UR1976_46

1976/46. Vibrational effects to be expected within the boundaries of the Housing Commission development at Bridgewater resulting from the operation of Hobart Quarries Ltd Bridgewater Quarry.

P. Allan

Bridgewater Quarry is sited at Parkholm [EN197694] in the vicinity of Bridgewater north-east of the River Derwent. The land, owned by Hobart Quarries Pty Ltd, is some 214 ha in extent with boundaries on the Midland Highway, Old Beach Road and the Jordan River (fig. 1).

The owners have operated a quarry at Giblin Street on Mount Stuart for 28 years which still accounts for a major portion of their production, but the steady encroachment of private housing development in the immediate vicinity led to increasingly stringent restrictions on the operation and a premature limit to its economic viability.

In 1968 the Company foresightedly acquired its present land holdings at Bridgewater with the intention of developing a replacement for the existing Giblin Street operation along with an open ended expansion geared to the steadily increasing demand for basic raw material. While the development of the area is now complete the essential expansion, which must take place before the wind-up of the Giblin Street operation can be contemplated, has been placed in jeopardy by the premature encroachment of housing on the new site.

Land zoning in the vicinity envisaged heavy and extractive industry along with some commercial in the immediate vicinity of the operations with residential confined south of Old Beach Road.

In 1974 the Housing Department engaged the firm of P.G. Pak-Poy and Associates Pty Ltd to carry out a Strategic Development Study of the Bridgewater area. The study clearly favoured a non-encroachment policy to the quarry and advised the Housing Department to involve itself in a "minimum initial cost outlay on land that is not essential for the future development of housing in the State".

Although advised to keep 1000 metres from the quarry, the Housing Department proceeded with the planning and initial works on housing to within 600 metres of the quarry and began preliminary planning for an area to the north of the Old Beach Road and immediately adjacent to the quarry. Reports from the Special Duties Inspector of Mines on the vibration levels certain to be generated led to the cancellation of the plans for the adjacent area but only to a slow-down in the preparation work immediately to the south of the Old Beach Road.

First tests indicated that alterations in the subsurface geology could deleteriously affect the vibration attenuation as the quarry approached its southern limit and this became the subject of a separate investigation.

Before arriving at the stage of establishing any firm levels of vibration, work proceeded on developing a basic method of blasting which would give a minimum vibration at source and a consistent resultant at the property boundaries. There was also an indication that some improvement could be obtained at the quarry by study of and experimentation with, the actual blasting. It was found, for instance, that due to a policy decision within the Readymix Group a "standard" blasting method had been introduced into the quarry which involved the use of a limited number of millisecond delays in a round so that 6 holes per delay were fired in a round of some 36 holes. This resulted in the use of part-series delay detonators *e.g.*

1-6; 7-12; 13-18, the last named part-series being a pulse generator on a 30 ms period due to the even interval used on this stage of the series. Vibration tests gave an extrapolated particle velocity of 9 - 12 mm/sec which is 63% of the limit imposed by the SAA Explosives Code (CA23) for structural damage with a factor of safety of six. Such vibration is however some four to six times the general complaint level and obviously had to be reduced while at the same time maintaining production in the quarry.

By utilising two complete millisecond series of detonators and increasing the number of holes, the charges per delay were reduced from six to two. By designing an interference pattern at source into the order of firing while using the complete series, the vibration levels on extrapolation were reduced to 1 - 2 mm/sec particle velocity, a reduction in excess of 80%. Vibrational test data on this phase of the operations is given in Appendix 1.

The interference pattern introduced aimed at reducing the explosives factor at a point source by separating like delays to a minimum of three holes apart *i.e.* the series is inserted so that at least two charges are placed between like numbers. The full theoretical round obtained by this method is shown in Appendix 3 and its effective operation has been field-tested and proven in the quarry where to date the results have been eminently acceptable for both production and vibration. The indicated vibration range extrapolated from the field test is shown in Appendix 2 for a radius of 500 m from the face.

The normal drilling pattern now consists of three rows of 20 m holes on a 2.5 x 2.5 pattern to maintain a 16 m face and establish a level quarry floor with good toe clearance.

The total weight of explosives used per round should not exceed 1700 kg or 89.5 kg per delay. Full delay series should always be used and inserted into the pattern so that at least two holes intervene between like delay numbers and full advantage should be taken of any available free faces.

A 36 - 38 hole round under these conditions should produce some 7 500 tonnes per blast (or 375 000 typ) which is considered an adequate quantity per blasting day per week.

Where secondary firing is necessary, it is not considered essential for delay series firing when the criterion for estabilishing the number of shots fired at any one time is taken as the total weight of explosives used. This should not exceed 1 kg.

In conditions of fog or low cloud secondary firing should not take place nor should it be carried out at a distance from the quarry face greater than twice the face height if that face is to be effective as a sound barrier.

With closely controlled blasting it can be predicted that vibrations surrounding the quarry will be below structural damage levels but to expect them to be below complaint level, which can be as low as a particle velocity of 0.5 mm/sec, is unrealistic at any point within 1 km of the blast point.

Present blasting is confined to Fridays between 11.30 a.m. and 2.30 p.m. the leeway on time being essential for absorbing unforseen circumstances. When the production expands blasting will have to be carried out

on additional days, *i.e.* the blast size will remain constant while the frequency of blasts will increase.

When building up the blasting days they should be kept spread for as long as possible in something like the following manner:

2nd blast day to be introduced - Wednesday
3rd blast day to be introduced - Monday
4th blast day to be introduced - Tuesday
5th blast day to be introduced - Thursday

Secondary firing should be done on the blasting day, within the blasting period and, where possible, at approximately the same time, say 12 noon, so that surrounding residents become habituated to the procedure.

The quarry will be required at some future date to go deeper and this is worthy of immediate consideration along with an extension of the present working face towards the eastern boundary. The present working face could be reduced in height by 3 m with a consequent saving in drilling and explosives without any detrimental effect on production.

As mentioned in relation to secondary firing this face is presently effective as a sound barrier but should it advance any further than its present position this advantage will be lost while establishing a second, lower face.

The second working face should be established now and planned to reach a final height of 13 m with the present working face reduced to the same height, *i.e.* the total working depth of the quarry to be 26 m. The lower face can approach to within 50 m of the present face which should then be worked to leave behind a 3 m toe bench which will later be absorbed into the lower face to bring it to its full 13 m. While this face is being initially developed production in the quarry can be maintained by extending the upper face to the east at a height of 13 m (final) while taking advantage of the present face as a sound barrier.

Blasting at depth could result in a slight increase in transmitted vibration levels and the preliminary development being somewhat removed from the protection of the present face could give rise to short-time noise problems which will be eliminated progressively as the gap between the faces is reduced.

The general and specific noise levels associated with the quarry have been measured and are shown in Appendix 4. Blasting noise is minimal and, except in conditions of low cloud, indiscernable from the normal noises in the area.

Vibration levels within the boundaries of the housing development and particularly in the area between Old Beach Road and the new re-alignment will be above the nuisance level throughout the life of the quarry but should consistently remain a fraction of the structural damage threshold level and favourably comparable to that normally associated with continual heavy traffic. Such vibration can however highlight any basic structural weaknesses in a building particularly where foundation fill, expansive clay soil or inadequate foundation preparation can lead to differential settlement.

Considering this report and previous advice on the area the Housing Department should seriously reconsider the construction of further houses if they are not to be involved with considerable recurring maintenance

costs over a number of years.

Should the department decide to continue with the development it should be on the basis of acceptable risk and great care and responsibility will require to be exercised by their inspectors in ensuring preparatory and foundation work for the situation to which they have perversely committed themselves.

[24 June 1976]

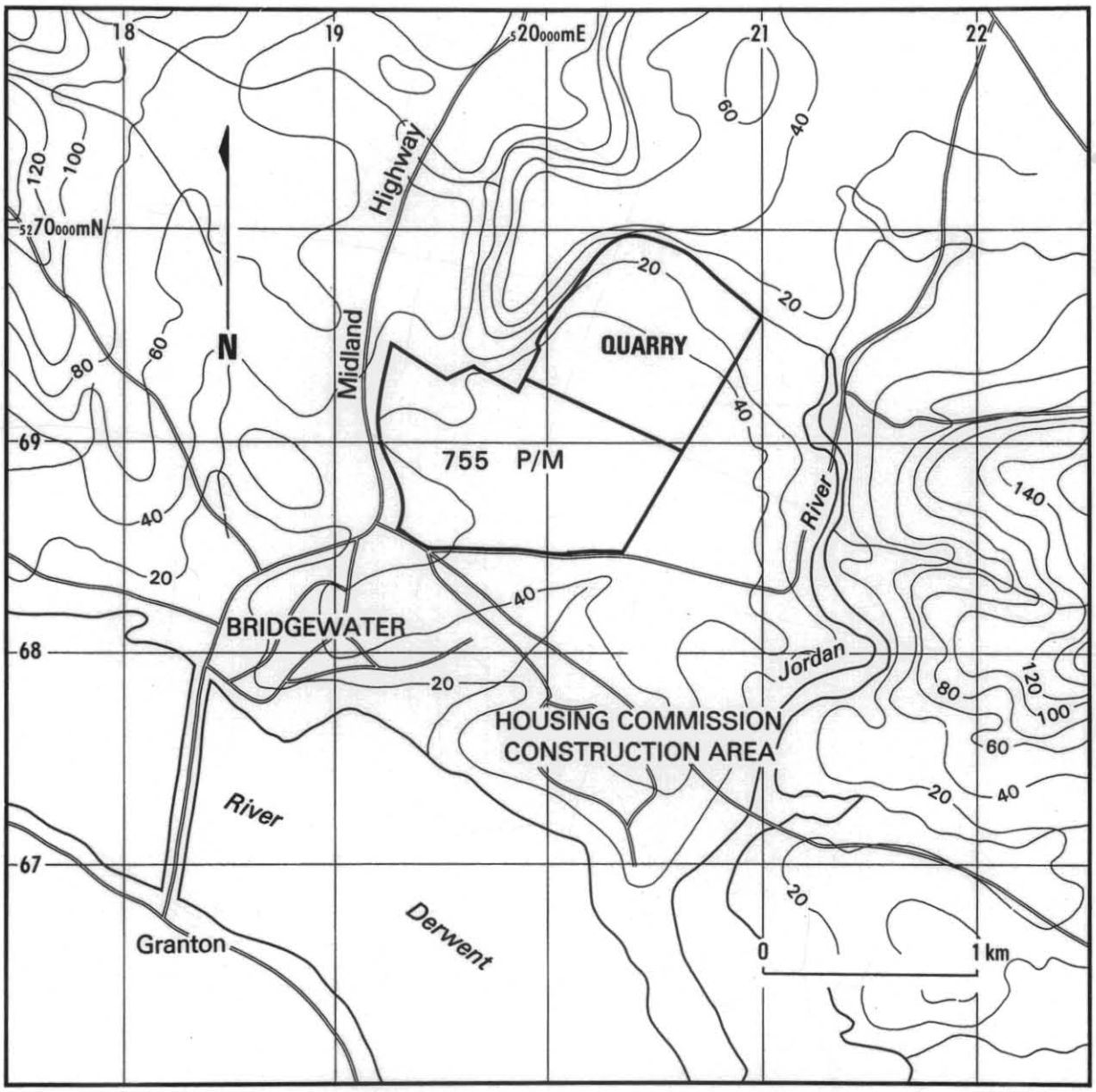


Figure 1. *Location of quarry lease area.*

5 cm

APPENDIX 1

Monitor Site Vibrational Test Data - Blasting Sequence

(Detection head No. 1 ∿ normal: Detection head No. 2 ∿ amplified)

Date: 21.4.1976

No. of holes - 36

Explosives used:	700 kg AN60 808 kg ANFO Total 1508 kg or 42± kg/hole
Delay series used:	13 - 18
Maximum holes per delay:	7
Maximum charge per delay:	293 kg

Vibration readings

Head 1

½ wave	Calibration factor	True ½ wave (X)	X^2	ΣX^2	Particle Velocity
5	0.79	6.33	40.0577		
4.25	0.92	4.62	21.3404	93.0387	9.6 mm/s
4.5	0.80	5.625	31.6406		

Date: 29.4.1976

No. of Holes - 34

Explosives used:	525 kg AN60 851 kg ANFO Total 1376 or 40± kg/hole
Delay series used:	0 - 5
Maximum holes per delay:	6
Maximum charge per dealy:	243 kg

Vibration readings

Head 1

½ wave	Calibration factor	½ wave (X)	X^2	ΣX^2	Particle velocity
3.0	.80	3.75	14.063		
2.5	.85	2.94	8.651	28.811	5.368
2.0	.81	2.47	6.097		

Head 2

4.25	2.46	1.73	2.985		
4.5	2.73	1.65	2.717	9.971	3.158
5.0	2.42	2.066	4.269		

4.263 mm/s

Date: 6.5.1976 - Overcast with rain and fog

No. of holes - 36

Explosives used:	525 kg AN60 851 kg ANFO Total 1376 kg or 38± kg/hole
Delay series used:	0 - 18
Maximum holes per delay:	2
Maximum charge per delay:	76 kg

Vibration readings

Head 1

½ wave	Calibration factor	True ½ wave (X)	X^2	ΣX^2	Particle velocity
1.25	.79	1.58	2.4964		
1.0	.92	1.09	1.1881	4.5681	2.14
0.75	.80	0.94	0.8836		

Head 2

4.0	2.42	1.65	2.7225		
5.0	2.46	2.03	4.1209	10.4915	3.24
4.5	2.35	1.91	3.6481		

2.69 mm/s

Date: 21.5.1976

No. of holes - 36

Explosives used:	1675 kg AN60 nil ANFO Total 1675 kg or 46.5± kg/hole
Delay series used:	0 - 18
Maximum holes per delay:	2
Maximum charge per delay:	93 kg

Vibration readings

Head 1

½ wave	Calibration factor	True ½ wave (X)	X^2	ΣX^2	Particle velocity
0.5	.79	.633	.4005		
0.75	.92	.815	.6646	1.4557	1.206
0.5	.80	.625	.3906		

Head 2

1.5	2.42	.620	.3842		
1.0	2.46	.407	.1652	.7305	.8547
1.0	2.35	.426	.1811		

1.03 mm/s

Date: 27.5.1976

No. of holes - 32

Explosives used:	225 kg AN60 1064 kg ANFO Total 1289 kg or 40± kg/hole
Delay series used:	0 - 16
Maximum holes per delay:	2
Maximum charge per delay:	81 kg

Vibration readings

Head 1

½ wave	Calibration factor	½ wave (X)	X^2	ΣX^2	Particle velocity
0.75	.79	.949	.9013		
0.75	.92	.815	.6646	2.4448	1.56
0.75	.80	.938	.8789		

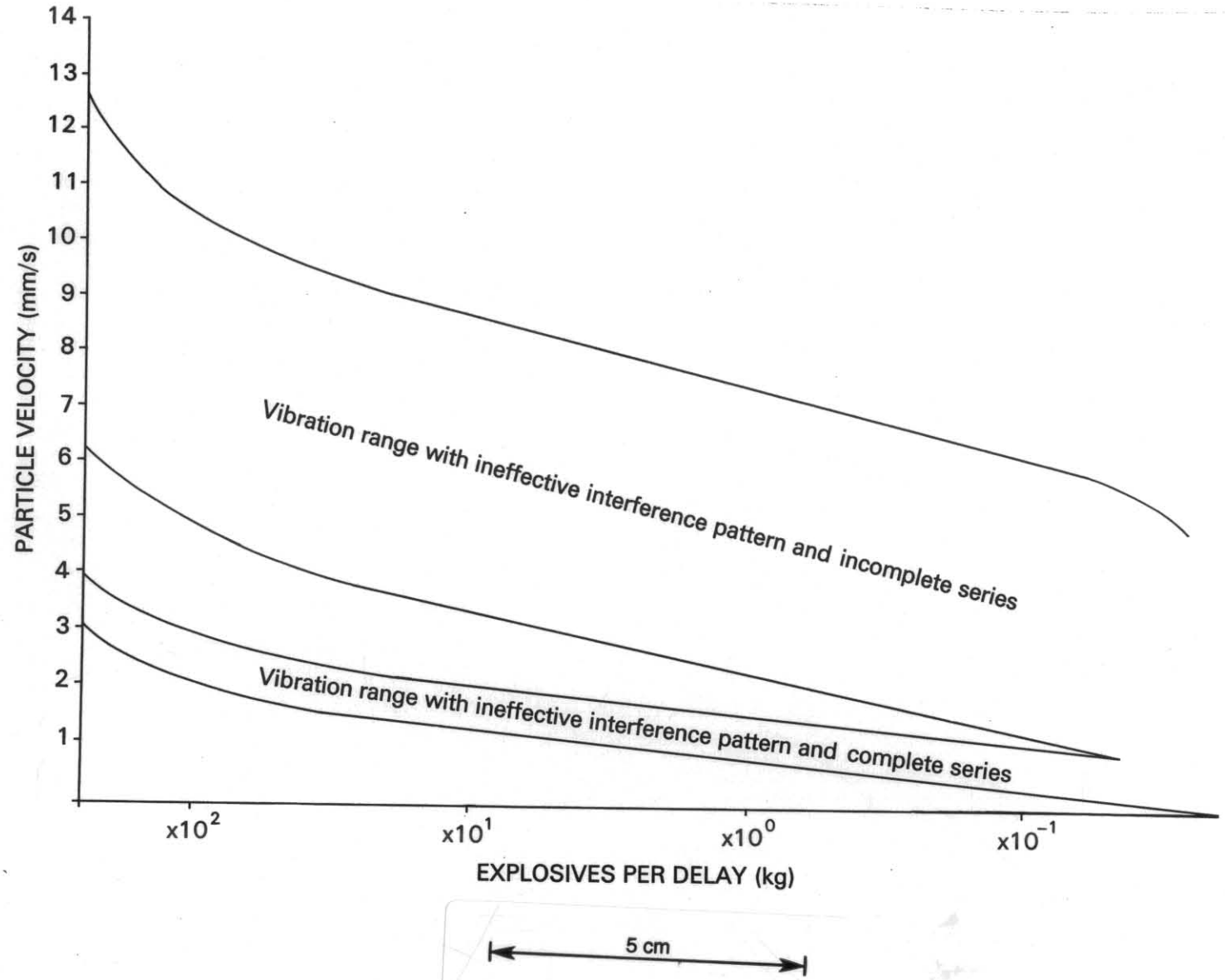
Head 2

2.25	2.42	.9298	.8644		
1.5	2.46	.6098	.3718	2.3679	1.54
2.5	2.35	1.064	1.1317		

1.55 mm/s

APPENDIX 2

Predicted vibration range at 500 m radius, Bridgewater quarry.

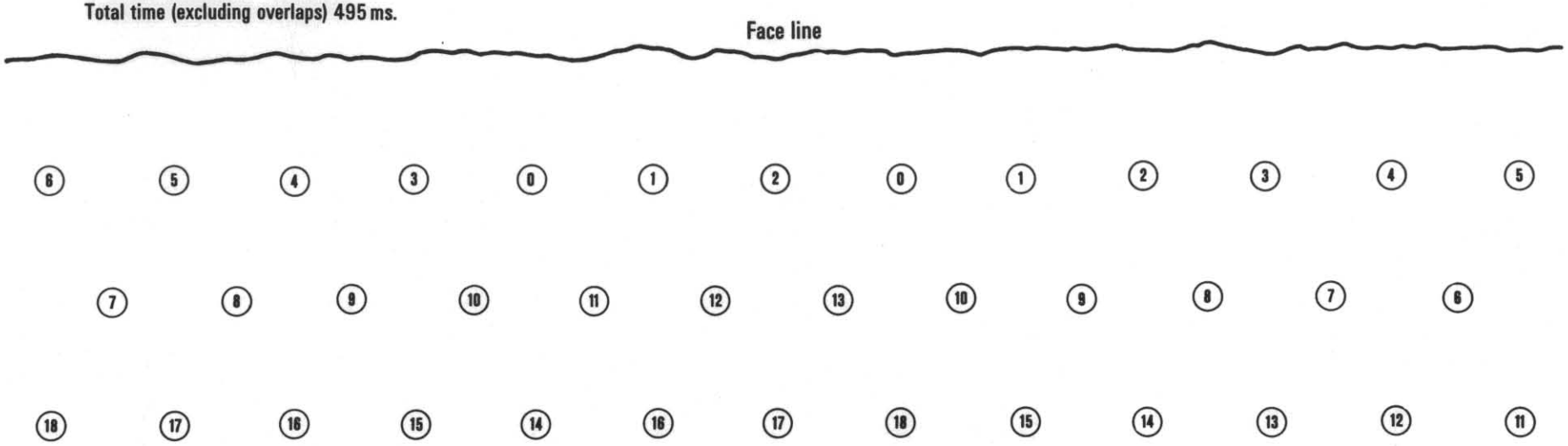


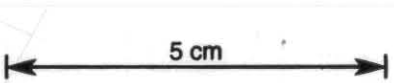
APPENDIX 3

Full interference round for use in free–breaking material

Burden and spacing 2.5 m.
Middle row may be adjusted to take advantage of end-on free face.
Interval between any two adjacent shots in any direction **Minimum ~ 23 ms.**
Maximum ~ 315 ms.

Time to fire front row ~ 155 ms.
Time to fire middle row ~ 185 ms.
Time to fire back row ~ 215 ms.
Total time (excluding overlaps) 495 ms.





APPENDIX 4

Typical noise levels in the vicinity of Bridgewater Quarry.

A. Measurements taken in Quarry vehicle park, being representative of the general noise level developed at source.

		dB(A)
(1)	Background noise level when all work is stopped *i.e.* birds, cattle, sheep, etc.	36
(2)	CAT 950 moving around stockpile area.	68
(3)	CAT 950 crowding into stockpile.	74
(4)	CAT 950 tipping into empty steel tray vehicle.	78
(5)	Constant level without above peaks.	72
(6)	General level when traffic moving.	76
B.	Access road under power lines.	
(1)	Normal operating quarry noise.	42
(2)	With vehicles backing and filling.	48
(3)	Public traffic noise from Old Beach Road.	46
(4)	Public traffic noise from Midland Highway.	48
C.	Access road, 50 m from junction with Midland Highway.	
(1)	Normal car traffic	slow 54 fast 58
(2)	Trucks	63
(3)	Noise from sawmill.	43
(4)	Gravel trucks on access road.	68
(5)	Gravel trucks pulling on to Highway.	62
(6)	Gravel trucks turning from Highway.	70
(7)	Noise from quarry plus extraneous.	42
D.	Lease boundary - Old Beach Road.	
(1)	Old Beach Road traffic	54
(2)	Noise from Bridgewater housing development.	46
(3)	Noise from quarry.	41
(4)	Noise from quarry with drill operating.	42