevant here to note that AS 2187.2 states: "Airblast is proportional to the cube root of the charge mass. This limits the effectiveness of charge mass reduction as a method of reducing airblast levels; Other factors are often more important, especially confinement of blasthole charges".

PREDICTION OF VIBRATION LEVELS

25. Vibration levels are calculated and stated as a peak particle velocity ('PPV') value and measured in millimetres per second (mm/s).

26. Predicted vibration levels for properly designed, drilled and charged blasts in medium strength rock can be calculated. I have used a 'K' value based on records of blast monitoring previously undertaken at Deepdell North and South Pits in 2001 to 2003 and note that many blasts did not generate sufficient vibration to trigger the instruments. These values are likely to be representative of proposed blasting.

27. This can be verified and calibrated at the earliest occasions of smaller, conservative, pilot-scale blasts conducted at the commencement of blast operations in opening up the new pit.

28. The formula used for predicting vibration levels is:

$$V = K \times \left(\frac{\sqrt{W}}{D} \right)^{1.6}$$

where:

V = peak particle velocity (PPV)
W = explosives charge per delay (kg)
D = distance to damageable "target" (m)
K is a constant related to rock properties & blast design

VIBRATION PREDICTIONS FOR DEEPDELL NORTH PROJECT

29. The following Table has been calculated using the AS2187.2 formula, using a 'K' value of 1450 which is about double the number back-calculated from the historical records as shown in the table above. This is the first built-in safety factor in my vibration impact predictions.

30. Typical blasthole designs and configurations may have up to 3 holes per delay (MIC) and I have used the explosives charge mass for waste blasting because it gives a worst case as this mode of blasting employs more explosives than for ore shots. This is the second built-in safety factor in my vibration impact predictions.

MIC# (kg)	Distance (metres)	ppv (mm/s)
1350	500m	22.3
1350	1000m	7.3
1350	1500 m *	3.8
1350	2000 m	2.4
1350	2300 m	1.9
1350	3600 m **	1.0

(MIC = maximum instantaneous charge)

* Howard residence = ~1500m
** O'Connell residence = ~3600m

31. It is clear that expected vibration levels for any sensitive residences beyond ~1500m are less than the 5 mm/s safe limits stated in the Standard. I understand that there are no sensitive sites (not including OceanaGold-owned property and services) within 1000m of the blasting locations.

32. An additional safety factor is that if any actual vibration recordings approach the acceptable 5mm/s value for any blast location, then the operators can simply and substantially reduce the vibrations by adjusting the MIC by either changing the initiation timing to have less holes per delay, or by reducing the kg per hole. The Standards for vibration also allow for an occasional vibration level to be up to 10 mm/s (1 in 20 blasts) whilst still ensuring no damage whatsoever.

PREDICTION OF AIRBLAST LEVELS

33. It is difficult to accurately predict airblast levels because of a diversity of blasting configurations and the effects of orientation, weather and topography. According to AS2187.2 an airblast level of 115 to 120 dBL is considered reasonable for human comfort.

34. Airblast levels are readily reduced by increasing the stemming length on blastholes, and this technique would typically be used, if necessary, in the highest bench levels where there is less opportunity for airblast levels to be reduced by enclosure within the pit itself. Airblast will reduce as the mine benches get deeper with time. As such the airblast levels are expected to remain less than 115 dBL at the nearest sensitive receptors throughout mining of the proposed pit.

35. AS 2187.2 2006: section J7.2 Airblast overpressure, indicates that Airblast levels are commonly estimated using the following cube root scaling formula:

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

Where

- P = pressure (kPa)
- Q = explosives charge mass (kg)
- R = distance from charge (m)
- Ka = site constant
- a = site exponent

$$P = 40 X \left(\frac{R}{Q^{1/3}} \right)^{-1.45}$$

36. Applying this to the Deepdell situation gives an indication of calculated air over-pressure values (kPa) using the latest AS2187.2 formula, and equivalent dBL levels for the larger 1350kg per hole waste blasting designs using a site exponent (ά) of -1.45, the site constant (Ka) of 40 which is appropriate given the blast design methodology (MIC = Maximum Instantaneous Charge = effective 'Q')

MIC (kg)	Distance (metres)	Overpressure (kPa)	Airblast (dBL)
1350	1500 m *	0.032	103
1350	2000 m	0.021	92
1350	2300 m	0.017	86
1350	3600 m **	0.009	71

- * Howard residence = ~1500m
- ** O'Connell residence = ~3600m

37. According to calculations using the AS2187.2 Standard, the predicted airblast levels are well below the 115 dBL limit at the prescribed residences

S.42A REPORTS AND RECOMMENDATIONS

38. The Waitaki District Council s.42A report by Mr Purves notes the vibration effects of the proposal and the assessments provided as part of the application in paragraphs 129 and 130. Mr Purves comments that no vibration assessment supports the conclusions regarding vibration in the report I prepared.[3]

39. The vibration effects conclusions in my report are based on an earlier vibration effects report that I prepared for OceanaGold for this proposal in January 2018. This report is referred to in my letter dated 26th March 2020 which was provided to Otago Regional Council by OceanaGold on 1 April 2020 as part of further information requests. The earlier vibration report referred to in that correspondence is still valid, and is attached to this evidence as Annexure 2 and provides the assessments informing my conclusions on the vibration effects of the proposal.

[3] Mr Purves notes however in paragraph 132 of the Waitaki District Council s.42a report that he is satisfied with the approach taken in the proposed conditions to address air blast effects of the blasting and notes further in paragraph 147 that vibration effects of the operations appear to be manageable and should be able to be adequately addressed through conditions of consent;

CONCLUSIONS

40. I have not identified any environmental impacts of the proposed blasting program that are likely to cause adverse effects or discomfort to specified neighbouring houses or sensitive sites. Issues concerning vibration, airblast and flyrock can be managed using best practice techniques to ensure that significant adverse effects do not arise.

41. The Standard AS2187.2 (2006) states that a ground vibration level of 5 mm/s is acceptable for human comfort and well below any level of damage to housing. The specified residences will experience predicted vibration levels of 3.8mm/s at Howard's residence (1.5 km) and 1.0mm/s at O'Connell residence (3.6 km). These levels are below the acceptable vibration limit and the Howards have provided written approval for the proposed activities.

42. An airblast level of 120 decibels is acceptable for human comfort and well below any level of damage to housing. AS2187.2 states that damage (even of a cosmetic nature) has not been found to occur at airblast levels below 133 dBL

43. Using the latest formula, the two private residences have predicted airblast levels of 103 dBL at Howard's residence (1.5 km) and 71 dBL at O'Connell residence (3.6 km). These values are well below human discomfort levels and can be further reduced by increasing stemming lengths if there is any concern.

Yours faithfully

Nick Elith B.E. (Mining)
Explosives Engineer
Special Blasting Applications

ANNEXURE 1 SUMMARY OF EXPERTISE

Nicholas Elith

Bachelor of Engineering (Mining) University of Sydney 1971

POSITION Principal Blasting Consultant - technick Consulting P/L. - Consulting Mining Engineers

DATE OF BIRTH 27-07-1948

PREVIOUS AFFILIATIONS Member; Australasian Institute of Mining & Metallurgy, Member; International Society of Explosives Engineers

EXPERIENCE 50 years involvement in explosives and blasting practices.

1971 to Present:

- Principle Blasting Consultant : technick Consulting Pty. Ltd.
- Consulting to the mining, quarrying and construction industries in:
- Blasting principles and Blasting Physics applications
- Safety and Cost Efficiency in blasting; Opencut and Underground
- Blast Design and implementation - Opencut and Underground
- Conducting On-site drilling & blasting Operational Audits
- Initiation Systems application and design
- Field evaluation of new explosives and Initiation Systems technologies
- Technical writing: Blasting manuals, Operational Procedures
- Training resources, graphics, Safety / promotional materials
- Competency-based Shotfirer training (Opencut & Underground)
- Author of Opencut and Underground blasting manuals
- Underground Coal Mine Shotfiring, Training, Risk Assess, Design, Audit
- Demolitions: Structures, Buildings, Machinery (steel, concrete etc.)
- Submarine / Underwater blasting and demolitions
- Environmentally sensitive blast design, analysis and supervision
- Investigation of explosives accidents and Incidents
- Legal "Expert Witness" representation

ANNEXURE 2 TECHNICAL REPORT JANUARY 2018B MINING VIBRATION ASSESSMENT – DEEPDELL NORTH STAGE III PROJECT

Technical Report

January 2018b

for

Marty Hughes; Senior Projects Engineer

OceanaGold (New Zealand) Limited

Mining Vibration Assessment – Deepdell North Stage III Project

Macraes New Zealand

I am a mining engineer who has specialised in explosives technology and commercial blasting applications for my 45+ year career. As outlined in my CV (Appendix) I work in most areas of civil and mining blasting including opencut and construction blasting. A major portion of my work in the past 30 years has been in managing Risk Assessments, blasting project evaluation, auditing blasting performances and training engineers and shotfirers in safe & efficient blasting.

Nick Elith B.E. Mining

MAusIMM, Member ISEE

Principal Blasting Consultant

techNick Consulting P/L

Consulting Explosives Engineers

30 January 2018

Limit of Liability

TechNick makes considerable effort to ensure an accurate understanding of client requirements but recognises in particular the uncertainties of site geology. The information contained in this report is as accurate as possible based on provided data. TechNick accepts no liability to any person for any injury, loss or damage resulting from the use of or reliance upon the information contained in this report or for any injury, loss or damage resulting from the omission of any information in this report. No expressed or implied warranties are given other than mandatory obligations implied by Commonwealth, State or Territory legislation.

Contents

1. REPORT OBJECTIVES

In this report I have conducted simple modelling of expected blast designs similar to those used at the current “OceanaGold” New Zealand Limited Macraes gold project because similar blasting parameters will be use for the Deepdell North project. From these designs I have calculated anticipated vibration and airblast levels. I then consider the implications of these predicted blasting effects on the nearest sensitive sites and particularly residential houses not owned by OceanaGold.

2. EXECUTIVE SUMMARY

i. I have not identified any environmental impacts of the proposed blasting program that are likely to cause adverse effects or discomfort to specified neighbouring houses or sensitive sites. Issues concerning vibration, airblast and flyrock can be managed using best practice techniques to ensure that significant adverse effects do not arise.

ii. The AS / NZ Standard AS/NZ 2187.2 (2006) states that an occasional ground vibration level of up to 10 mm/s are acceptable for human comfort and well below any level of damage to housing. The two residences beyond 1km will experience acceptable vibration levels.

iii. An airblast level of 120 decibels is acceptable for human comfort and well below any level of damage to housing. The two residences beyond 1km will experience acceptable airblast levels.

iv. Other consequences of blasting, such as flyrock and dust generation, will need to be managed. Potential hazards can be adequately addressed by continuing to apply the mitigation measures successfully used at Macraes Gold Project over recent years.

3. BLAST REQUIREMENTS

Mining activity will revolve around development of the new Deepdell North openpit and associated waste rock stack. This activity will be similar in nature to the activities already taking place at Macraes gold project. Drilling and blasting will cause some noise, vibration, flyrock and dust events.

Mitigation measures will include the following:

- Designing the blast initiation sequence to avoid excessive timing overlaps
- Accurate survey and layout of drill hole positions
- Checking depths and angles of holes after drilling
- Rechecking hole depths immediately before charging
- Suitable priming practices including the location of primer
- Continuous monitoring of explosives charging
- Checking explosives, column rise
- Ensuring stemming quality and quantity are as per design
- On-bench attention to initiation delay detonators

Best blasting practices and appropriate mitigation measures will greatly assist in reducing the impacts of these activities.

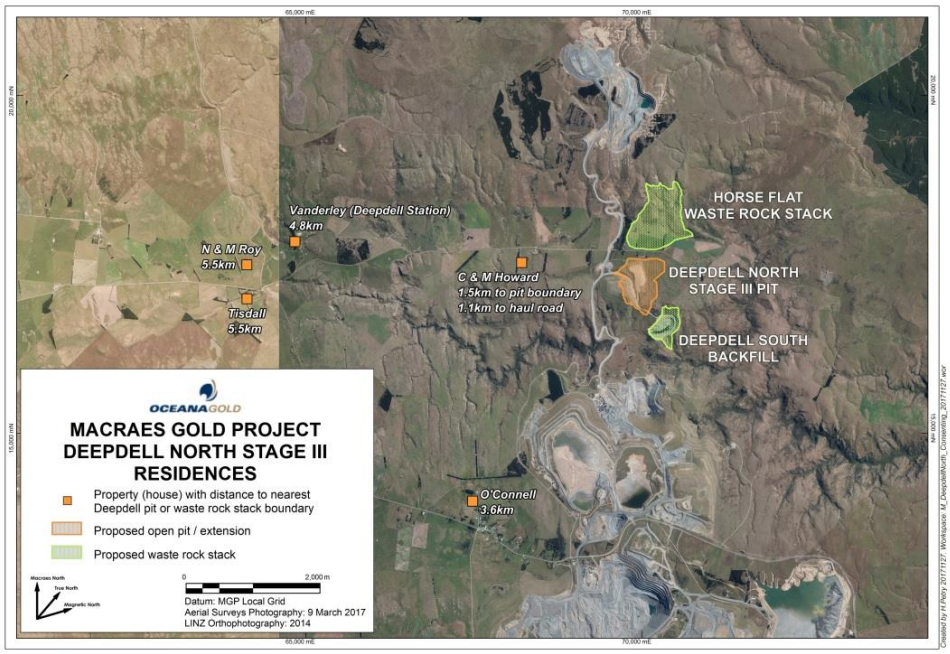
4. SENSITIVE AREAS

In assessing blasting impacts I have considered which residences might be considered the most sensitive. Two residences owned by OGL are closest to the open pit are within 1km of the proposed mining. These are untenanted and will remain so. One of these will cease to exist as it is in the area of the waste rock stack and the southern one will be either dismantled or used for mine operations as a shift staging area. As such any effects on these residences have not been included in this report.

Two privately-owned residences have been identified within a range of 3.6km from blasting activities. These are:

i. Howard residence = ~ 1.5 km from Deepdell North Open Pit boundary
ii. O'Connell residence = ~ 3.6 km from Deepdell North Open Pit boundary

Deepdell North Station is not considered to be at any risk as it is much further away ~ 4.8 km from the Deepdell North Open Pit boundary



5. BLAST DESIGN CHARACTERISTICS

Blast designs for the Deepdell North Open Pit including drilling, charging, stemming and firing procedures will be essentially the same as those used at the existing Macraes goldmine operations so I have used these values to calculate predicted environmental effects for the Deepdell North Open Pit. The following table gives an indication of typical blast design parameters and explosives charge mass per hole, and per delay interval (MIC = Maximum Instantaneous Charge) for the types of blasting employed at OceanaGold open pits at Macraes gold project. In this table I have used a 'worst case' initiation design where up to 3 holes are firing next to one another and simultaneously giving maximum vibration reinforcement. In fact this does not occur in practice since holes will have selected, pre-determined millisecond delays and as per previous blasting records, charges firing at similar time intervals will be distributed physically throughout the blast pattern so will not give full reinforcement of vibration.

	Ore	Waste
Diameter (mm)	102mm	229mm
Explos/hole (kg)	50 kg	450 kg
Explos MIC (kg) to 3 holes / delay	200 kg	1350 kg

1.1.1 EXISTING RESOURCE CONSENT CONDITIONS MACRAES:

OceanaGold holds resource consents for mining operations at Macraes gold project which impose conditions upon blasting activities. OceanaGold proposes that the same parameters and conditions (appropriately modified) will apply to the Deepdell North project.

The conditions include:

"Blasting shall be restricted to within the following hours:

- Monday-Friday 9am to 5.30pm
- Saturday and Sunday 10am to 4.30pm."

"Vibration due to blasting or any other activity associated with the mining operation, when measured at any point within the notional boundary of any dwelling not owned by the consent holder, school or church outside the Macraes Mining Project Mineral Zone as defined by the Waitaki District Plan, deemed operative on 23 August 2010 shall not exceed a peak particle velocity measured in the frequency range 3-12 Hz of 5 mm/sec provided this level may be exceeded on up to 5% of the total number of blasts over a period of 12 months. The level shall not exceed 10 mm/sec at any time."

"Airblast overpressure from blasting associated with the mining operation, when measured at any point within the notional boundary of any dwelling not owned by the consent holder, school or church outside the Macraes Mining Project Mineral Zone as defined by the Waitaki District Plan, deemed operative on 23 August 2010 shall not exceed a peak non-frequency-weighted (Linear or flat) level of 115 decibels (dB), provided this level may be exceeded on up to 5% of the total number of blasts over a period of 12 months. The level shall not exceed 120 dB (Linear peak) at any time. For the purpose of this consent, C-frequency-weighting may be considered equivalent to the Linear or Flat-frequency-weighting."

At the two closer private residences (Howard residence (1.5 km) and O'Connell residence (3.6 km)) the above resource consent conditions for times of blasting, vibrations and airblast are able to be met for the Deepdell North project.

1.1.2 BLAST-INDUCED VIBRATIONS

Vibration levels are calculated and stated as a peak particle velocity ('PPV') value and measured in millimetres per second (mm/s).

Predicted vibration levels for properly designed, drilled and charged blasts in medium strength rock can be calculated. I have used a 'K' value based on records of blast monitoring previously undertaken at Deepdell North and South Pits in 2001 to 2003 (see Table below and note that many blasts did not generate sufficient vibration to trigger the instruments) These values are likely to be representative of proposed blasting.

This can be verified and calibrated at the earliest occasions of smaller, conservative, pilot-scale blasts conducted at the commencement of blast operations in opening up the new pit.

1..1 WHAT VIBRATION ARE ACCEPTABLE?

The following extract is from the Standard AS: 2187.2 (2006)

APPENDIX J TABLE J4.5(A) GROUND VIBRATION LIMITS FOR HUMAN COMFORT

Category	Type of blasting operations	Peak component particle velocity (mm/s)
Sensitive site*	Operations lasting longer than 12 months or more than 20 blasts.	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
Sensitive site*	Operations lasting for less than 12 months or 20 blasts.	10 mm/s maximum unless agreement is reached with occupier that a higher limit may apply
Occupied non-sensitive sites, such as factories and commercial premises	All blasting	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

* Sensitive site includes private houses & low rise residential buildings, theatres, schools, etc occupied by people.

1..2 HISTORICAL VIBRATION READINGS AT DEEPDELL NORTH

The following table contains records of actual blast monitoring Deepdell North from 2001 to 2003. We don't have vibration recordings for a number of these blasts and one reason for this can be that the vibration levels were too low to trigger the monitor. This appears to the most likely explanation because those blasts that do have an actual vibration reading have produced low particle velocities.

Date	Blast Location	Monitor Location	Distance to Blast (m)	RPPV (mm/s)	Peak Sound(dBA)	Wind Direction	MIC @ 2 holes/ delay	K' value
27-Feb-01	Deepdell Pit	Deer paddocks	1000	3	<100		1000	754
01-Mar-01	Deepdell Pit	Deer paddocks	1000	2.5	<100	NW	1000	628
08-Mar-01	Deepdell Pit	Deer paddocks	1000	2.5	<100		1000	628
14-May-01	Deepdell Pit	Deer paddocks	1000	0.4	<100	SW		
21-May-01	Deepdell Pit	Deer paddocks	1000	0.8	<100			
21-Jun-01	Deepdell Pit	Howards House	1000	0.4	<100	SW		
26-Jun-01	Deepdell Pit	Howards House	1000	2.1	<100		1000	527
16-Jul-01	Deepdell Pit	Historic Reserve	1000	0	<100	NE		
31-Jul-01	Deepdell Pit	Howards House	1000	0	<100	SW		
28-Aug-01	Deepdell Pit	Historic reserve	1000	2	<100		1000	502
24-Sep-01	Deepdell Pit	Howards House	1500	0	<100	Ne		
03-Sep-02	Deepdell Pit	Howards House	1500	0		S		
24-Oct-02	Deepdell Pit	Historic Reserve	800	0		S		
24-Oct-02	Deepdell Pit	Historic Reserve	800	0				
30-Oct-02	Deepdell Pit	Howards House	1500	0		S		
17-Dec-02	Deepdell Pit	Historic Reserve	1200	0	<100			
28-Mar-03	Deepdell Pit	Historic Reserve	800	0	<100	N		
03-Oct-03	Deepdell Pit	Historic Reserve	1000	0.3	<100			

Records of blast monitoring Deepdell North 2001 to 2003

The formula used for vibration is:

$$\mathbf{V} = \mathbf{K} \times \left(\frac{\sqrt{\mathbf{W}}}{\mathbf{D}} \right)^{1.6}$$

where:

V = peak particle velocity (PPV)

W = explosives charge per delay (kg)

D = distance to damageable “target” (m)

K is a constant related to rock properties & blast design

1.1.3 VIBRATION PREDICTIONS FOR DEEPDELL NORTH PROJECT

The following Table has been calculated using the AS/New Zealand 2187.2 Standard formula, using a 'K' value of 1450 which is about double the number back-calculated from the historical records as shown in the table above. This is the first built-in safety factor in my vibration impact predictions.

Typical blasthole designs and configurations may have up to 3 holes per delay (MIC) and I have used the explosives charge mass for waste blasting because it gives a worst case as this mode of blasting employs more explosives than for ore shots. . This is the second built-in safety factor in my vibration impact predictions.

MIC# (kg)	Distance (metres)	ppv (mm/s)
1350	500m	22.3
1350	1000m	7.3
1350	1500 m *	3.8
1350	2000 m	2.4
1350	2300 m	1.9
1350	3600 m **	1.0

(MIC = maximum instantaneous charge)

* Howard residence = ~1500m
** O'Connell residence = ~3600m

It is clear that expected vibration levels for any sensitive residences beyond ~1500m are less than the 5 mm/s safe limits stated in the Standard. I understand that there are no sensitive sites (not including OceanaGold-owned property and services) within 1000m of the blasting locations.

As a third safety factor it should be noted that if any actual vibration recordings approached the lower acceptable 5mm/s value for any blast location, then the operators can simply and substantially reduce the vibrations by adjusting the MIC by either changing the initiation timing to have less holes per delay, or by reducing the kg per hole. The Standards for vibration also allow for an occasional vibration level to be up to 10 mm/s (1 in 20 blasts) whilst still ensuring no damage whatsoever.

1.1.4 AIRBLAST

It is difficult to accurately predict airblast levels because of a diversity of blasting configurations, especially the stemming lengths chosen, and the effects of orientation, weather and topography. According to AS/NZ 2187.2 an airblast level of 115 to 120 dBL is considered reasonable for human comfort. AS/NZ 2187.2 states:

> ***J5.3 Damage limits -*** *From Australian and overseas research, damage (even of a cosmetic nature) has not been found to occur at airblast levels below 133 dBL The probability of damage increases as the airblast levels increase above this level. Windows are the building element currently regarded as most sensitive to airblast, and damage to windows is considered as improbable below 140 dBL.*

The following table gives an indication of calculated air over-pressure values using the AS/New Zealand 2187.2 formula, for the higher kg per hole waste blasting designs.

$$\mathbf{P} = \mathbf{K} \times \left(\frac{\sqrt[3]{\mathbf{W}}}{\mathbf{D}} \right)^{1.2}$$

(MIC = maximum instantaneous charge)

MIC (kg)	Distance (metres)	Airblast (dBL)
1350	1000m	117
1350	1500 m *	113
1350	2000 m	110
1350	2300 m	108
1350	3600 m **	104

* Howard residence = ~1500m
** O'Connell residence = ~3600m

It is worth noting that the airblast levels, measured in dBL, are based on a logarithmic scale. This means that a decrease of 6 dBL represents a halving of the absolute air over-pressure as measured in kilopascals. A corollary to this is that even if the actual blast air pressure was double the prediction at 1500m, the airblast dBL level would still only reach 119 dBL which according to the AS/NZ 2187.2 is acceptable for human comfort for a small percentage of blasts.

Strong winds will increase the airblast levels in the down wind direction. A wind strength of about 33 km/hr increases the air overpressure level by 6 dBL if strong winds are blowing toward the Howard residence at the time a larger waste blast is planned for firing, then it would be wise to postpone the blast until later in the day when more favourable wind directions occur, or the wind levels drop. Alternatively the blast could be postponed until a favourable time the next day. This practice is common in some mining operations because winds in the morning are often quite different, calmer and favourable compared to those in the afternoon.

I have perused documents relating to seasonal wind directions in the area including “Macraes Mine - Summary of Ambient Air Monitoring Results for 2016.doc”; of January 2018 and “DDN3 Wind Rose” for Macraes Flat. It is incumbent on the mine operations management to make an assessment of the weather conditions on the day of any proposed blast to decide the appropriate actions and timing of blasting events to ensure neighbours are not disturbed and all blasts are compliant with regulations.

Airblast levels are readily reduced by increasing the stemming length on blastholes, and this may be appropriate in the highest bench levels. Airblast will reduce as the mine benches get deeper with time. As such the airblast levels are expected to remain less than the 115 dBL safe limits stated in the Standard.

It is unlikely that this level will be exceeded under normal operating conditions, although extra attention may be needed if the prevailing wind is strong and toward the Howard’s residence.

6. BLASTING RISK ASSESSMENT - BLAST ACTIVITIES AND HAZARDS

Blasting activities have risks that must be eliminated or mitigated by exercising best practice and procedures. Best practice will ensure safety and environmental assurance. The following table indicates most of the more common blasting hazards and steps to control them.

Activity	Potential hazards & effects	Recommended elimination measures
Flyrock – to 50 m	Mild damage to facilities	Use earth cover buffer Control stemming

Flyrock – to 200 m	Personnel injury	Specified clearances and enforced QA procedure
Airblast damage	Break windows @ 75m (150dBL)	Stemming and charge controls
Airblast – Surprise neighbours	Complaints, objections, Anxiety	Levels at privately owned houses will be below limits (<115 dBL) Apply normal Stemming and controls
Vibration – blasting at zero to 1000m	Houses will experience acceptable levels of vibration under 5 mm/s	Initiation systems designed to achieve not more than 3 holes / delay
Blast initiation	Premature initiation, unauthorised vehicles on bench or within zone	Control of firing line location Effective blast clearance
Overcharged holes QA	Flyrock bursts, vibration	Managed onsite charging procedure
Uncontrolled Spectators	Injury	Supervision, controls, communication
Misfires	Explosion, digging problems	Procedures
Severe weather Lightning	Difficulty charging correctly Initiation of blast	Procedure No fire if lightning closer than 7 km - Check weather
Explosives Handle / Store	Injury, tampering Unapproved quantities transport	Regulations, Approvals, Licensing Establish approved site

7. CONCLUSIONS

i. I have not identified any environmental impacts of the proposed blasting program that are likely to cause adverse effects or discomfort to specified neighbouring houses or sensitive sites. Issues concerning vibration, airblast and flyrock can be managed using best practice techniques to ensure that significant adverse effects do not arise.

ii. The AS / NZ Standard AS/NZ 2187.2 (2006) states that a ground vibration level of 5 mm/s is acceptable for human comfort and well below any level of damage to housing. The two residences beyond one kilometre will experience predicted vibration levels of 3.8mm/s at Howard's residence (1.5 km) and 1.0mm/s at O'Connell residence (3.6 km). These levels are below the acceptable 5mm/s vibration limit for 95% of blasts and well below the occasional allowable vibration of 10mm/s which according to the NZ Standard is still expected to cause no damage at all. OGL owned residences within 1km are untenanted and will not be tenanted during the operations of the Deepdell North Project.

iii. An airblast level of 120 decibels is acceptable for human comfort and well below any level of damage to housing. AS/NZ 2187.2 states that damage (even of a cosmetic nature) has not been found to occur at airblast levels below 133 dBL

iv. The two private residences have predicted airblast levels of 113 dBL at Howard's residence (1.5 km) and 104 dBL at O'Connell residence (3.6 km). These levels are well below any threshold of damage (133 decibels) or human discomfort (over 120dBL) and can be further reduced by increasing stemming lengths if there is any concern.

v. Other consequences of blasting, such as flyrock and dust generation, will need to be managed. Potential hazards can be adequately addressed by continuing to apply the mitigation measures successfully used at Macraes Gold Project over recent years.

vi. Having stated my opinion that no damage is likely to occur to the nearest houses, it may be prudent, and give comfort and assurance to the neighbours, that OGL is committed to being a good citizen and caring for people's welfare and property, by carrying out a current property condition survey in conjunction with the home owners.

Yours faithfully

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Special Blasting Applications