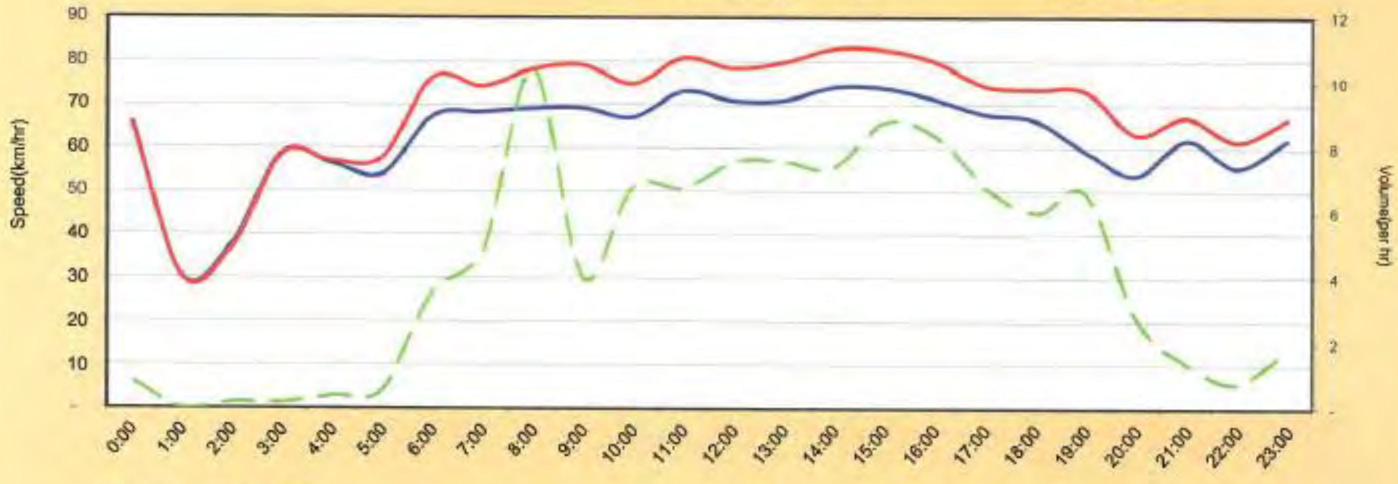
austraffic

Volume & Speed Data

All Vehicles

Ave. Speed	68.5	**Direction:**	Two ways
85%ile	82.0	**Day:**	WeekDay Avg
Vehicles/Day	105	**Week:**	Current



Tiyces Lane Egress Point

Tiyces Lane

APPENDIX 4

Pavement Condition Report

Pavement Management Services - 30 March 2009

Pavement Management Services

MARIAN VALE PASTORAL COMPANY PTY LTD

PAVEMENT CONDITION REPORT: TIYCES LANE, HUME HIGHWAY TO PROPOSED QUARRY ENTRANCE – 2009

REPORT NO. R2009142-1

VER	REV	REVISION DESCRIPTION	VER. DATE	PREPARED BY	REVIEWED BY
1	0	First draft for client review	28 April 09	D.Scruby	J. Erskine

Winner	Winner	Winner	Finalist	Winner	Winner	Featured in
Gold Award Specialist Services	New or improved Technique	NSW Eng Excellence Awards	National Eng Excellence Awards	Most Innovative Product	Export award	Australian Technology Show Case

EXECUTIVE SUMMARY

Fugro PMS was commissioned by Marian Vale Pastoral Pty Ltd to conduct a pavement condition survey of Tiyces Lane, Goulburn between Hume Highway to the proposed quarry entrance. Length of pavement to be surveyed was approximately 2 km in length. Structural testing using a Falling Weight Deflectometer was conducted on 30th March 2009 in the outer wheel path at 100 m intervals in order to determine the current structural capacity of the pavement.

Based on the traffic data provided a total 20 yr design traffic volume of 2.33×10^4 ESA's was derived for the unloaded lane 1 and 3.08×10^5 ESA's for the loaded lane 2 and has been considered to remain constant for the entire project section. The results of the remaining life assessment indicate that Tiyces Lane overall has sufficient structural capacity to carry the design traffic volumes based on pure empirical methods. From the analysis one area of concern was observed in Lane 1 at 0.450 km from the Hume Highway and a slight deficiency in Lane 2 at 0.500 km from the Hume Highway.

The results of the structural testing indicate that the base material is of a variable quality ranging from fair to good quality with an overall characteristic modulus of 317 MPa in the prescribed direction and 325 MPa in the counter direction. The subbase material was found to be of an average to very poor quality and again highly variable throughout the project section but typically very poor quality. The characteristic modulus was found to be 44 MPa and 45 MPa respectively for the unloaded and loaded lanes. The high variability observed in the subbase modulus values may be attributed to possible differences between the assumed subbase thickness of 200 mm and the actual thicknesses, which are unknown. The subgrade material is of variable quality ranging from poor to fair quality but typically fair with an overall characteristic modulus in the prescribed and counter lanes of 57 MPa and 67 MPa respectively.

At present the stiffness of the base material supports the remaining life results, which suggest that there is sufficient capacity in the pavement to carry the design traffic volumes. Whilst the stiffness of the pavement is variable this variability does not impact the empirical remaining life results presented as the analysis uses the deflection (beam) values only, which are independent of the pavement thickness.

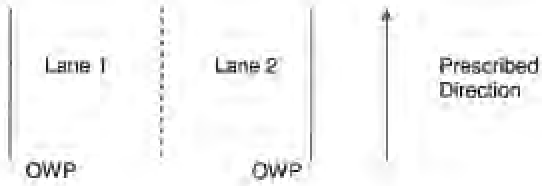
Table of Contents

1 INTRODUCTION

1.1 Introduction and Background

Fugro PMS was commissioned by Marian Vale Pastoral Pty Ltd to conduct a pavement condition survey of Tiyces Lane, Goulburn between Hume Highway to the proposed quarry entrance. Length of pavement to be surveyed was approximately 2 km in length (4 lane km). Lane 1 was considered to be from Hume Highway to the quarry entrance. Lane 2 was considered to be in the counter direction to Lane 1 as illustrated in Figure 1-1 following.

Figure 1-1: Lane Naming Convention



1.2 Objective

The objective of this condition report is to determine the structural adequacy of the pavement from a Falling Weight Deflectometer (FWD) survey with regards to the proposed quarry and the increase in trafficking.

1.3 Scope of Work

The scope of work covered:

- Structural condition survey for the assessment of structural capacity of the pavement.
- Determine pavement condition

1.4 Referenced Documents

1. ASTM D4694 "Standard Test Method for Deflection with a Falling – Weight – Type Impulse Load Devices" American Society fro Testing Materials, Conshohocken, PA, 2002
2. PMS-TP4-FWD "Falling Weight Deflectometer (FWD) Test Procedure" Fugro PMS, Sydney, 2000.
3. PMS-QP4-002 "Flexible Pavement Design Procedure" Fugro PMS, Sydney
4. Austroads Pavement Design "A guide to the Structural Design of Road Pavements" Kelvin Press, Manly Vale NSW, 1992.

2 METHOD AND ASSUMPTIONS

2.1 Location Details

Testing was performed along Tiyces Lane between the Hume Highway and the proposed quarry entrance. Table 2-1 following, summarises the details used for this project and Figure 2-1 following, is a map of the sites.

Table 2-1: Section Locations

Section	Identifier	Lane	Start Location	End Location	Length (m)
Tiyces Lane	000001A1	Prescribed (Lane 1)	Hume Highway	Proposed Quarry Entrance	2000
	000001A2	Counter (Lane 2)	Proposed Quarry Entrance	Hume Highway	2000

Figure 2-1: Site Location

2.2 Test Methods

2.2.1 FWD Testing

The FWD testing was conducted on 30th March 2009 in accordance with ASTM D4606 [1] and PMS-TP4-FWD [2]. The FWD testing measured the pavement condition in the outer wheel path at 100 m intervals with an offset of 50 m between both trafficable lanes. At each test point a target load of 700 MPa was applied and peak defections were recorded from 9 geophones, with spacing ranging from 0 m (under the centre of the load) to a distance of 1.5 m from the load.

2.3 Remaining life Assessment

2.3.1 Back-Calculations and Forward Calculations

Based on the results of the FWD testing and pavement thickness, the existing pavement layer modulus values were back-calculated using the ELMOD computer program and the radius of curvature method. The back-calculation was completed in accordance with the procedure stated in PMS-QP4-002 [3], with the following assumption used:

- Base layers comprise a 2 coat spray seal wearing course and unbound granular material with a total depth of 220 mm from zero chainage to approx. 1.00 km
- Base layers comprise an unbound granular material with a total depth of 200 mm from 1.00 km to 2.05 km
- Sub-base layer comprises of the existing gravel layer thickness with a total depth of 200 mm
- There was an infinite depth to bed rock

Once the existing pavement layer modulus values were determined from back calculations, the equivalent beam and curvature readings were determined from the FWD testing, based on the regression equation § 4.3 of PMS-QP4-002 [3].

2.3.2 Deflection Based Approach

The structural life of the pavement was assessed by means of the deflection based approach, still commonly used in Australia. The approach used for the determination of the structural life was based on the deflection measurements in terms of beam only, with the beam results being related to structural life in accordance with § 10 of the Austroads Design Guide [4].

Deflection measurements in terms of curvature were not included due to the pavement being an unbound granular pavement with and unsealed or thin spray sealed surface and subject to permanent deformation only as the primary mode of failure.

3 PAVEMENT CONDITION RESULTS

3.1 Structural Assessment

3.1.1 Design Traffic

Traffic count data were provided by the Laterals, estimating 14 truck movements per day, each with a capacity of 37 tonnes once the quarry has opened. Current traffic counts have not been supplied, though it is believed that there are currently zero truck movements per day.

This report has assumed a five axle articulated vehicle with axle loads as presented in Figure 3-1, to be representative of the proposed quarry trucks.

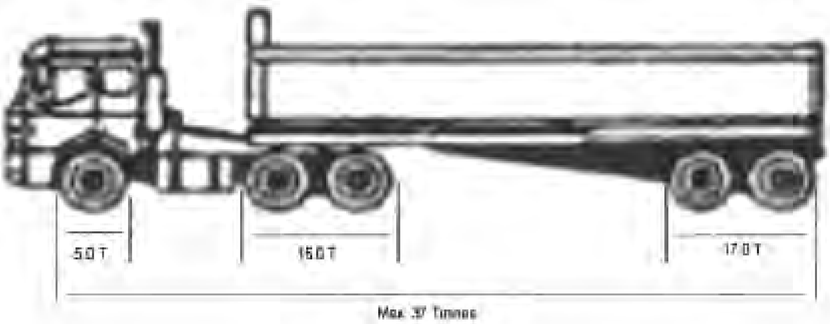


Figure 3-1 Axle Configuration and Loading

As the loading on each axle group is in excess of the equivalent standard axle group load presented in Table following the equivalent ESA's / axle group based on the fourth power law has been used in the traffic calculation.

Table 3-1 Axle Group Loads

Axle Group	Equivalent Standard Axle Group Load (kN)	Axle Group Load (kN)		ESA's / Axle Group	
		Loaded	Unloaded	Loaded	Unloaded
Single axle with single tyres (SAST)	53	49	40	0.73	0.32
Tandem Axle with dual tyres (TADT)	135	147	40	1.41	0.01
Tandem Axle with dual tyres (TADT)	135	167	40	2.34	0.01
Total				4.48	0.34

From this data a total 20 yr design traffic volume of 2.33×10^4 ESA's was derived for the unloaded lane 1 and 3.08×10^5 ESA's for the loaded lane 2 and has been considered to remain constant for the entire project section.

3.1.2 FWD Test Results

The results of the structural testing indicate that the base material in both directions is of a fair to good quality with an overall characteristic modulus of 317 MPa in the prescribed direction and 325 MPa in the counter direction. It should also be noted that the base modulus varies substantially in both the prescribed and counter direction.

The subbase material is of an average to very poor quality and highly variable throughout the project section but typically very poor quality. The characteristic modulus based on a 90^{th} percentile level of confidence is 44 MPa and 45 MPa respectively in the unloaded (Lane 1) and loaded (Lane 2) directions. The high variability observed in the subbase modulus values may be attributed to difference between assumption of the subbase layer comprising 200 mm of existing gravel and actual thicknesses which are unknown. As this analysis is based on empirical methods and the modulus results aren't used in the analysis but rather are provided for additional supporting / reference purposes such discrepancies will not affect the interpretation of the final results. The sub grade material is of poor to fair quality and highly variable but typically fair with an overall characteristic modulus in the prescribed and counter lanes of 57 MPa and 67 MPa respectively.

At present the stiffness of the base material suggests that there is sufficient capacity in the pavement to carry the design traffic volumes, though there is one area of concern between 0.450 km and 0.500 km in both lanes with Lane 1 exhibiting the greatest deficiency.

The FWD testing results can be found in Appendix A. Results have been presented with the chainage values increasing from Hume Highway to the proposed quarry entrance.

3.2 Remaining Life Assessment

The results of the remaining life assessment indicate that Tiyces Lane overall has sufficient structural capacity to carry the design traffic volumes based on pure empirical methods. Though (as previously stated) there is one area of concern in Lane 1 at 0.450 km from the Hume Highway and a slight deficiency in Lane 2 at 0.500 km from the Hume Highway. Whilst there is a high degree of variability in the modulus results of the base, subbase and subgrade, this variability does not impact the remaining life results as these use the deflection (beam) values only which are independent of thickness.

The empirical remaining life calculations sheets can be found in Appendix A.

4 CONCLUSIONS

Based on the traffic data provided a total 20 yr design traffic volume of $2.33x10^4$ ESA's was derived for the unloaded lane 1 and $3.06x10^6$ ESA's for the loaded lane 2 and has been considered to remain constant for the entire project section. The results of the remaining life assessment indicate that Tiyces Lane overall has sufficient structural capacity to carry the design traffic volumes based on pure empirical methods. From the analysis one area of concern was observed in Lane 1 at 0.450 km from the Hume Highway and a slight deficiency in Lane 2 at 0.500 km from the Hume Highway.

The results of the structural testing indicate that the base material is of a variable quality ranging from fair to good quality with an overall characteristic modulus of 317 MPa in the prescribed direction and 325 MPa in the counter direction. The subbase material was found to be of an average to very poor quality and again highly variable throughout the project section but typically very poor quality. The characteristic modulus was found to be 44 MPa and 45 MPa respectively for the unloaded and loaded lanes. The high variability observed in the subbase modulus values may be attributed to possible differences between the assumed subbase thickness of 200 mm and the actual thicknesses, which are unknown. The subgrade material is of variable quality ranging from poor to fair quality but typically fair with an overall characteristic modulus in the prescribed and counter lanes of 57 MPa and 67 MPa respectively.

At present the stiffness of the base material supports the remaining life results, which suggest that there is sufficient capacity in the pavement to carry the design traffic volumes. Whilst the stiffness of the pavement is variable this variability does not impact the empirical remaining life results presented as the analysis uses the deflection (beam) values only, which are independent of the pavement thickness.

5 APPENDIX A – STRUCTURAL TEST RESULTS

Pavement Management Services

ABN 84 002 245 329
Unit 7B/26 Powers Rd, Seven Hills, NSW 2147
Phone +61 2 9674 9488

Report No: ODS2009142-1
Test Method: PMS-TP4
Analysis Method: PMS-QP4-002
Job No: 2009142
Client: Marulan Vale Pastoral Co
Tested By: Jason Hawken
Testing Date: 30-Mar-09
Test Equipment: HWD 100

ESA's/Lane/Day: 2
Annual Growth Rate: 3%
Design Traffic Intensity (20 years): 2.33E+04 ESA
Tolerable Beam: 1.85 mm
Tolerable Curvature: 0.41 mm
WMAPT (Singleton): 22.5 °C
Overlay Design Material: Granular (Granular/Asphalt)
Report Date: 29-Apr-09

Empirical Overlay Design Report - Spray Seal Surfaced Unbound Pavement

Tiyces Lane from Hume Highway to the proposed quarry entrance, Goulburn.

Chainage (km)	Temp (°C)	Lane	Thickness (mm) Base	Thickness (mm) Subbase	Modulus (MPa) Base	Modulus (MPa) Subbase	Modulus (MPa) Subgrade	Temp Adjusted Beam Deflection	Temp Adjusted Curvature	Design Overlay (mm) Granular Overlay	Remaining Life Calc's. (Current Pavement) ESA's	Remaining Life Calc's. (Current Pavement) Years
0.05	28.3	1	220	200	692	83	170	0.63	0.27	0	4.9E+08	20
0.15	28.6	1	220	200	2193	24	878	0.36	0.17	0	1.0E+11	20
0.25	28.9	1	220	200	911	72	214	0.48	0.22	0	5.2E+09	20
0.35	29.1	1	220	200	760	120	72	0.66	0.19	0	3.2E+08	20
0.45	29.3	1	220	200	139	82	37	2.10	1.10	99	3.5E+03	4
0.55	29.4	1	220	200	454	322	73	0.62	0.32	0	5.1E+08	20
0.65	29.3	1	220	200	538	44	166	0.93	0.36	0	1.1E+07	20
0.75	29.5	1	220	200	525	194	82	0.76	0.28	0	7.9E+07	20
0.85	29.5	1	220	200	383	518	57	0.75	0.29	0	8.7E+07	20
0.95	29.5	1	220	200	633	175	143	0.63	0.26	0	4.5E+08	20
1.05	29.6	1	200	200	317	202	67	0.97	0.48	0	7.0E+06	20
1.15	29.6	1	200	200	445	211	101	0.78	0.34	0	6.1E+07	20
1.25	29.6	1	200	200	454	94	77	0.96	0.36	0	7.8E+06	20
1.35	29.6	1	200	200	597	281	96	0.67	0.25	0	2.5E+08	20
1.45	29.6	1	200	200	734	98	133	0.70	0.20	0	1.7E+08	20
1.55	29.5	1	200	200	992	227	244	0.43	0.20	0	2.1E+10	20
1.65	29.6	1	200	200	615	360	90	0.59	0.20	0	8.4E+08	20
1.75	29.6	1	200	200	919	225	244	0.42	0.20	0	2.8E+10	20
1.85	30.7	1	200	200	7522	2	4602	0.35	0.19	0	1.7E+11	20
1.95	30.8	1	200	200	281	362	35	0.98	0.44	0	7.7E+06	20
2.05	31.0	1	200	200	753	78	306	0.62	0.26	0	5.3E+08	20
MEAN					**994**	**179**	**376**	**0.73**	**0.31**			
STANDARD DEVIATION					**1514**	**130**	**981**	**0.36**	**0.19**			
CHARACTERISTIC NUMBERS					317	44	57	0.96	0.44	0	7.7E+06	20

NOTE:
1. Characteristic Numbers are based on a 90th percentile confidence level
2. Lane 1 is in the prescribed direction and the unloaded lane
3. Base comprises of spray seal and 200 mm gravel layer and subbase assumes 200 mm of existing gravel layer
4. Calculations are based on empirical methods and should only be used to provide an indication of structural capacity or as seed values in a mechanistic design procedure
5. The overlay requirements indicate the thickness of additional material required to overcome any structural deficiencies of the pavement based on the pavement consisting of a spray seal wearing course and being subject to only permanent deformation as the primary modes of pavement failure.
6. The remaining life calculations are based on the above assumptions and considering only the beam deflection

Pavement Management Services

ABN 84 002 245 329
Unit 7B/26 Powers Rd, Seven Hills, NSW 2147
Phone +61 2 9674 9488

Report No:	CO52009142-1	**ESA's/Lane/Day:**	31	
Test Method:	PMS-TP4	**Annual Growth Rate:**	3%	
Analysis Method:	PMS-QP4-002	**Design Traffic Intensity (20 years):**	3.08E+05	ESA
Job No:	2009142	**Tolerable Beam:**	1.27	mm
Client:	Marian Vale Pastoral Co.	**Tolerable Curvature:**	0.24	mm
Tested By:	Jason Hawken	**WMAPT (Singleton):**	22.3	°C
Testing Date:	30-Mar-09	**Overlay Design Material:**	Granular	(Granular/Asphalt)
Test Equipment:	HWD 100	**Report Date:**	29-Apr-09	

Empirical Overlay Design Report - Spray Seal Surfaced Unbound Pavement

Tiyces Lane from the proposed quarry entrance to Hume Highway, Goulburn.

Chainage (km)	Temp (°C)	Lane	Thickness (mm) Base	Thickness (mm) Subbase	Modulus (MPa) Base	Modulus (MPa) Subbase	Modulus (MPa) Subgrade	Temp Adjusted Beam Deflection	Temp Adjusted Curvature	Design Overlay (mm) Granular Overlay	Remaining Life Calc's. (Current Pavement) ESA's	Remaining Life Calc's. (Current Pavement) Years
0.10	30.7	2	220	200	771	166	196	0.48	0.22	0	6.5E+09	20
0.20	30.7	2	220	200	1131	98	262	0.41	0.20	0	3.1E+10	20
0.30	30.7	2	220	200	1046	22	442	0.56	0.25	0	1.0E+09	20
0.40	30.7	2	220	200	636	60	129	0.69	0.29	0	1.9E+08	20
0.50	30.7	2	220	200	256	130	43	1.38	0.49	28	2.1E+05	15
0.60	30.7	2	220	200	458	84	118	0.87	0.38	0	1.9E+07	20
0.70	30.9	2	220	200	329	92	87	1.09	0.46	0	2.2E+06	20
0.80	30.9	2	220	200	480	86	116	0.82	0.32	0	3.6E+07	20
0.90	31.1	2	220	200	509	40	159	1.00	0.36	0	5.2E+06	20
1.00	31.1	2	220	200	483	46	107	0.94	0.45	0	8.9E+06	20
1.10	31.1	2	200	200	638	154	62	0.68	0.30	0	2.2E+08	20
1.20	31.2	2	200	200	666	357	136	0.54	0.21	0	2.3E+09	20
1.30	31.2	2	200	200	290	84	68	1.16	0.57	0	1.2E+06	20
1.40	31.2	2	200	200	470	234	73	0.74	0.26	0	1.0E+08	20
1.50	31.3	2	200	200	688	204	81	0.68	0.24	0	2.3E+08	20
1.60	31.3	2	200	200	681	402	127	0.50	0.16	0	4.9E+09	20
1.70	31.3	2	200	200	377	117	110	0.88	0.40	0	1.9E+07	20
1.80	31.3	2	200	200	542	423	77	0.61	0.24	0	5.4E+08	20
1.90	31.4	2	200	200	1058	169	560	0.39	0.23	0	4.6E+10	20
2.00	31.4	2	200	200	681	140	156	0.57	0.24	0	1.3E+09	20
MEAN					**620**	**157**	**156**	**0.75**	**0.32**			
STANDARD DEVIATION					**248**	**115**	**130**	**0.26**	**0.11**			
CHARACTERISTIC NUMBERS					**325**	**45**	**67**	**1.10**	**0.46**	**0**	**2.1E+06**	**20**

NOTE:
1. Characteristic Numbers are based on a 90th percentile confidence level
2. Lane 2 is in the counter direction with all chainage values increasing in the prescribed direction and assumes trucks in loaded state
3. Base comprises of spray seal and 200 mm gravel layer and subbase assumes 200 mm of existing gravel layer
4. Calculations are based on empirical methods and should only be used to provide an indication of structural capacity or as seed values in a mechanistic design procedure
5. The overlay requirements indicate the thickness of additional material required to overcome any structural deficiencies of the pavement based on the pavement consisting of a spray seal wearing course and being subject to only permanent deformation as the primary modes of pavement failure.
6. The remaining life calculations are based on the above assumptions and considering only the beam deflection

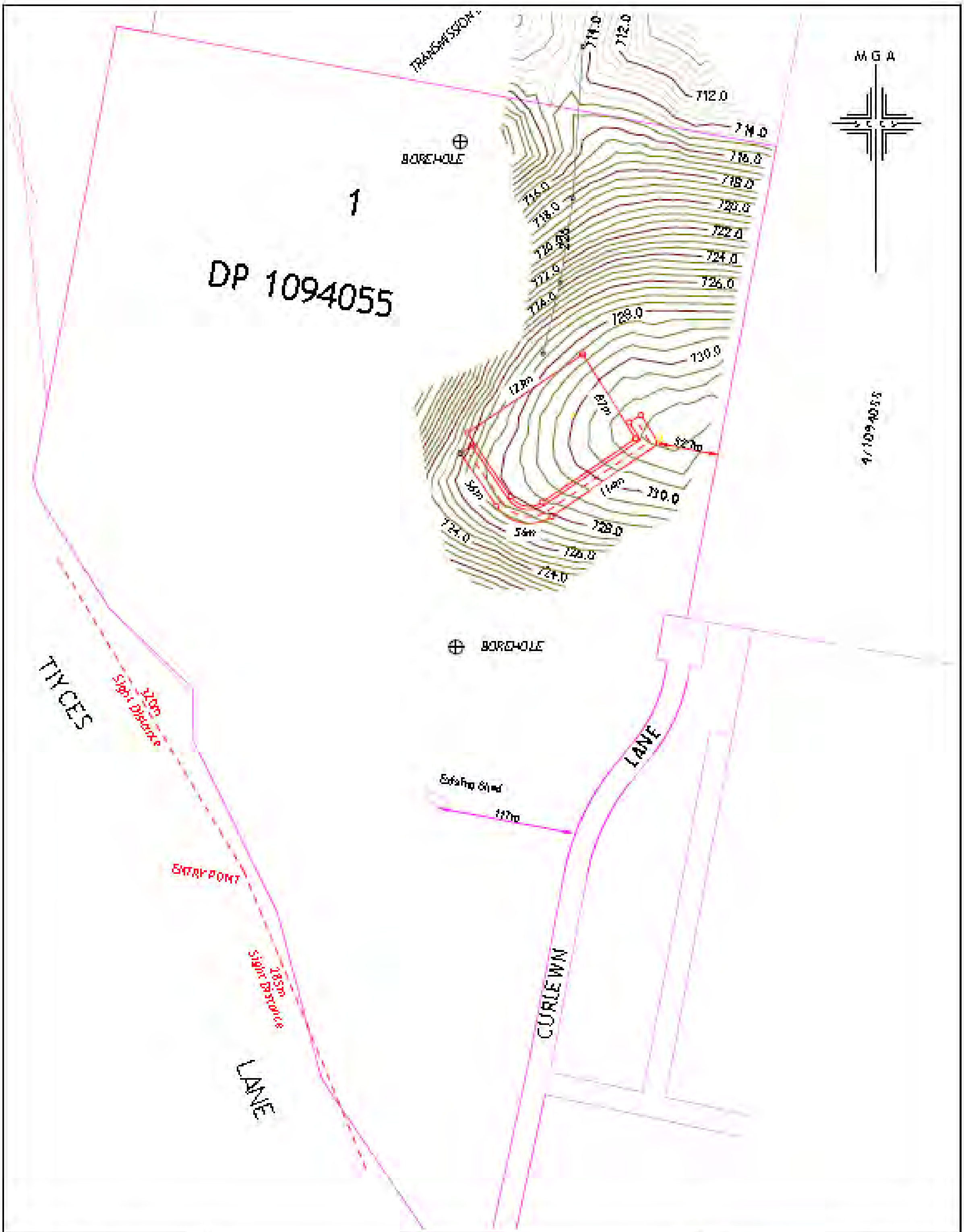
Prepared by ....
Glenn (Senior Project Engineer)

PMS QF4 001
Rev:1 Ver:2
Ver Date: Dec 07

APPENDIX 5

Sight Distance Survey

Southern Cross Consulting Surveyors



SCALE - 1:3000
AZIMUTH - MGA
CONTOUR INTERVAL - 0.5m
DATUM - AHD
DATE - 9 DEC 2016
REF - 22903-161209A

ARGYLE QUARRY
PLAN SHOWING PROPOSED
EGRESS POINT TIYCES LANE

SCCS
SOUTHERN CROSS
CONSULTING SURVEYORS
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F: 02 4822 1365
Email : admin@sccsurveyors.com.au

APPENDIX 6

Austroads Guide To Road Design Part 4a: Unsignalised And Signalised Intersections

Table 3.2

Table 3.2: Safe intersection sight distance (SISD) and corresponding minimum crest vertical curve size for sealed roads (S<L)

<table>
<tr><th colspan="2" rowspan="3">Design speed (km/h)</th><th colspan="6">Based on safe intersection sight distance for cars[1]
h_1 = 1.1; h_2 = 1.25, d = 0.36[2]; Observation time = 3 s</th></tr>
<tr><th colspan="2">R_T = 1.5s[3]</th><th colspan="2">R_T = 2.0s</th><th colspan="2">R_T = 2.5s</th></tr>
<tr><th>SISD (m)</th><th>K</th><th>SISD (m)</th><th>K</th><th>SISD (m)</th><th>K</th></tr>
<tr><td colspan="2">40</td><td>67</td><td>4.9</td><td>73</td><td>6</td><td>-</td><td>-</td></tr>
<tr><td colspan="2">50</td><td>90</td><td>8.6</td><td>97</td><td>10</td><td>-</td><td>-</td></tr>
<tr><td colspan="2">60</td><td>114</td><td>14</td><td>123</td><td>16</td><td>-</td><td>-</td></tr>
<tr><td colspan="2">70</td><td>141</td><td>22</td><td>151</td><td>25</td><td>-</td><td>-</td></tr>
<tr><td colspan="2">80</td><td>170</td><td>31</td><td>181</td><td>35</td><td>-</td><td>-</td></tr>
<tr><td colspan="2">90</td><td>201</td><td>43</td><td>214</td><td>49</td><td>226</td><td>55</td></tr>
<tr><td colspan="2">100</td><td>234</td><td>59</td><td>248</td><td>66</td><td>262</td><td>74</td></tr>
<tr><td colspan="2">110</td><td>-</td><td>-</td><td>285</td><td>87</td><td>300</td><td>97</td></tr>
<tr><td colspan="2">120</td><td>-</td><td>-</td><td>324</td><td>112</td><td>341</td><td>124</td></tr>
<tr><td colspan="2">130</td><td>-</td><td>-</td><td>365</td><td>143</td><td>383</td><td>157</td></tr>
<tr><td rowspan="3">Minimum SISD capability provided by the crest vertical curve size[4]</td><td>Car at night[5]</td><td colspan="6">d = 0.46, h_1 = 0.65 m, h_2 = 1.25 m, observation time = 2.6 s.
d = 0.46, h_1 = 1.1 m, h_2 = 0.75 m, observation time = 2.5 s.</td></tr>
<tr><td>Truck</td><td colspan="6">d = 0.24, h_1 = 2.4 m, h_2 = 1.25 m, observation time = 3.0 s.</td></tr>
<tr><td>Truck at night[5]</td><td colspan="6">d = 0.29, h_1 = 1.05 m, h_2 = 1.25m, observation time = 1.8 s.
d = 0.29, h_1 = 2.4m, h_2 = 0.75m, observation time = 3.0s.</td></tr>
</table>

1. If the roadway is on a grade, calculate the safe intersection sight distance (SISD) values using the correction factors in Table 3.3 (or use the formulae in Section 4.3 of the *Guide to Road Design – Part 3: Geometric Design* (Austroads 2009a)) by applying the average grade over the braking length.

2. A coefficient of deceleration of greater than 0.36 is not provided in this table. The provision of SISD requires more conservative values than for other sight distance models (e.g. the stopping sight distance model allows values up to 0.46 in constrained situations). This is because there is a much higher likelihood of colliding with hazards at intersections (that is, other vehicles). Comparatively, there is a relatively low risk of hitting a small object on the road (the stopping sight distance model).

3. A 1.5 s reaction time is only to be used in constrained situations where drivers will be alert. Typical situations are given in Table 5.2 of the *Guide to Road Design – Part 3: Geometric Design* (Austroads 2009a). The general minimum reaction time is 2 s.

4. These check cases assume the same combination of design speed and reaction time as those listed in the table, except that the 120 km/h and 130 km/h speeds are not used for the truck cases.

5. Many of the sight distances corresponding to the minimum crest size are greater than the range of most headlights (that is, 120–150 m). In addition, tighter horizontal curvature will cause the light beam to shine off the pavement (assuming 3 degrees lateral spread each way).

Notes:

To determine SISD for trucks around horizontal curves, use Equation 2 with an observation time of 2.5 s.

Combinations of design speed and reaction times not shown in this table are generally not used.

H. Materials testing results prepared by various construction materials testing laboratories incorporating:

a. Boral Initial Aggregate Stripping Tests.

b. Boral Methylene Blue Absorption Value Test.

c. Boral Sampling Results.

d. Boral Sieve Test for Crushed Aggregate.

e. Petrographic report.

GEOCHEMPET SERVICES, MALENY

Geochempet Services

ABN 980 6945 3445
PETROLOGICAL and GEOCHEMICAL CONSULTANTS

Principals: K.E. Spring B.Sc.(Hons), MAppSc
H.M. Spring B.Sc.
19 Centenary Drive
MALENY Q 4552

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PETROGRAPHIC REPORT
ON A CURLEWIN BASALT (YELLOW) AGGREGATE SAMPLE (75061)
FROM CURLEWIN QUARRY

prepared for

BORAL RESOURCES (NSW) PTY LTD
MATERIALS TECHNICAL SERVICES

Order Number: 4243822

Invoice Number: 00001833

Client Ref: George Calvar

Issued by

K. E. Spring B.Sc.(Hons), MAppSc
4 October 2007

OCTOBER, 2007
Bo071006t.doc

GEOCHEMPET SERVICES, MALENY

Sample Number : 75061 **Date Sampled** : 30/08/07

Sample Type : Curlewin Basalt (yellow) aggregate

Client : Antiquaire Pty Ltd (482/07) **Source** : Curlewin Quarry

Work Requested : Petrographic analysis in relation to suitability for use as concrete aggregate

Methods : Account taken of ASTM C 295 Standard Guide for *Petrographic Assessment of Aggregates for Concrete* and of the content of the 1996 joint publication of the Cement and Concrete Association of Australia and Standards Australia**,** entitled *Alkali Aggregate Reaction - Guidelines on Minimising the Risk of Damage to Concrete Structures in Australia*

Identification : Olivine basalt

Description :

The sample consisted of about 1 kg of hard, robust, angular fragments of clean finely crystalline basalt. The rock is largely greyish black and unweathered, but slight weathering is expressed as light brown limonite staining on old exposed parts of the recently crushed fragments.

A thin section was prepared to permit detailed microscopic examination in transmitted polarised light of 12 random fragments. An approximate mineralogical composition of the rock, expressed in volume percent and based on a brief count of 100 widely spaced observation points falling within sectioned the random fragments, is :

Primary components

49%	feldspar (about 47% plagioclase and 2% orthoclase)
21%	clinopyroxene
9%	remnant olivine
6%	opaque oxide (magnetite and/or ilmenite)
<1%	apatite

Secondary minerals

8%	green to brown clay of smectite style (nontronite)
7%	iddingsite
trace	limonite

In thin section the crushed fragments are seen to be of uniform style (but with variations in grain size) and they display porphyritic, hypidiomorphic, subophitic, mildly to moderately flow-aligned, finely crystalline textures of basaltic style. Phenocrysts are subhedral and range up to 1.5 mm in size. The groundmass is dominated by mildly to moderately aligned feldspar laths about 0.1 to 0.5 mm long, tightly interlocked with subophitic pyroxene grains about 0.5 to 1.5 mm in size and accompanied by smaller grains of other minerals.

Olivine forms subhedral phenocrysts and groundmass grains all showing slight to moderate alteration to iddingsite and brown smectite clay along minor internal fractures. Additional green clay of smectite style occurs as disseminated, small interstitial patches and clusters of patches (possibly after orthoclase). Other groundmass components comprise fresh, twinned plagioclase laths, fresh subophitic, zoned mauve to faintly brown clinopyroxene (titaniferous augite), fresh equant grains of opaque oxide (magnetite and possibly ilmenite) and minor anhedral, interstitial grains of slightly clouded orthoclase and fine, acicular fresh apatite.

Comments and Interpretations :

For engineering purposes, the rock represented in the supplied aggregate sample (labelled 75061) from Curlewin Quarry is considered to be holocrystalline **olivine basalt**, a basic volcanic rock. It was originally altered to green clay of smectite style (nontronite) by deuteric processes (i.e by processes operating during cooling of the original lava) but is now partly oxidized. More recently the rock has been slightly and superficially weathered.

For engineering purposes, the rock represented in the supplied aggregate sample may be summarised as:

- **olivine basalt** (a basic volcanic igneous rock type)
- holocrystalline and characterised by a tough, subophitic texture
- non-porous
- largely unweathered (only slight and essentially superficial weathering observed)
- lightly altered (the average secondary mineral content is about 15%, comprising green to brown smectite clay occurring mainly in interstitial patches and iddingsite as a slight to moderate alteration of disseminated olivine grains)
- **hard**
- **strong**

The basalt is predicted to be **durable.**

The basalt lacks free silica: consequently, it is predicted to be **innocuous in relation to alkali-silica reactivity** in concrete.

Thus, basalt of the type represented in the supplied sample is predicted to be a **suitable for use in concrete aggregate.**

Free Silica Content : Nil.

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TEST REPORT

CLIENT: Argyle (NSW) Pty. Limited
PROJECT: Retesting of the original Curlewin Basalt sample
TEST METHOD: AS1141 – Methods for Sampling and Testing Aggregates

FILE NO: 482/14
REQUEST NO: 57649

Sample Description:		Curlewin Basalt
Date Rceived:		27.5.14
Laboratory Sample No:		154324
Test Method	**Test**	**Results**
AS1141.11.1*	% Passing A.S.Sieve	
	26.5mm	100
	19.0mm	97
	13.2mm	73
	9.5mm	53
	6.7mm	38
	4.75mm	28
	2.36mm	17
	1.18mm	11
AS1141.12	Material finer than 75 micron (%)	3
AS1141.6.1	Particle Density (Dry) t/m^3	2.83
	Particle Density (SSD) t/m^3	2.86
	Apparent Particle Density t/m^3	2.92
	Water Absorption (%)	1.1
AS1141.22	Aggregate Dry Strength (kN)	393
	Aggregate Wet Strength (kN)	307
	Wet/Dry Strength Var. (%)	22
	Fraction tested (mm)	-19.0+9.5
	The amount of significant breakdown (%)	<0.2
	Size of cylinder used: 150mm diam.	
AS1141.24	Sodium Sulphate Soundness	
	(Total weighted % Loss)	0.8
	Fraction tested:	
	-19.0mm+13.2mm (% Loss)	0.5
	-13.2mm+9.5mm (% Loss)	0.6
	-9.5mm+4.75mm (% Loss)	0.7
	-4.75mm+2.36mm (%Loss)	2.2
	-2.36mm+1.18mm (%Loss)	1.2
AS1141.32	Weak Particles (%)	Nil
	The % of original sample passing 2.36mm = 17.2	

*Sample washed over 75 micron sieve as per AS1141.11.1 Clause 5.6.

Sample submitted by client

P. Miller, QC File, File

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Kamal Ali

Approved Signatory [signature]

Date 18.6.14 Serial No. 126454

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NATA Accredited Laboratory
Number: **547**

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PO Box 400, Winston Hills NSW 2153
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CLIENT: Figtree Reserve Super Fund FILE NO: 482/07
PROJECT: Quality Control – Testing of Curlewin Basalt (Yellow)
TEST PROCEDURE: AS1141 – Sampling and Testing Aggregates; RTA – Materials Testing Manual Vol. 1

Laboratory Sample No:	75061
Date Received:	30.8.07
Sample Description:	Curlewin Basalt (Yellow)

Test Method	**Test**	**Results**
AS1141.11*	% Passing A.S.Sieve	
	26.5mm	100
	19.0mm	90
	13.2mm	52
	9.5mm	29
	6.7mm	14
	4.75mm	4
	2.36mm	Nil
	1.18mm	Nil
AS1141.12	Material finer than 75 micron (%)	Nil
AS1141.14	Mis-shapen Particles (%)	
	Ratio 2:1	10
	Ratio 3:1	1
AS1141.15	Flakiness Index (%)	16
AS1141.4	Uncompacted Bulk Density (t/m^3)	1.47
	Compacted Bulk Density (t/m^3)	1.59
AS1141.6.1	Particle Density (Dry) t/m^3	2.84
	Particle Density (SSD) t/m^3	2.87
	Apparent Particle Density t/m^3	2.93
	Water Absorption (%)	1.1
AS1141.24	Sodium Sulphate Soundness	
	Total weighted (% Loss)	0.6
	Fraction tested:	
	-26.5+19.0mm (% Loss)	0.4
	-19.0+13.2mm (% Loss)	0.3
	-13.2+9.5mm (% Loss)	0.7
	-9.5+4.75mm (% Loss)	0.9
RTA T 262	Moisture Content (%)	0.8
AS1141.23	Los Angeles Value Grd. 'B' (% Loss)	13

*Sample washed over 75 micron sieve as per AS1141.11 Clause 5.6.

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Approved Signatory [signature] Richard Bawer

Date 19.9.07 Serial No. 64048

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CLIENT: Figtree Reserve Super Fund

FILE NO: 482/07

PROJECT: Quality Control – Testing of Curlewin Basalt (Yellow)

TEST PROCEDURE: AS1141 – Sampling and Testing Aggregates; RTA – Materials Testing Manual Vol. 1

Laboratory Sample No:		75061
Date Received:		30.8.07
Sample Description:		Curlewin Basalt (Yellow)
Test Method	**Test**	**Results**
AS1141.32	Weak Particles (%)	Nil
	The % of original sample passing 2.36mm sieve = 0.2	
AS1141.22	Dry Strength (kN)	388
	Wet Strength (kN)	293
	Wet/Dry Strength Variation (%)	24
	Fraction tested (mm)	-19.0+9.5
	The amount of significant breakdown (%)	<0.2

Sample submitted by client.

Peter F. Millar, File, Ref: 4695.Rep

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CLIENT: FIGTREE RESERVE SUPER FUND　　　　FILE NO: 482/07

PROJECT: Full Aggregate Testing of Curlewin Basalt.

TEST PROCEDURE:
AS1012.20 - Determination of Chloride and Sulfate in Hardened Concrete & Concrete Aggregates
AS1141.31 - Determination of Light Particles
AS1141.35 - Detection of Sugar
AS1141.13 - Material Finer than 2 Micron

Laboratory Sample No:	75061
Date Received:	30.08.07
Sample Description:	Curlewin Basalt (Yellow)
Field No:	4

TEST RESULTS

% Chloride as Cl^-	0.004
% Sulfate as SO_3	0.24
% Light Particles	Nil
Sugar	Not Detected
% Material Finer than 2 micron (μm)	Not Applicable

Samples submitted by the client.

P.F.Millar, File

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Approved Signatory F. Grima　　FRANK GRIMA

Date 18-9-07　　Serial No. 64049

NATA Accredited Laboratory
Number: 547

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Test Report

CLIENT: FIGTREE RESERVE SUPER FUND **FILE NO:** 482/07

PROJECT: Testing of Curlewin Basalt (Yellow) **DATE REC'D:** Aug. 2007

TEST METHOD:
Accelerated Mortar Bar Test for AAR Assessment to RTA T363

LAB SAMPLE NO:	MATERIAL	DESCRIPTION
75061	Curlewin Basalt (Yellow)	Rec. 30/08/2007
ID # 32120	SL Cement	BCSC

Results:

Age (days)	Expansion % (Ave. of 3 specimens)
3	0.00
7	0.01
10	0.01
14	0.01
17	0.01
21	0.01

PERFORMANCE CRITERION:

% Expansion at 21 Days		Aggregate Reactivity Classification
Coarse Aggregate	Fine Aggregate	
<0.10	<0.15	Non Reactive
≥0.10, <0.4	≥0.15, <0.45	Having Potential for Slow/Mild AAR
≥0.40	≥0.45	Having Potential for Substantial AAR

Peter F. Millar, Mat File, File

Muans Abdulnebe

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Approved Signatory

Date 28-09-07 *Serial No.* 64108

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CLIENT: FIGTREE RESERVE SUPER FUND

File No : 482 / 08

PROJECT: Testing of Curlewin Basalt (Yellow) for MBV.

TEST PROCEDURE :
International Slurry Surfacing Association No.145 - Methylene Blue Adsorption Value

Laboratory Sample Number :	87726
Date Received :	30.08.07
Sample Description :	Curlewin Basalt (Yellow) Sample A.
Field Number :	4

TEST RESULTS :

Methylene Blue Adsorbed (mg/g)	2.0

Sample submitted by client.

P. F. Millar , File

SAM DEBRINCAT

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Approved Signatory
Date 4.12.08 Serial No. 73847

Page 1 of 1

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CLIENT: Figtree Reserve Super Fund

FILE NO: 482/07

PROJECT: Quality Control: Testing of Curlewin Basalt Aggregate

TEST PROCEDURE: RTA – Materials Testing Manual Vol. 1

Laboratory Sample No:	75062
Date Received:	13.11.07
Sample Description:	Curlewin Basalt Sample B

Test Method	Test	Results
RTA T230	Resistance to stripping of cover aggregates and binders Binder: C170 + 1% Redicote N422 Aggregate: As received precoated with Boral Precoat Ex Sami (% Stripped) Softening point of binder: 46.5°C Oven temp. for 24 hrs conditioning: 67°C Particles crumbled: 1	 Nil
RTA T238	Initial adhesion for cover aggregates and binders Binder: C170 + 1% Redicote N422 + 7% cutter Aggregate: As received precoated with Boral Precoat Condition: Soaked (% Stripped) Condition: Unsoaked (% Stripped) L.A. Kerosene used as cutter.	 5 5

Sample of aggregate submitted by client.

P.F. Millar, File, Ref: 4737.Rep

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Approved Signatory [signature] W. Komsta

Date 17.12.07 Serial No. 65890

NATA Accredited Laboratory Number: 547

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Test Report
POLISHED AGGREGATE FRICTION VALUE

CLIENT: Figtree Reserve Super Fund
PROJECT: Quality Control:
SAMPLE DESCRIPTION: Curlewin Basalt – Sample B
SIZE OF AGGREGATE TESTED: -13.2+9.5mm

DATE TESTED: 13.12.07

FILE NO: 482/07

DATE SAMPLED: Unknown
DATE RECD: 13.11.07
LOCATION: Curlewin
LAB. SAMPLE NO: 75062

Samples were prepared as per AS1141.41 and tested in a wet condition as per AS1141.42 prior to and after polishing. The samples were polished using the procedure of AS1141.41.

A reference aggregate sample, "Panmure Basalt" is included with each testing run. This sample acts as a control on test performance and is used to standardise the sample results. After polishing, the samples were again tested in the wet condition according to AS1141.42.

Test Method	Test	Results for the Test Sample	Results for Panmure Reference Specimen PAN No. 50K
AS1141.41/42			
	Sample mean friction value corrected for temperature before polishing.	80	75
	Sample mean friction value corrected for temperature after polishing.	54	51
	Polished aggregate friction value (PAFV) for the test sample after polishing.	54	-

The air temperature during the friction test was 23°C .
Sample submitted by client.

Peter F. Millar, File, Ref: 4737.Rep

W. Komsta

NATA

Approved Signatory

Date 17.12.07 Serial No. 65891

NATA Accredited Laboratory
Number: 547

GEOCHEMPET SERVICES, MALENY

Sample Number :	75061	**Date Sampled** :	30/08/07
Sample Type :	Curlewin Basalt (yellow) aggregate		
Client :	Antiquaire Pty Ltd (482/07)	**Source** :	Curlewin Quarry
Work Requested :	Petrographic analysis in relation to suitability for use as concrete aggregate		
Methods :	Account taken of ASTM C 295 Standard Guide for *Petrographic Assessment of Aggregates for Concrete* and of the content of the 1996 joint publication of the Cement and Concrete Association of Australia and Standards Australia**,** entitled *Alkali Aggregate Reaction - Guidelines on Minimising the Risk of Damage to Concrete Structures in Australia*		
Identification :	Olivine basalt		

Description :

The sample consisted of about 1 kg of hard, robust, angular fragments of clean finely crystalline basalt. The rock is largely greyish black and unweathered, but slight weathering is expressed as light brown limonite staining on old exposed parts of the recently crushed fragments.

A thin section was prepared to permit detailed microscopic examination in transmitted polarised light of 12 random fragments. An approximate mineralogical composition of the rock, expressed in volume percent and based on a brief count of 100 widely spaced observation points falling within sectioned the random fragments, is :

Primary components

49%	feldspar (about 47% plagioclase and 2% orthoclase)
21%	clinopyroxene
9%	remnant olivine
6%	opaque oxide (magnetite and/or ilmenite)
<1%	apatite

Secondary minerals

8%	green to brown clay of smectite style (nontronite)
7%	iddingsite
trace	limonite

In thin section the crushed fragments are seen to be of uniform style (but with variations in grain size) and they display porphyritic, hypidiomorphic, subophitic, mildly to moderately flow-aligned, finely crystalline textures of basaltic style. Phenocrysts are subhedral and range up to 1.5 mm in size. The groundmass is dominated by mildly to moderately aligned feldspar laths about 0.1 to 0.5 mm long, tightly interlocked with subophitic pyroxene grains about 0.5 to 1.5 mm in size and accompanied by smaller grains of other minerals.

Olivine forms subhedral phenocrysts and groundmass grains all showing slight to moderate alteration to iddingsite and brown smectite clay along minor internal fractures. Additional green clay of smectite style occurs as disseminated, small interstitial patches and clusters of patches (possibly after orthoclase). Other groundmass components comprise fresh, twinned plagioclase laths, fresh subophitic, zoned mauve to faintly brown clinopyroxene (titaniferous augite), fresh equant grains of opaque oxide (magnetite and possibly ilmenite) and minor anhedral, interstitial grains of slightly clouded orthoclase and fine, acicular fresh apatite.

Comments and Interpretations :

For engineering purposes, the rock represented in the supplied aggregate sample (labelled 75061) from Curlewin Quarry is considered to be holocrystalline **olivine basalt**, a basic volcanic rock. It was originally altered to green clay of smectite style (nontronite) by deuteric processes (i.e by processes operating during cooling of the original lava) but is now partly oxidized. More recently the rock has been slightly and superficially weathered.

For engineering purposes, the rock represented in the supplied aggregate sample may be summarised as:

- **olivine basalt** (a basic volcanic igneous rock type)
- holocrystalline and characterised by a tough, subophitic texture
- non-porous
- largely unweathered (only slight and essentially superficial weathering observed)
- lightly altered (the average secondary mineral content is about 15%, comprising green to brown smectite clay occurring mainly in interstitial patches and iddingsite as a slight to moderate alteration of disseminated olivine grains)
- **hard**
- **strong**

The basalt is predicted to be **durable.**

The basalt lacks free silica: consequently, it is predicted to be **innocuous in relation to alkali-silica reactivity** in concrete.

Thus, basalt of the type represented in the supplied sample is predicted to be a **suitable for use in concrete aggregate.**

Free Silica Content : Nil.

I. Plans incorporating various relevant site, geological and Council planning instruments:

a. Extent of Basalt Outcrop.

b. Cadastre & Cainozoic Map.

c. Regolith Map.

d. Solid geology Map.

e. Site Plan - Aerial Photograph.

f. Site Plan - Topographic map.

g. GMLEP 2009 Land Zone Map.

h. GMLEP 2009 Biodiversity Map.

i. Sheet 1 - Proposed Site Office Plan.

Sheet 2 – Proposed Site Office.

j. Acceleration Lane Concept Design 8/2/17.

k. Acceleration Lane Concept Design 8/2/17 Aerial.

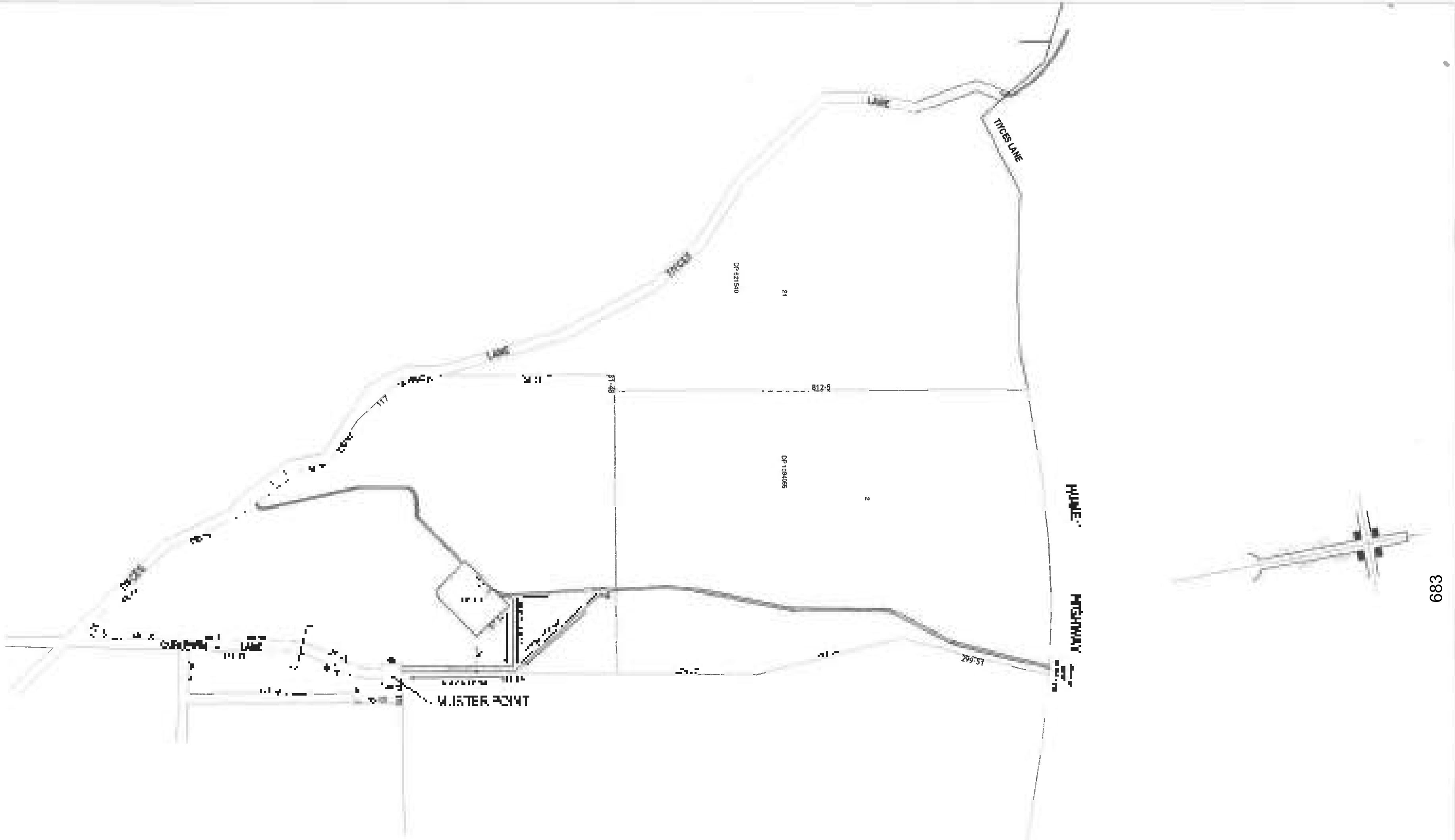
l. Visual Aspects Plan.

m. Deceleration Lane Plan 16039_DA01_External Roadworks General Arrangement Plan-Issue02.

n. Deceleration Lane Plan 16039_DA02_Cross sections – Sheet 1-Issue02.

o. Deceleration Lane Plan 16039_DA03_Cross sections – Sheet 2-Issue02.

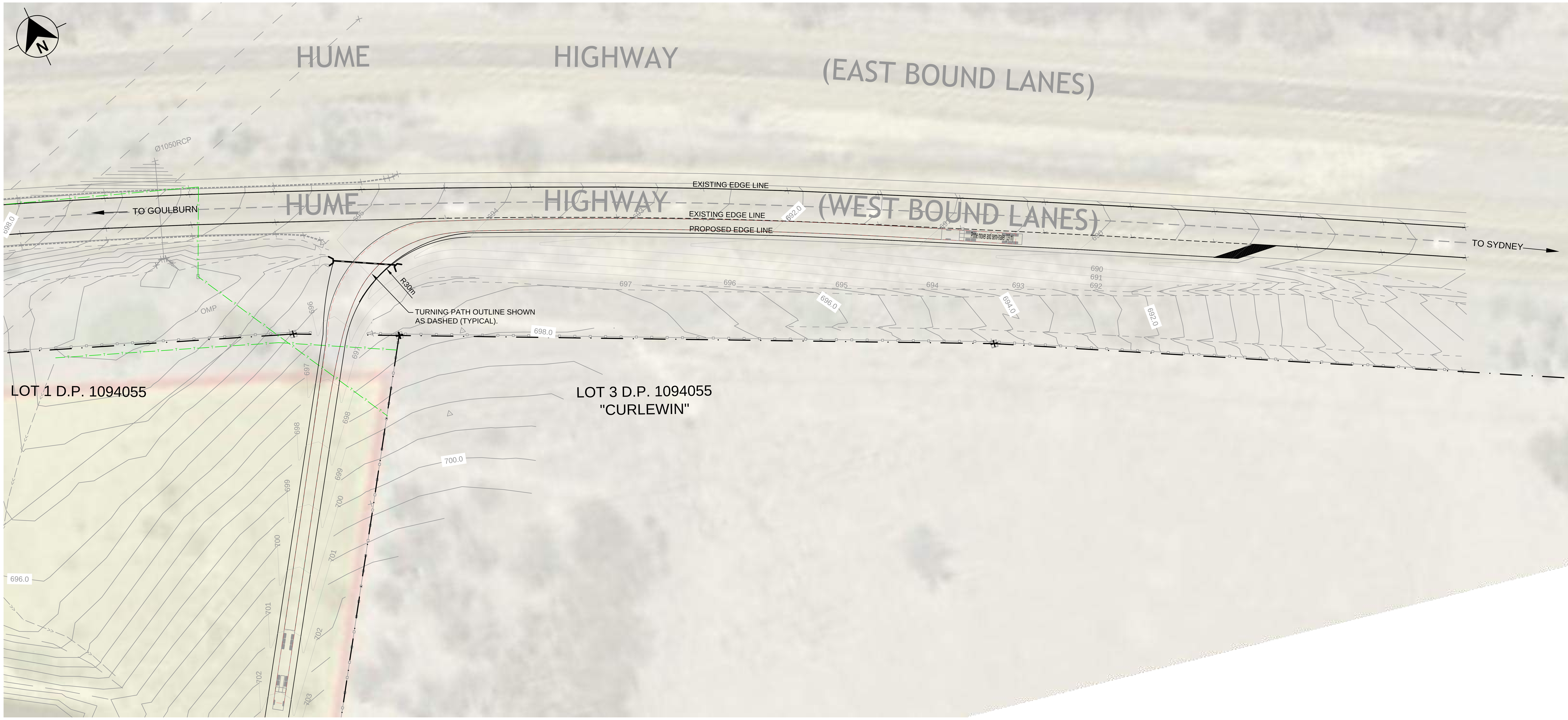
p. Deceleration Lane Plan 16039_DA04_Vehicular turning movement plan – Prime Mover & Semi trailer (19m)-Issue01.



Sheet Subject: EMERGENCY EXIT PLAN	LATCHALS PLANNING ENGINEERING & MANAGEMENT	GOULBURN MULWAREE COUNCIL
		PROPOSED BASALT QUARRY
		LOTS 1 & 2 DP 1094055
		63 CURLEWIN LANE BOXERS CREEK

Sheet No.	No. of Sheets	Sheet size
1	1	A

NOT FOR CONSTRUCTION



PLAN VIEW

SCALE 1:500

CAD File Name: N:\(B) Projects\16XXX\16039 63-65 Tiyces Lane, Boxers Creek\(E) Drawings\16039_DA04_Vehicular Turning Movement Plan - Prime Mover & Semi-trailer (19m).dwg

ISSUE		DESIGN	DRAWN	CHECKED	VERIFIED	DATE	AMENDMENTS/REVISION DETAILS
	01	C.N.	T.B.	C.N.		21/12/16	ISSUED FOR RMS APPROVAL

SCALE: 0 5 10 15 20 25m — SCALE: 1:500 (A1 SHEET)

ISSUED FOR: CONCEPT

L.G.A.: GOULBURN MULWAREE COUNCIL

WARNING: EXISTING UTILITY SERVICES ARE SHOWN AS INDICATIVE ONLY. CONTRACTOR IS NOT TO RELY ON THE DEPTH AND LOCATION OF UTILITIES SHOWN ON THE PLAN AND IS TO INVESTIGATE/LOCATE ALL SERVICES ON-SITE PRIOR TO DIGGING. CONTRACTOR IS TO NOTIFY THE DESIGN ENGINEER IF A CLASH WITH ANY EXISTING UTILITIES OCCURS ON SITE.

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ABN 56 163 789 393
www.ncengineers.com.au | (02) 4861 2042
Shop 25A 310-312 Bong Bong Street, Bowral NSW 2576

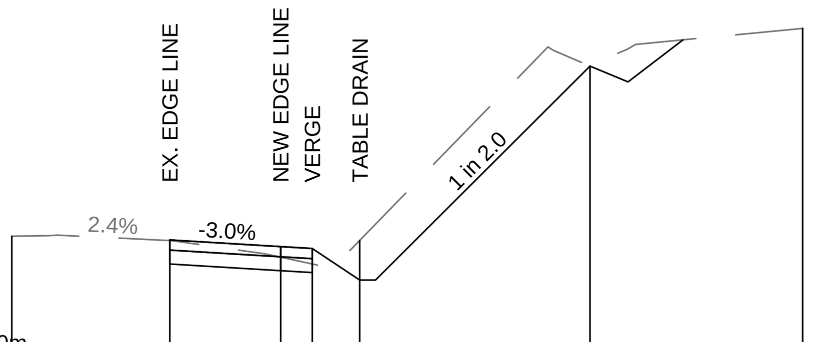
CLIENT: ARGYLE (NSW) Pty Ltd

PROJECT: LOT 1 & 2 D.P. 1094055 HUME HIGHWAY, BOXERS CREEK

DRAWING TITLE: VEHICULAR TURNING MOVEMENT PLAN - PRIME MOVER & SEMI-TRAILER (19m)

PROJECT No.	SUB-PROJECT No.	DRAWING No.	ISSUE	SHEET SIZE
16039	01	DA04	01	A1

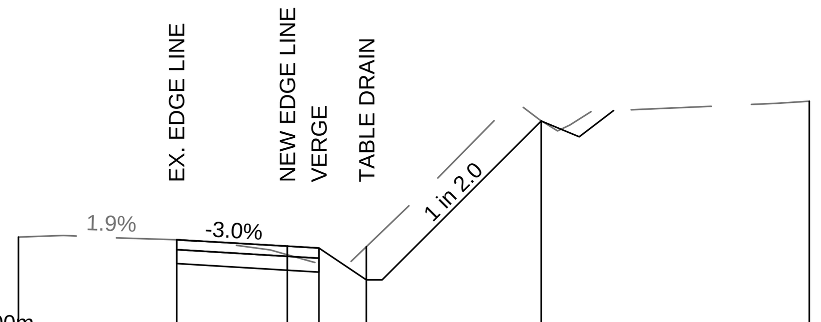
NOT FOR CONSTRUCTION



R.L. 688.500m

DESIGN CODE		C.L	RLM	REB	RTB	RBAT	
CUT/ FILL		0.008	0.166	0.245	-0.629	0.000	
DESIGN LEVELS		690.30	690.19	690.16	689.66	693.05	
EXISTING LEVELS	690.355	690.288	690.026	689.916	690.290	693.051	693.647
DESIGN OFFSET	-5.000	0.000	3.500	4.500	6.000	13.279	20.000

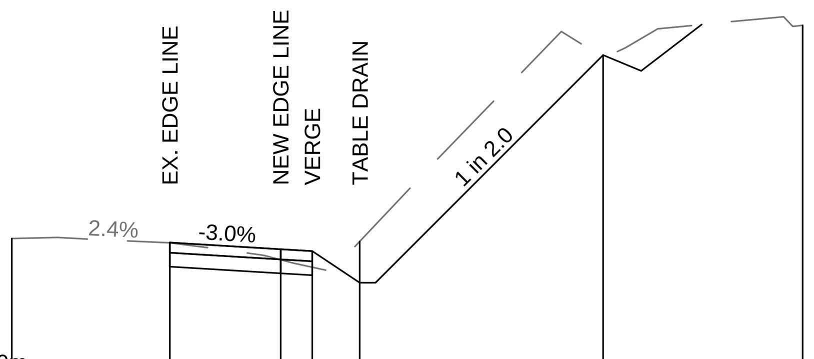
Ch 720.000 m
HUME HWY FL-S



R.L. 688.000m

DESIGN CODE		C.L	RLM	REB	RTB	RBAT	
CUT/ FILL		0.000	0.136	0.242	-0.523	0.000	
DESIGN LEVELS		689.486	689.381	689.351	688.851	691.365	
EXISTING LEVELS	689.525	689.486	689.245	689.109	689.374	691.365	691.676
DESIGN OFFSET	-5.000	0.000	3.500	4.500	6.000	11.528	20.000

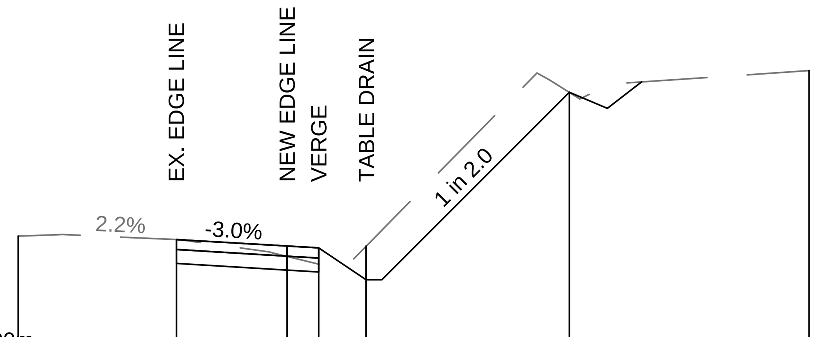
Ch 750.000 m
HUME HWY FL-S



R.L. 688.500m

DESIGN CODE		C.L	RLM	REB	RTB	RBAT	
CUT/ FILL		0.005	0.167	0.256	-0.652	0.000	
DESIGN LEVELS		690.57	690.46	690.43	689.93	693.53	
EXISTING LEVELS	690.630	690.561	690.294	690.175	690.583	693.531	693.999
DESIGN OFFSET	-5.000	0.000	3.500	4.500	6.000	13.700	20.000

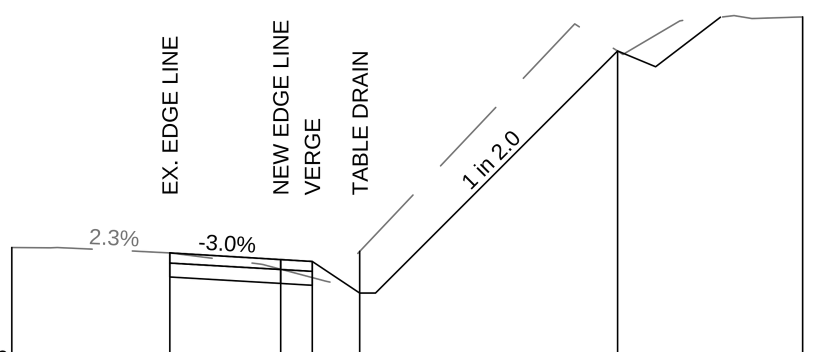
Ch 710.000 m
HUME HWY FL-S



R.L. 688.000m

DESIGN CODE		C.L	RLM	REB	RTB	RBAT	
CUT/ FILL		0.000	0.159	0.256	-0.489	0.000	
DESIGN LEVELS		689.763	689.658	689.628	689.128	692.089	
EXISTING LEVELS	689.816	689.763	689.499	689.372	689.617	692.089	692.432
DESIGN OFFSET	-5.000	0.000	3.500	4.500	6.000	12.423	20.000

Ch 740.000 m
HUME HWY FL-S



R.L. 689.000m

DESIGN CODE		C.L	RLM	REB	RTB	RBAT	
CUT/ FILL		0.001	0.155	0.257	-0.660	0.000	
DESIGN LEVELS		690.84	690.73	690.70	690.20	694.03	
EXISTING LEVELS	690.922	690.836	690.576	690.444	690.861	694.028	694.566
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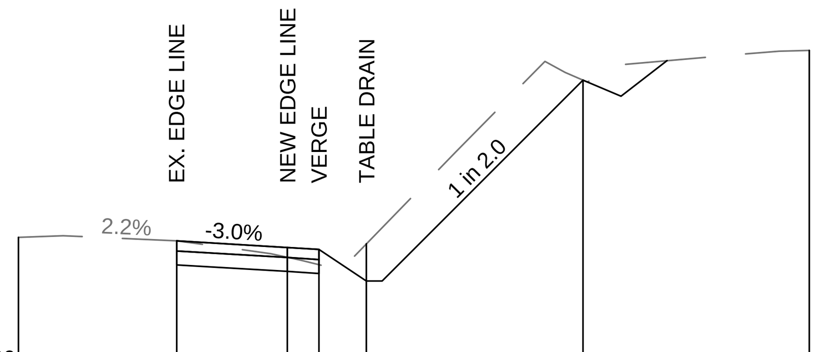
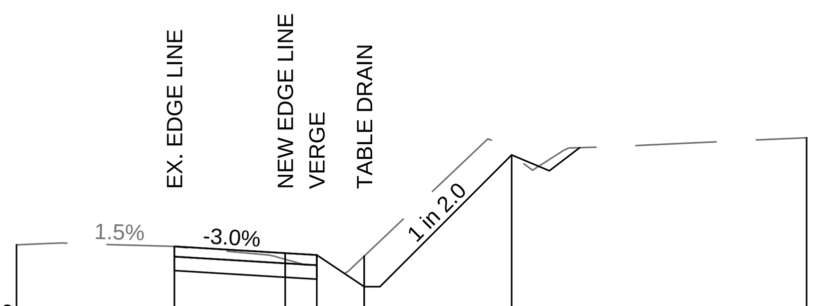
Ch 700.000 m
HUME HWY FL-S



R.L. 688.000m

DESIGN CODE		C.L	RLM	REB	RTB	RBAT	
CUT/ FILL		0.000	0.157	0.244	-0.587	0.000	
DESIGN LEVELS		690.03	689.92	689.89	689.39	692.57	
EXISTING LEVELS	690.083	690.026	689.764	689.647	689.978	692.565	693.037
DESIGN OFFSET	-5.000	0.000	3.500	4.500	6.000	12.848	20.000

Ch 730.000 m
HUME HWY FL-S



R.L. 688.000m

DESIGN CODE		C.L	RLM	REB	RTB	RBAT	
CUT/ FILL		0.000	0.097	0.198	-0.482	0.000	
DESIGN LEVELS		689.207	689.102	689.072	688.572	690.653	
EXISTING LEVELS	689.234	689.207	689.005	688.874	689.054	690.653	690.924
DESIGN OFFSET	-5.000	0.000	3.500	4.500	6.000	10.662	20.000

Ch 760.000 m
HUME HWY FL-S

CAD File Name: N:\(B) Projects\16XXX\16039 63-65 Tyces Lane, Boxers Creek\(E) Drawings\16039_DA03_Cross Sections - Sheet 2.dwg

ISSUE	DESIGN	DRAWN	CHECKED	VERIFIED	DATE	AMENDMENTS/REVISION DETAILS
01	C.N.	T.B.	C.N.		29/11/16	ISSUED FOR RMS APPROVAL
02	C.N.	T.B.	C.N.		21/12/16	ISSUED FOR RMS APPROVAL

SCALE
H: 0 2 4 10m — SCALE: 1:200 (A1 SHEET)
V: 0 1 2 3 4 5m — SCALE: 1:100 (A1 SHEET)

ISSUED FOR: CONCEPT

L.G.A.: GOULBURN MULWAREE COUNCIL

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CIVIL & ENVIRONMENTAL CONSULTING ENGINEERS
ABN 56 163 789 393
www.ncengineers.com.au | (02) 4861 2042
Shop 25A 310-312 Bong Bong Street, Bowral NSW 2576

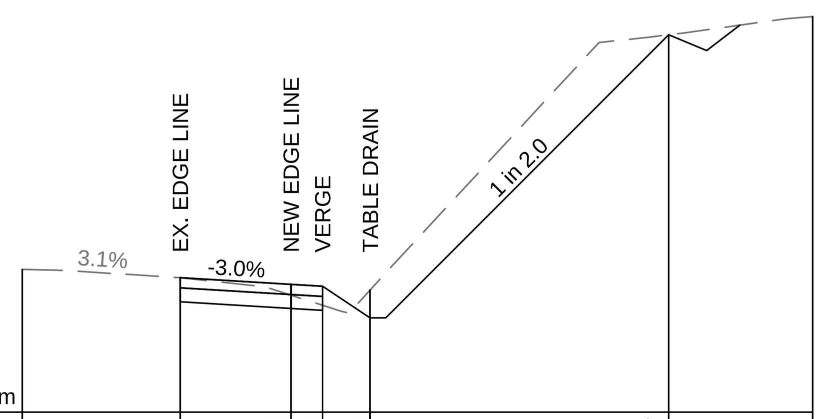
CLIENT: ARGYLE (NSW) Pty Ltd

PROJECT: LOT 1 & 2 D.P. 1094055 HUME HIGHWAY, BOXERS CREEK

DRAWING TITLE: CROSS SECTIONS SHEET 2 OF 2

PROJECT No.	SUB-PROJECT No.	DRAWING No.	ISSUE	SHEET SIZE
16039	01	DA03	02	A1

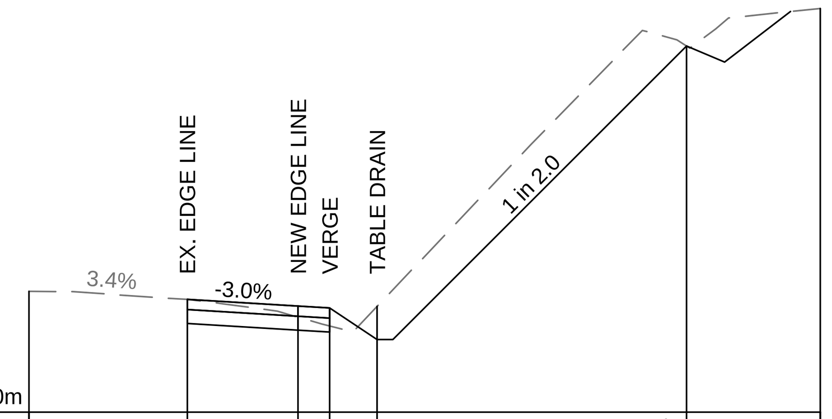
NOT FOR CONSTRUCTION



R.L. 691.500m

DESIGN CODE		C.L.	RLM	REB	RTB	RBAT	
CUT/ FILL		0.000	0.171	0.301	-0.439	0.000	
DESIGN LEVELS		693.62	693.52	693.49	692.99	697.46	
EXISTING LEVELS	693.755	693.623	693.348	693.187	693.427	697.463	697.751
DESIGN OFFSET	-5.000	0.000	3.500	4.500	6.000	15.450	20.000

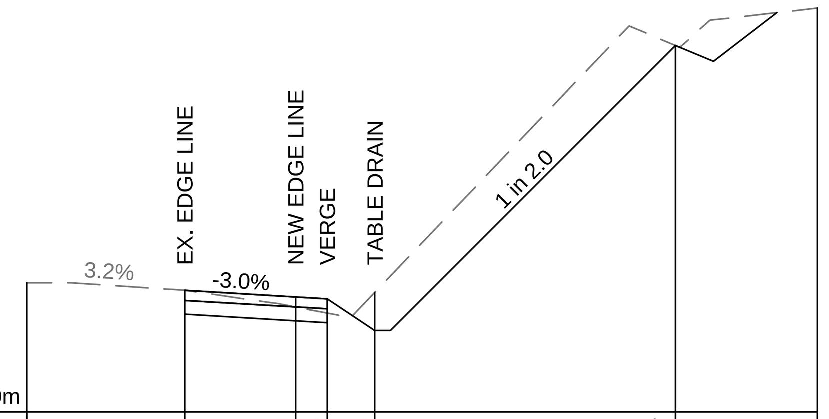
Ch 600.000 m
HUME HWY FL-S



R.L. 691.000m

DESIGN CODE		C.L.	RLM	REB	RTB	RBAT	
CUT/ FILL		0.000	0.175	0.284	-0.527	0.000	
DESIGN LEVELS		692.78	692.67	692.64	692.14	696.78	
EXISTING LEVELS	692.909	692.779	692.499	692.359	692.670	696.784	697.379
DESIGN OFFSET	-5.000	0.000	3.500	4.500	6.000	15.781	20.000

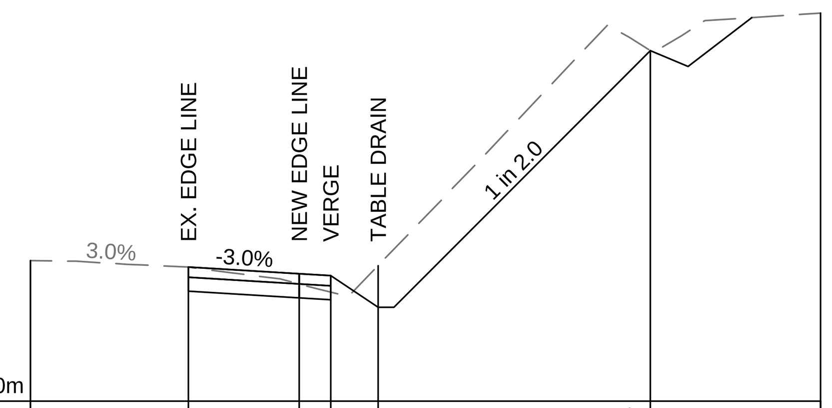
Ch 630.000 m
HUME HWY FL-S



R.L. 690.000m

DESIGN CODE		C.L.	RLM	REB	RTB	RBAT	
CUT/ FILL		0.000	0.160	0.226	-0.600	0.000	
DESIGN LEVELS		691.92	691.82	691.79	691.29	695.79	
EXISTING LEVELS	692.037	691.921	691.656	691.561	691.886	695.789	696.381
DESIGN OFFSET	-5.000	0.000	3.500	4.500	6.000	15.506	20.000

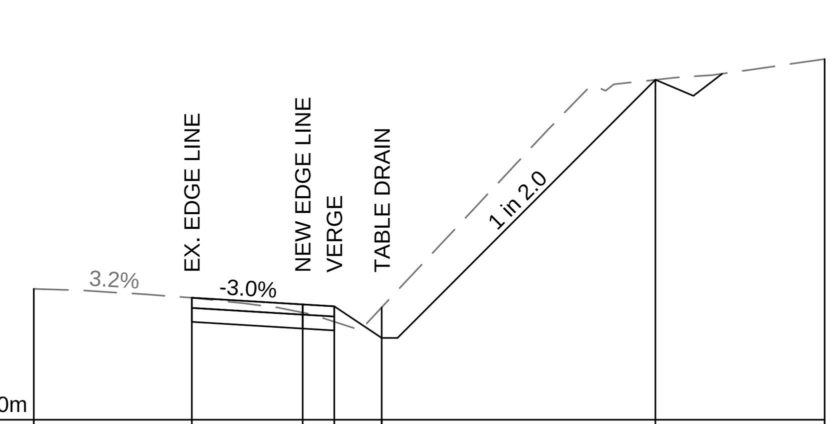
Ch 660.000 m
HUME HWY FL-S



R.L. 689.000m

DESIGN CODE		C.L.	RLM	REB	RTB	RBAT	
CUT/ FILL		0.000	0.161	0.260	-0.659	0.000	
DESIGN LEVELS		691.11	691.01	690.98	690.48	694.53	
EXISTING LEVELS	691.215	691.113	690.848	690.718	691.137	694.532	695.126
DESIGN OFFSET	-5.000	0.000	3.500	4.500	6.000	14.608	20.000

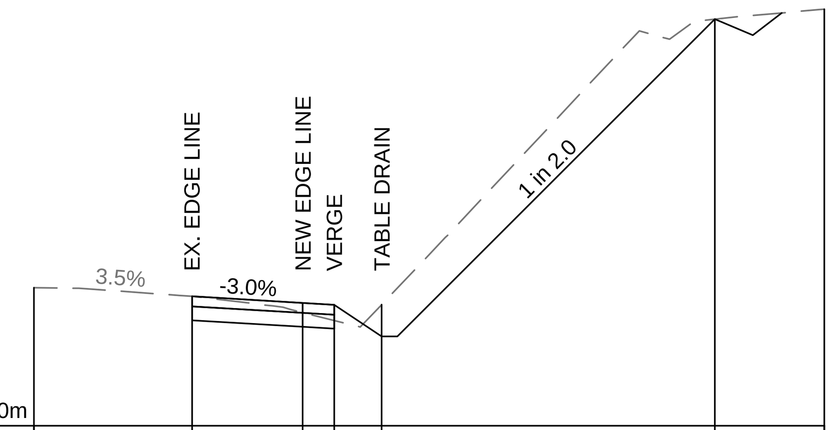
Ch 690.000 m
HUME HWY FL-S



R.L. 692.000m

DESIGN CODE		C.L.	RLM	REB	RTB	RBAT	
CUT/ FILL		0.000	0.128	0.244	-0.485	0.000	
DESIGN LEVELS		693.93	693.82	693.79	693.29	697.37	
EXISTING LEVELS	694.066	693.926	693.693	693.546	693.776	697.367	697.694
DESIGN OFFSET	-5.000	0.000	3.500	4.500	6.000	14.653	20.000

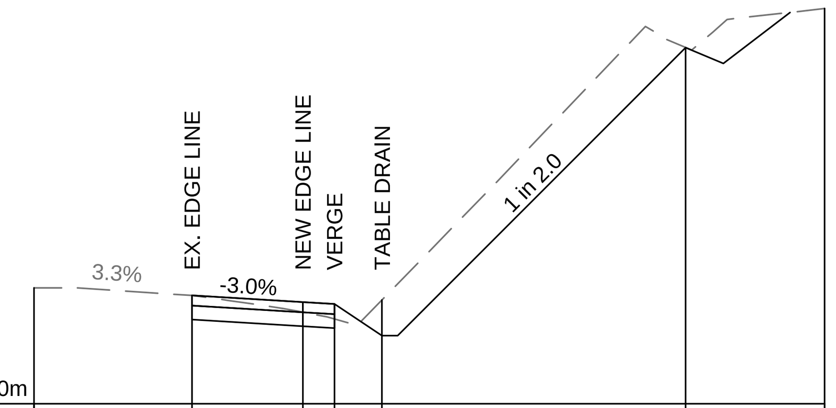
Ch 590.000 m
HUME HWY FL-S



R.L. 691.000m

DESIGN CODE		C.L.	RLM	REB	RTB	RBAT	
CUT/ FILL		0.000	0.154	0.249	-0.503	0.000	
DESIGN LEVELS		693.05	692.95	692.92	692.42	697.43	
EXISTING LEVELS	693.187	693.050	692.791	692.666	692.918	697.433	697.592
DESIGN OFFSET	-5.000	0.000	3.500	4.500	6.000	16.537	20.000

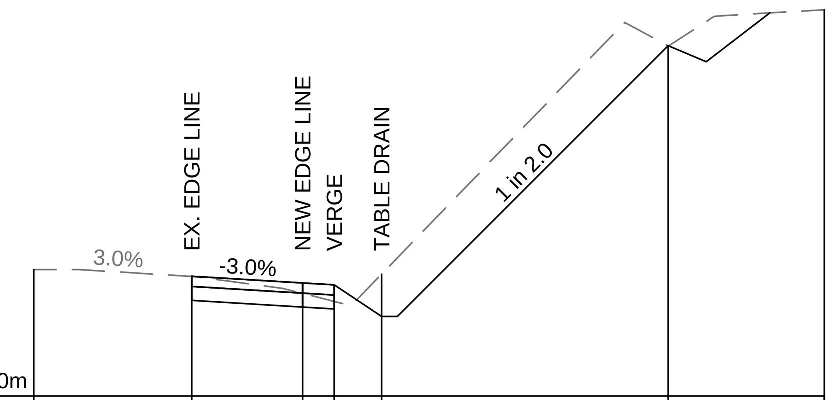
Ch 620.000 m
HUME HWY FL-S



R.L. 690.500m

DESIGN CODE		C.L.	RLM	REB	RTB	RBAT	
CUT/ FILL		0.000	0.158	0.235	-0.565	0.000	
DESIGN LEVELS		692.21	692.10	692.07	691.57	696.12	
EXISTING LEVELS	692.328	692.209	691.946	691.839	692.139	696.123	696.740
DESIGN OFFSET	-5.000	0.000	3.500	4.500	6.000	15.599	20.000

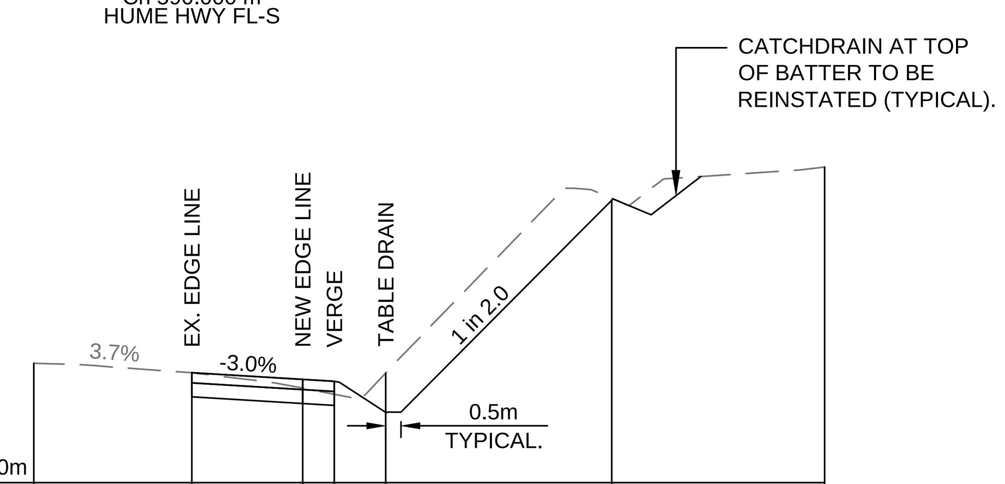
Ch 650.000 m
HUME HWY FL-S



R.L. 689.500m

DESIGN CODE		C.L.	RLM	REB	RTB	RBAT	
CUT/ FILL		0.000	0.164	0.260	-0.669	0.000	
DESIGN LEVELS		691.39	691.29	691.26	690.76	695.04	
EXISTING LEVELS	691.500	691.391	691.122	690.996	691.425	695.036	695.607
DESIGN OFFSET	-5.000	0.000	3.500	4.500	6.000	15.059	20.000

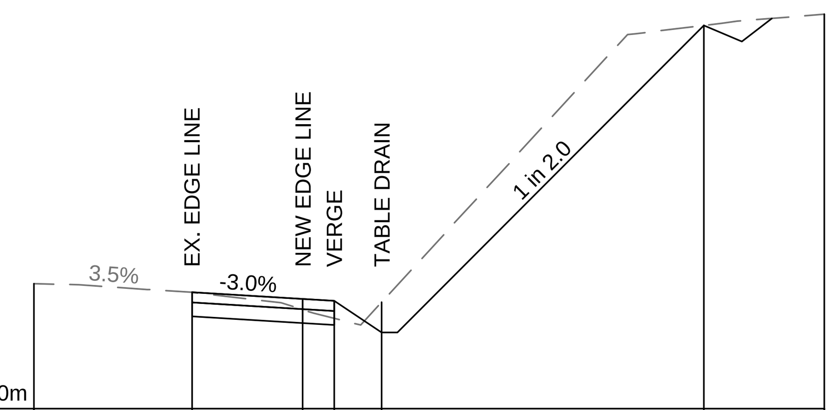
Ch 680.000 m
HUME HWY FL-S



R.L. 692.500m

DESIGN CODE		C.L.	RLM	REB	RTB	RBAT	
CUT/ FILL		0.000	0.138	0.204	-0.618	-0.025	
DESIGN LEVELS		694.23	694.13		693.61	696.96	
EXISTING LEVELS	694.382	694.232	693.989	693.893	694.227	696.985	697.481
DESIGN OFFSET	-5.000	0.000	3.500	4.500	6.123	13.277	20.000

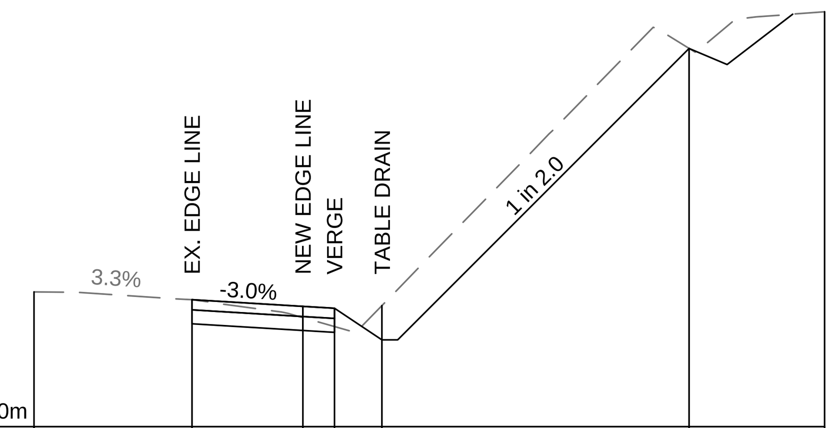
Ch 580.000 m
HUME HWY FL-S



R.L. 691.500m

DESIGN CODE		C.L.	RLM	REB	RTB	RBAT	
CUT/ FILL		0.000	0.170	0.277	-0.478	0.000	
DESIGN LEVELS		693.33	693.23	693.20	692.70	697.55	
EXISTING LEVELS	693.470	693.335	693.060	692.923	693.178	697.547	697.727
DESIGN OFFSET	-5.000	0.000	3.500	4.500	6.000	16.194	20.000

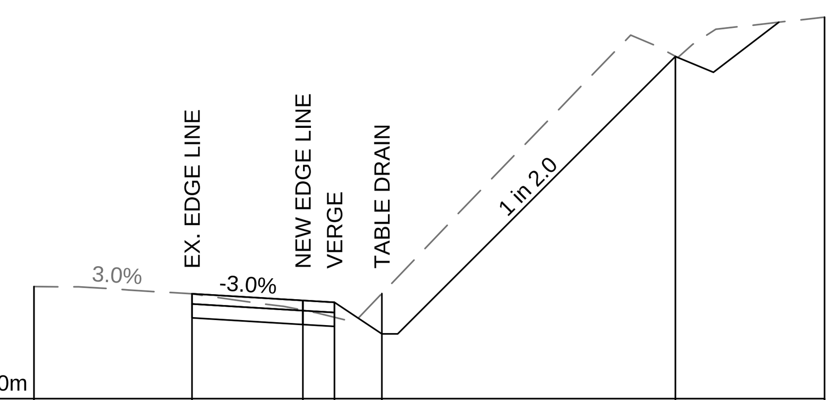
Ch 610.000 m
HUME HWY FL-S



R.L. 690.500m

DESIGN CODE		C.L.	RLM	REB	RTB	RBAT	
CUT/ FILL		0.000	0.175	0.289	-0.543	0.000	
DESIGN LEVELS		692.50	692.40	692.37	691.87	696.47	
EXISTING LEVELS	692.628	692.503	692.222	692.079	692.410	696.475	697.056
DESIGN OFFSET	-5.000	0.000	3.500	4.500	6.000	15.715	20.000

Ch 640.000 m
HUME HWY FL-S



R.L. 690.000m

DESIGN CODE		C.L.	RLM	REB	RTB	RBAT	
CUT/ FILL		0.000	0.153	0.236	-0.638	0.000	
DESIGN LEVELS		691.66	691.55	691.52	691.02	695.41	
EXISTING LEVELS	691.770	691.657	691.399	691.286	691.660	695.414	696.034
DESIGN OFFSET	-5.000	0.000	3.500	4.500	6.000	15.284	20.000

Ch 670.000 m
HUME HWY FL-S

CAD File Name: N:\(B) Projects\16XXX\16039 63-65 Tiyces Lane, Boxers Creek\(E) Drawings\16039_DA02_Cross Sections - Sheet 1.dwg

ISSUE	DESIGN	DRAWN	CHECKED	VERIFIED	DATE	AMENDMENTS/REVISION DETAILS
01	C.N.	T.B.	C.N.		29/11/16	ISSUED FOR RMS APPROVAL
02	C.N.	T.B.	C.N.		21/12/16	ISSUED FOR RMS APPROVAL

SCALE
H: 0 2 4 10m — SCALE: 1:200 (A1 SHEET)
V: 0 1 2 3 4 5m — SCALE: 1:100 (A1 SHEET)

ISSUED FOR
CONCEPT

L.G.A.
GOULBURN MULWAREE COUNCIL

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Novati Consulting Engineers Pty Ltd
CIVIL & ENVIRONMENTAL CONSULTING ENGINEERS
ABN 56 163 789 393
www.ncengineers.com.au | (02) 4861 2042
Shop 25A 310-312 Bong Bong Street, Bowral NSW 2576

CLIENT
ARGYLE (NSW) Pty Ltd

PROJECT
LOT 1 & 2 D.P. 1094055 HUME HIGHWAY, BOXERS CREEK

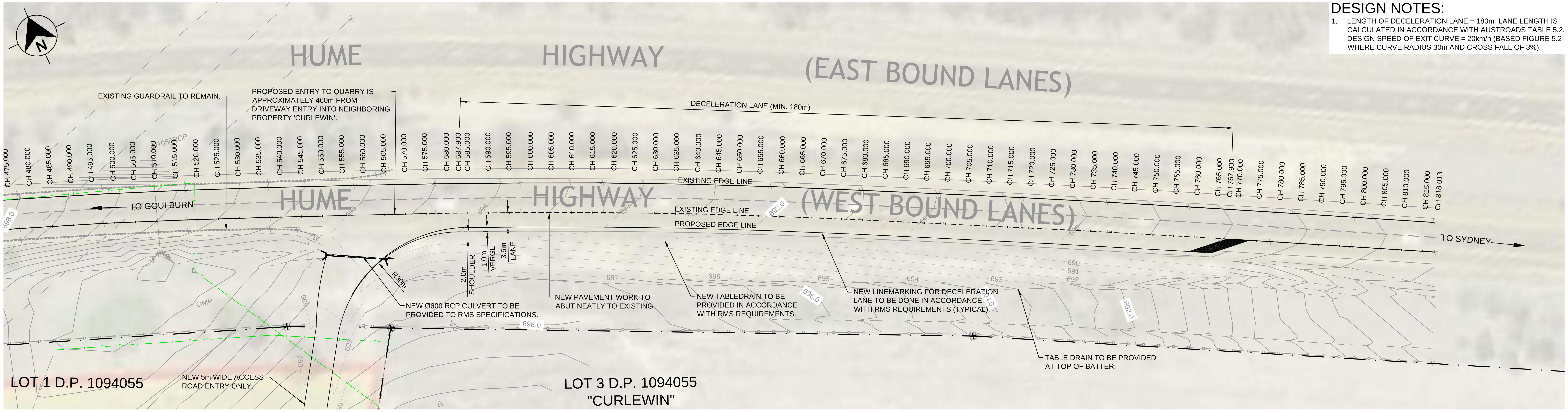
DRAWING TITLE
CROSS SECTIONS SHEET 1 OF 2

PROJECT No.	SUB-PROJECT No.	DRAWING No.	ISSUE	SHEET SIZE
16039	01	DA02	02	A1

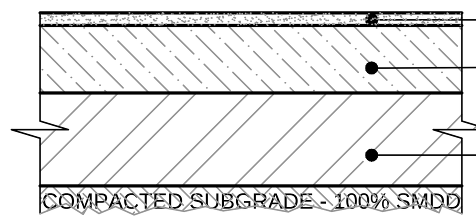
NOT FOR CONSTRUCTION

DESIGN NOTES:

1. LENGTH OF DECELERATION LANE = 180m LANE LENGTH IS CALCULATED IN ACCORDANCE WITH AUSTROADS TABLE 5.2. DESIGN SPEED OF EXIT CURVE = 20km/h (BASED FIGURE 5.2 WHERE CURVE RADIUS 30m AND CROSS FALL OF 3%).



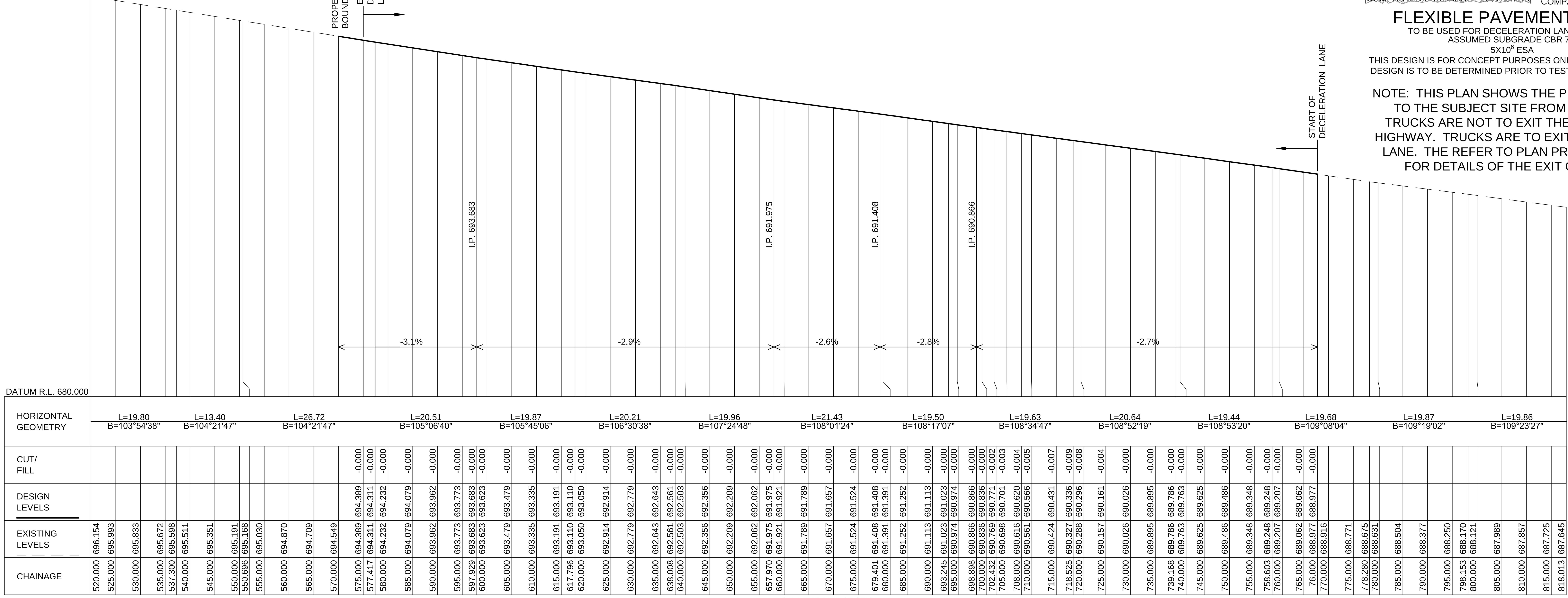
PLAN VIEW
SCALE 1:500



FLEXIBLE PAVEMENT DETAIL

TO BE USED FOR DECELERATION LANE WORKS.
ASSUMED SUBGRADE CBR 7%
5X10^6 ESA
THIS DESIGN IS FOR CONCEPT PURPOSES ONLY. FINAL PAVEMENT DESIGN IS TO BE DETERMINED PRIOR TO TESTING OF SUBGRADE.

NOTE: THIS PLAN SHOWS THE PROPOSED TRUCK ENTRY TO THE SUBJECT SITE FROM THE HUME HIGHWAY. TRUCKS ARE NOT TO EXIT THE SITE ONTO THE HUME HIGHWAY. TRUCKS ARE TO EXIT THE SITE FROM TIYCES LANE. THE REFER TO PLAN PREPARED BY 'LATERALS' FOR DETAILS OF THE EXIT ONTO TIYCES LANE.



LONGITUDINAL SECTION
HUME HWY FL-S Ch 520.000 to Ch 818.013
SCALES: HORIZONTAL 1:500 VERTICAL 1:100
HUME HWY FL-S

CAD File Name: N:\(B) Projects\16XXX\16039 63-65 Tiyces Lane, Boxers Creek\(E) Drawings\16039_DA01_External Roadworks General Arrangement Plan.dwg

ISSUE	DESIGN	DRAWN	CHECKED	VERIFIED	DATE	AMENDMENTS/REVISION DETAILS
01	C.N.	T.B.	C.N.		29/11/16	ISSUED FOR RMS APPROVAL
02	C.N.	T.B.	C.N.		21/12/16	ISSUED FOR RMS APPROVAL

SCALE
H: 0 5 10 15 20 25m SCALE: 1:500 (A1 SHEET)
V: 0 1 2 3 4 5m SCALE: 1:100 (A1 SHEET)

ISSUED FOR: CONCEPT

L.G.A.: GOULBURN MULWAREE COUNCIL

WARNING: EXISTING UTILITY SERVICES ARE SHOWN AS INDICATIVE ONLY. CONTRACTOR IS NOT TO RELY ON THE DEPTH AND LOCATION OF UTILITIES SHOWN ON THE PLAN AND IS TO INVESTIGATE/LOCATE ALL SERVICES ON-SITE PRIOR TO DIGGING. CONTRACTOR IS TO NOTIFY THE DESIGN ENGINEER IF A CLASH WITH ANY EXISTING UTILITIES OCCURS ON SITE.

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www.ncengineers.com.au | (02) 4861 2042
Shop 25A 310-312 Bong Bong Street, Bowral NSW 2576

CLIENT: ARGYLE (NSW) Pty Ltd

PROJECT: LOT 1 & 2 D.P. 1094055 HUME HIGHWAY, BOXERS CREEK

DRAWING TITLE: HUME HIGHWAY - ENTRY ONLY DECELERATION LANE PLAN

PROJECT No.	SUB-PROJECT No.	DRAWING No.	ISSUE	SHEET SIZE
16039	01	DA01	02	A1

Issue	Amendment	Date	
B	Inset, Fencing and minor changes	4/5/2017	Datum : AHD
A	Original	14/4/2017	Laterals Ref : 1707

Surveyed :
Designed :
Drawn : K Allen
Checked : R Mowle

SCALE 1:2500

Sheet No.	No. of Sheets	Sheet size
1	1	A1

LATERALS PLANNING ENGINEERING & MANAGEMENT
1st Floor, 35 Montague Street
Goulburn NSW 2580
Ph: 4821 0973 Fax: 4821 0954

Sheet Subject
VISUAL ASPECTS

GOULBURN MULWAREE COUNCIL
PROPOSED BASALT QUARRY
LOTS 1 & 2 DP 1094055
63 CURLEWIN LANE BOXERS CREEK
17033 HUME HIGHWAY BOXERS CREEK

Issue	Amendment	Date		
			Surveyed : Southern Cross Consultilng Surveyors	SCALE 1:1000
			Designed : Laterals Engineering & Management	
			Drawn : K Allen	
			Checked : R Mowle	
			Datum : AHD	Sheet No. 1 / No. of Sheets 1 / Sheet size A1
A	Original	8/2/2017	Laterals Ref : 1315	

LATERALS PLANNING ENGINEERING & MANAGEMENT

1st Floor, 35 Montague Street

Goulburn NSW 2580

Ph: 4821 0973 Fax: 4821 0954

Sheet Subject

ACCELERATION LANE CONCEPT

GOULBURN MULWAREE COUNCIL

PROPOSED BASALT QUARRY

LOTS 1 & 2 DP 1094055

65 CURLEWIN LANE BOXERS CREEK

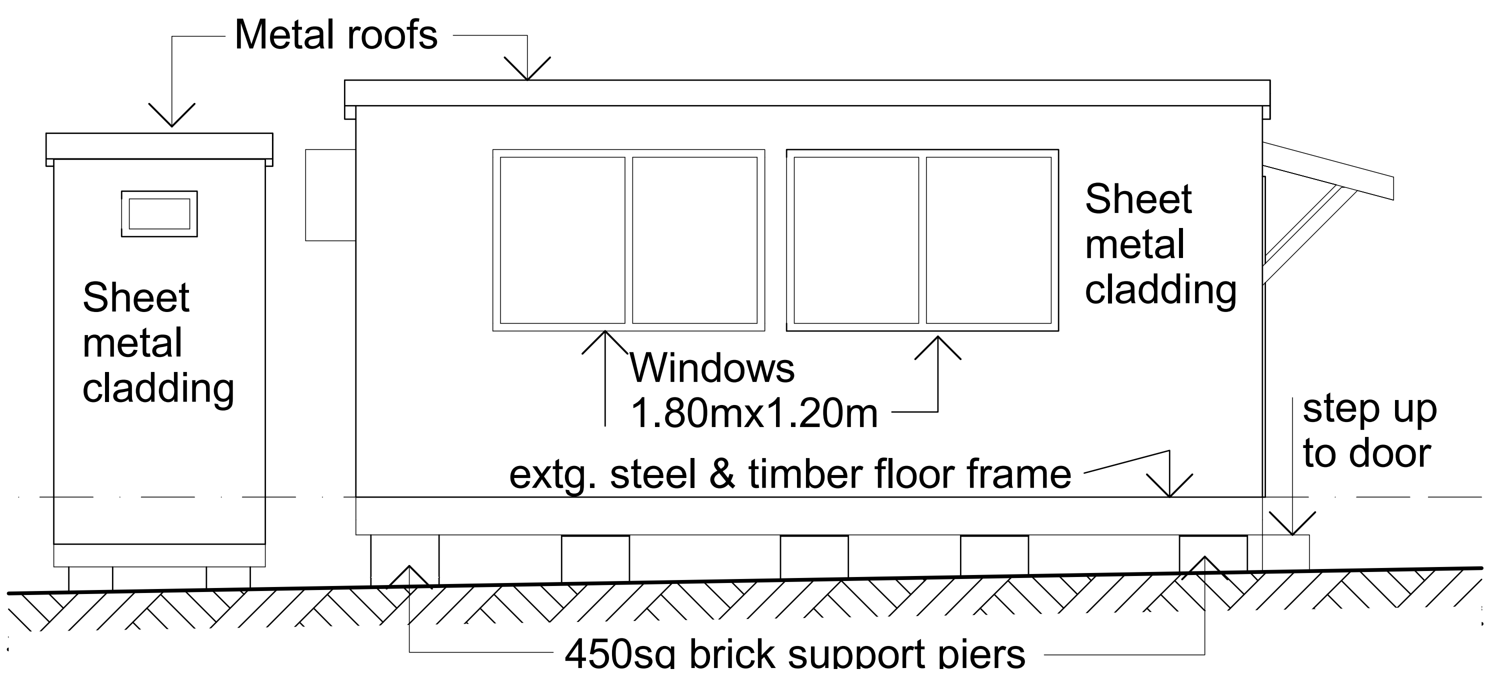
Issue	Amendment	Date			
			Surveyed : Southern Cross Consultilng Surveyors	SCALE 1:1000	LATERALS PLANNING ENGINEERING & MANAGEMENT
			Designed : Laterals Engineering & Management		
			Drawn : K Allen		
			Checked : R Mowle	Sheet No. 1 / No. of Sheets 1 / Sheet size A1	1st Floor, 35 Montague Street, Goulburn NSW 2580, Ph: 4821 0973 Fax: 4821 0954
			Datum : AHD		
A	Original	8/2/2017	Laterals Ref : 1315		

Sheet Subject
ACCELERATION LANE CONCEPT

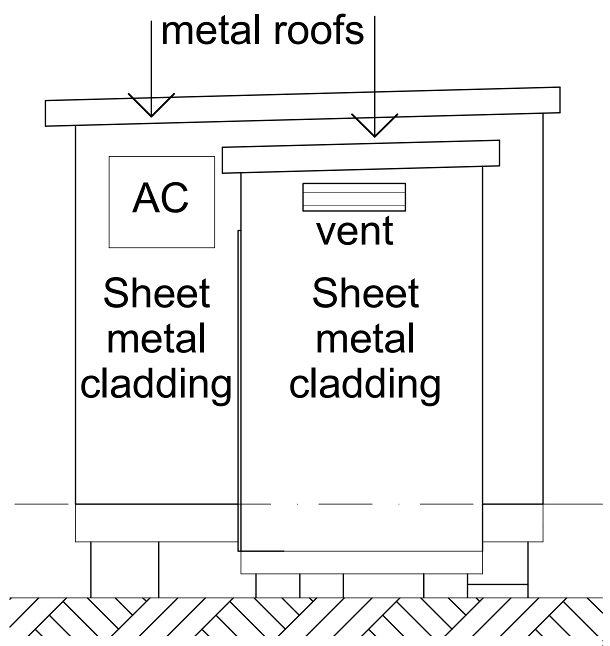
GOULBURN MULWAREE COUNCIL
PROPOSED BASALT QUARRY
LOTS 1 & 2 DP 1094055
65 CURLEWIN LANE BOXERS CREEK

The exterior of the proposed office building

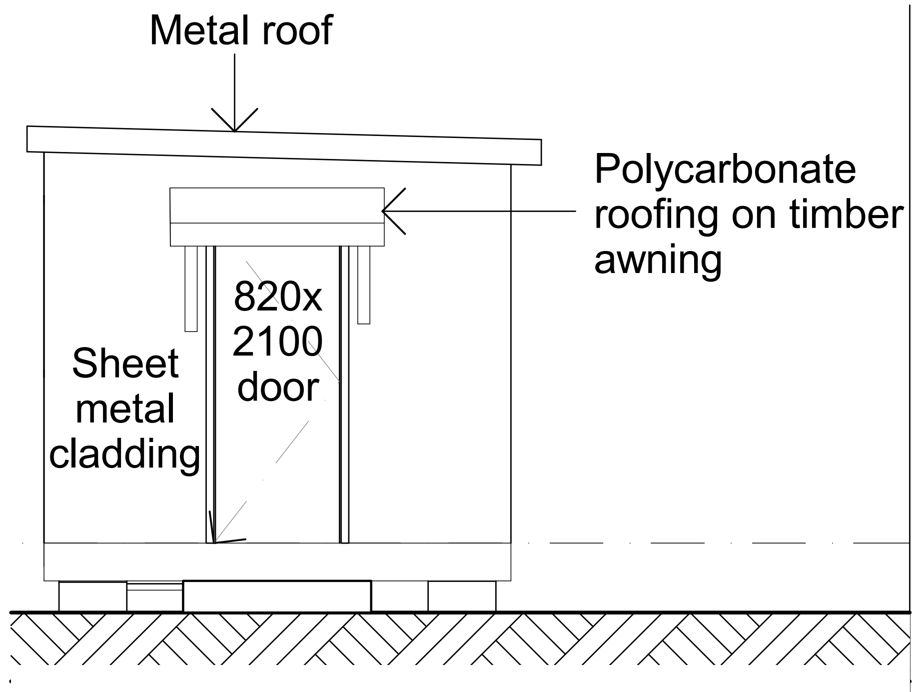
The inside of the existing structure



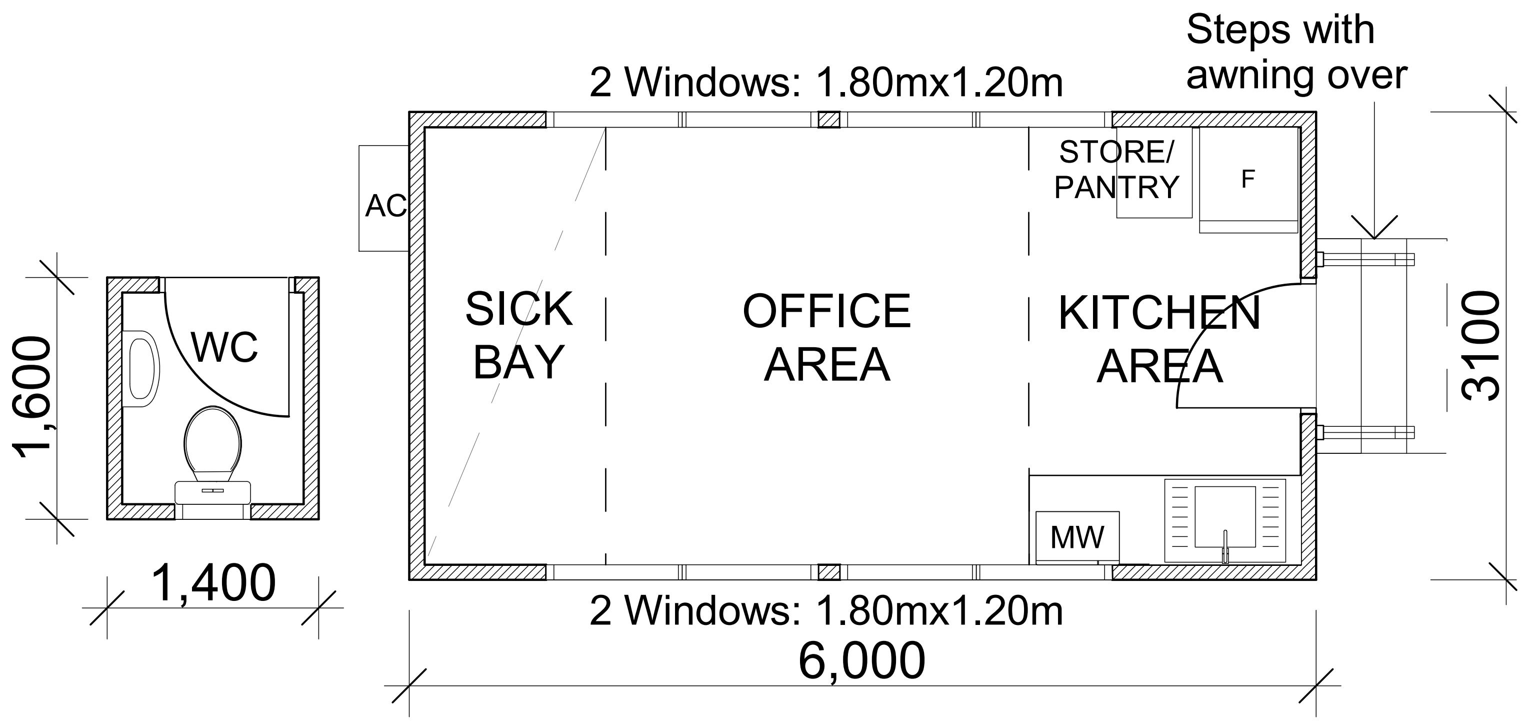
1. South Elevation 1:50



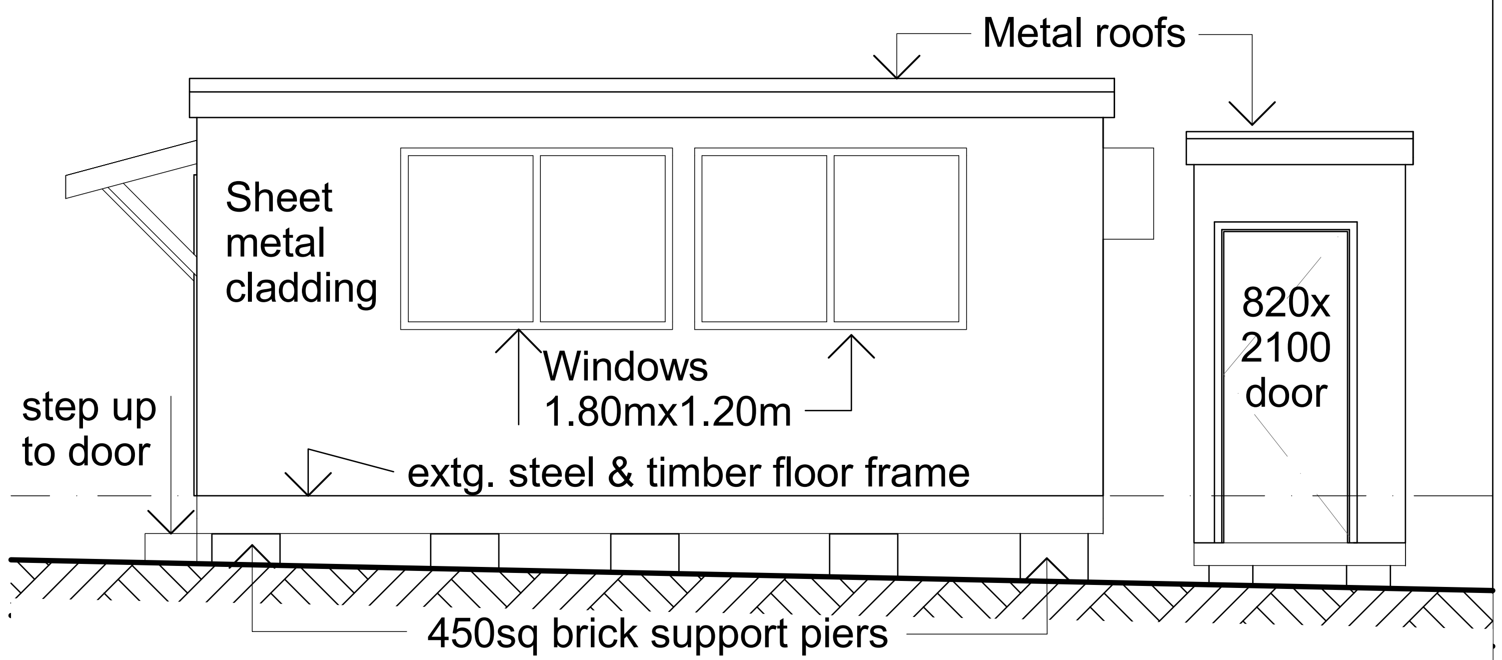
2. West Elevation 1:50



3. East Elevation 1:50



4. Ground Floor 1:50



5. North Elevation 1:50

LATERALS PLANNING NOTES:

1. The Building consists of an existing transportable structure which has been measured and plotted. Ceiling heights are 2.4m.
2. The building is proposed to be fully renovated to the above design and be re-painted.
3. Installation details are to be provided in a s68 Application.
5. Sheet 2 provides photographs of the existing structure.

NOTES:

① - TOILET FACILITIES & KITCHEN AREA TO DRAIN TO EFFLUENT DISPOSAL FACILITIES.

② - ON-SITE EFFLUENT DISPOSAL FACILITY TO BE INSTALLED ADJACENT TO SITE OFFICE & WC, IN ACCORDANCE WITH REPORTS BY SEEC & LATERALS PLANNING.

③ - SITE OFFICE TO CONSIST OF EXISTING TRANSPORTABLE BUILDING - REFER TO PHOTOS..

④ - WC/ ABLUTION FACILITY TO BE BUILT ON SITE - IN ACCORDANCE WITH THE BCA.

SHEET 1 of 2 SHEETS

N

Proposed Site Office Plan

PROPOSED SITE OFFICE & ABLUTION CLOSET FOR QUARRY SITE
AT 63 TIYCES LANE, BOXERS CREEK

COUNCIL ISSUE - 15/07/15
Drawing No. PM/ A02

Bert Hall Designs 9 Settlers Way, Westleigh, NSW - 2120.
Tel - (02) 9875 1314 (H) email: bert.hall44@gmail.com

Scale: 1: 50 @ A3 Date: July, 2015

KEY

Property boundary lines

Laterals Reference: 1707

Notes

1. This plan has been prepared for a development application to Council and should not be used for any other purpose.
2. Dimensions and area are subject to survey and to Council requirements.
3. Every lot may be subject to existing restrictions on the use of land and as required by future Development Application consent conditions, utility providers, Council and developer.
4. There have been no title searches undertaken with the Land & Property Information of NSW in relation to the subject lands.
5. No reliance should be placed on this plan for any financial dealing involving the land.
6. These notes form an integral part of the plan.

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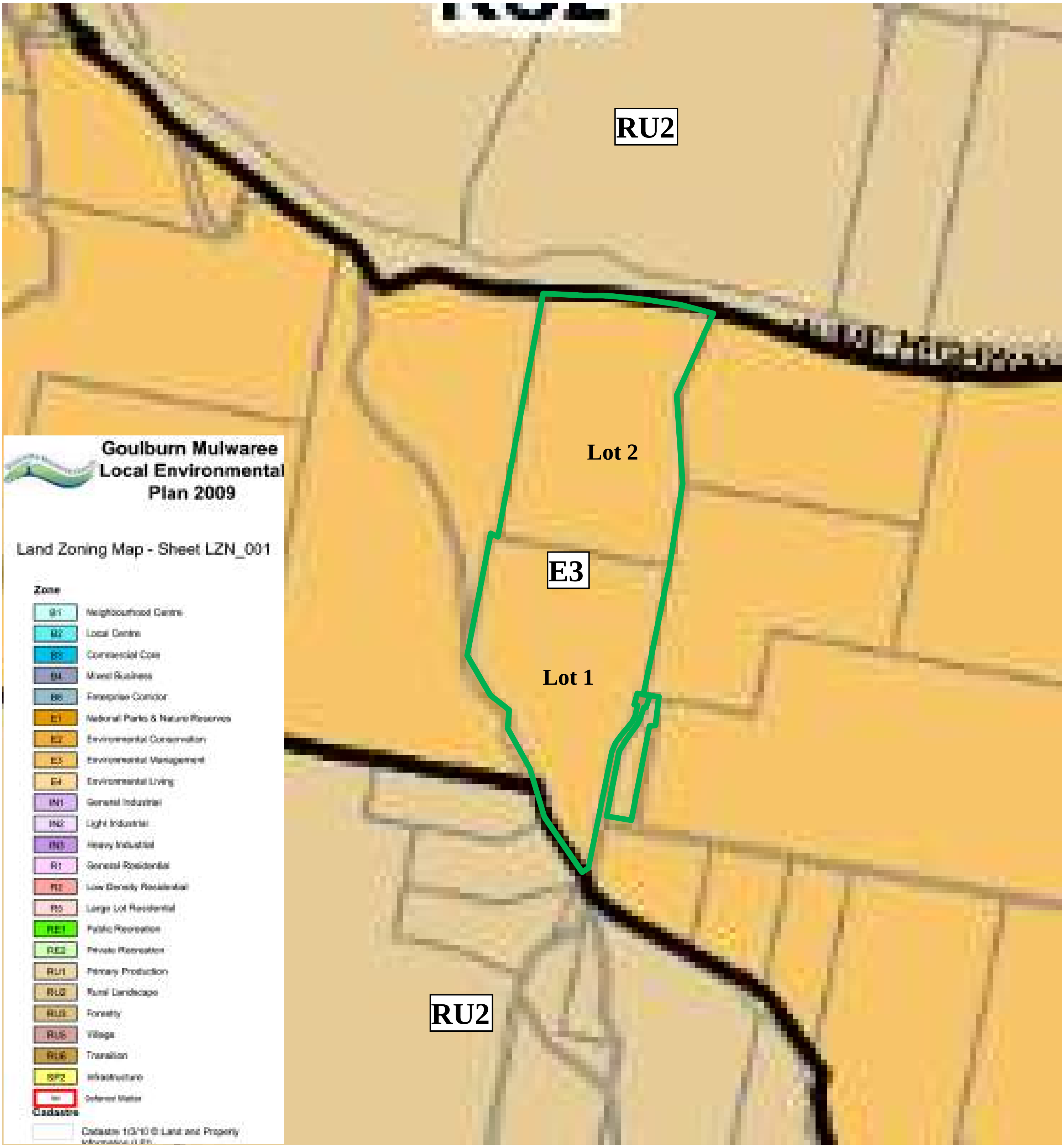
PLANNING
1st Floor, 35 Montague Street
(PO Box 1326) Goulburn 2580
Ph 02 4821 0973
Fax 02 4821 0954
Enquiries: www.laterals.com.au
ABN 86 252 197 269

SITE PLAN – GOULBURN MULWAREE LEP 2009 TERRESTRIAL BIODIVERSITY MAP

Proposed Basalt Quarry on Lots 1 & 2 DP 1094044 63 Curlewin Lane, Boxers Creek

Base map source: NSW Legislation web site.

Scale: Not calculated



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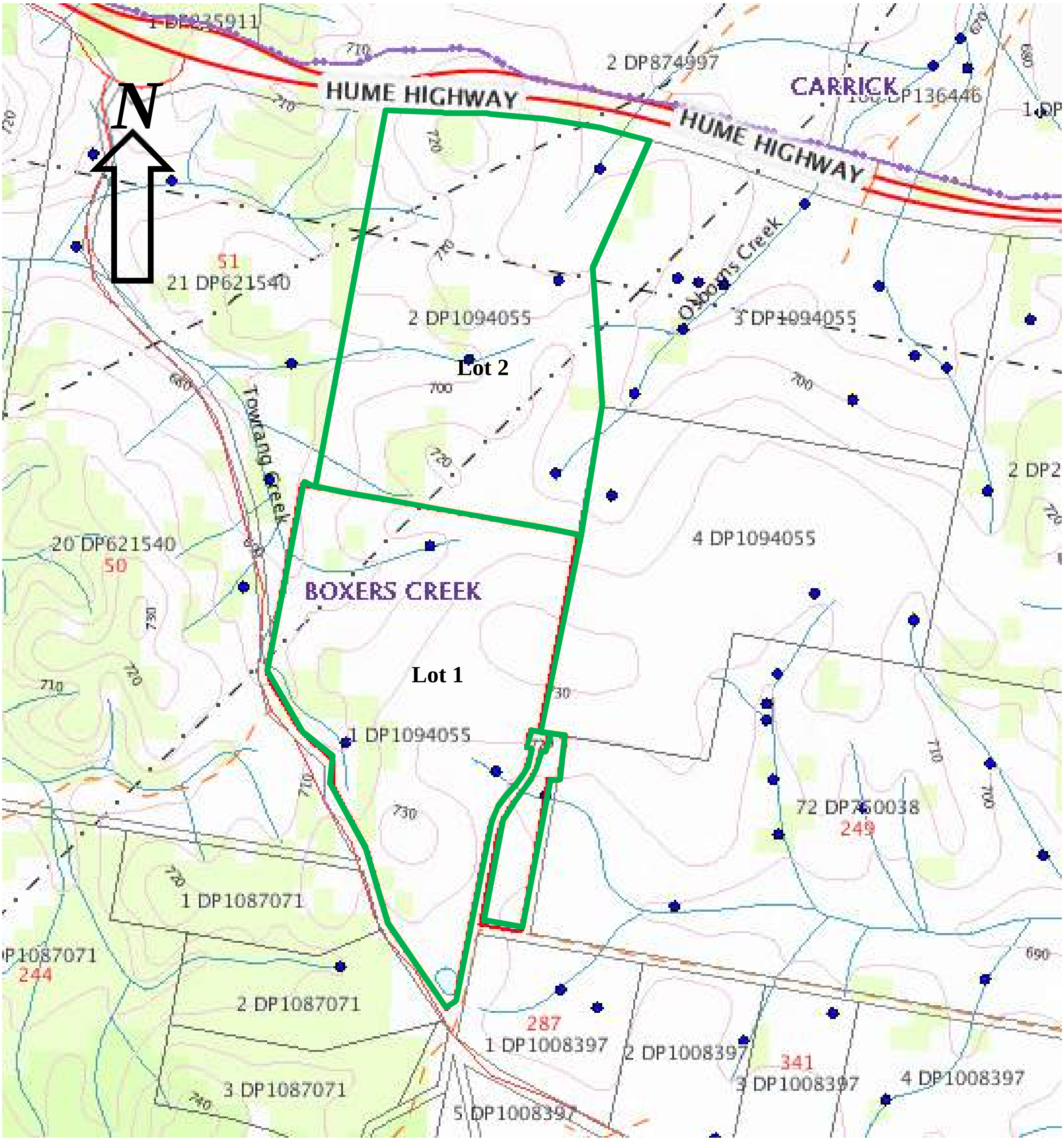
SITE PLAN – GOULBURN MULWAREE LEP 2009 LAND ZONE MAP
Proposed Basalt Quarry on Lot 1 DP 1094044
63 Curlewin Lane, Boxers Creek

Base map source: NSW Legislation web site.

Scale: Not calculated



KEY

Property boundary lines

Lot 2 DP 1094055 is shown for the provision of the right of way from The Hume Highway for the provision is access to Lot 1 DP 1094055.

Laterals Reference: 1707

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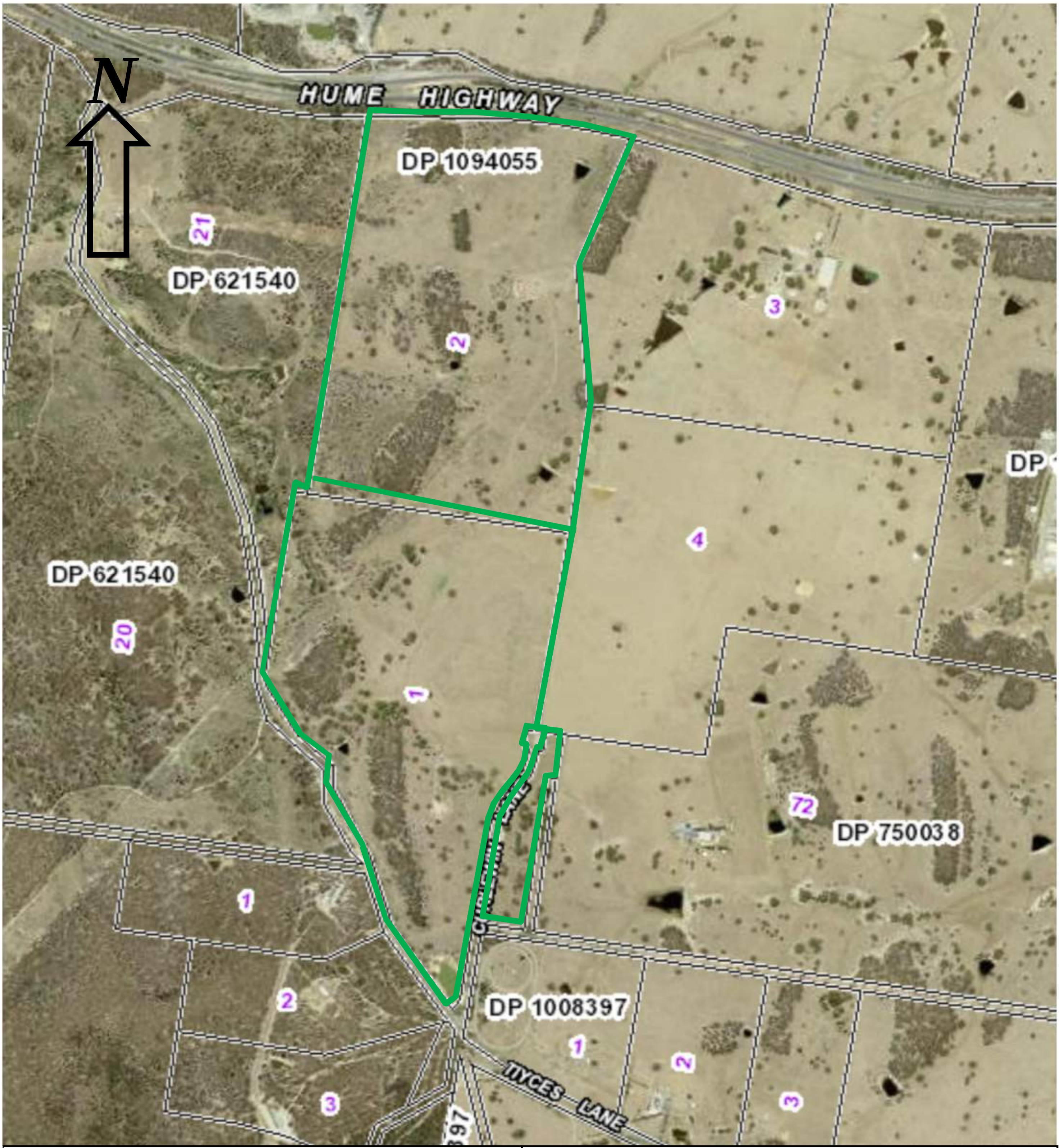
SITE PLAN – TOPOGRAPHIC MAP
Proposed Basalt Quarry on
Lots 1 & 2 DP 1094055
63 Curlewin Lane, Boxers Creek
17033 Hume Highway, Boxers Creek

Based on topographic map from the Department of lands Six Viewer web site. Used with permission.

Scale: Not calculated



KEY

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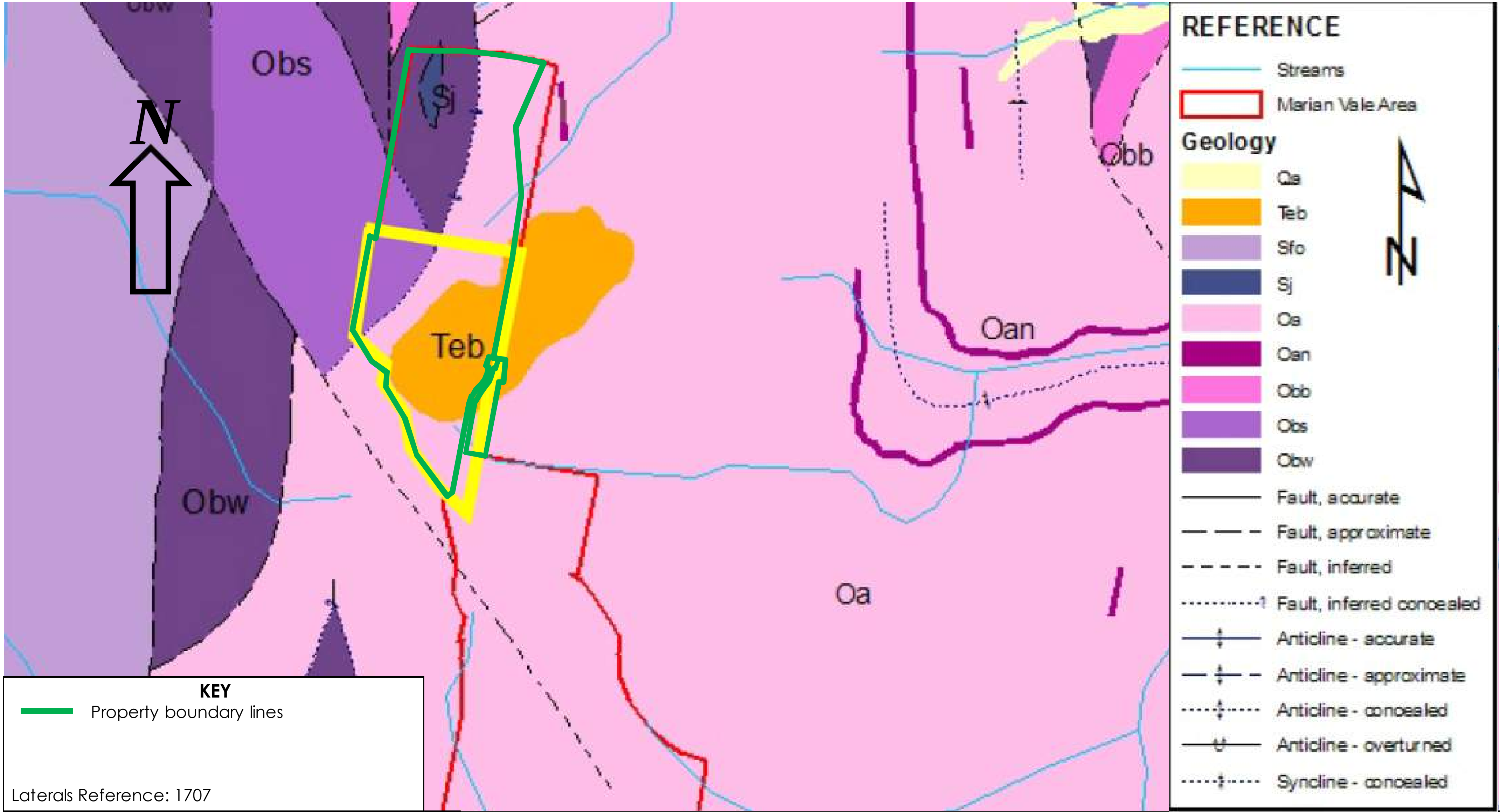
SITE PLAN – AERIAL PHOTOGRAPH
Proposed Basalt Quarry on
Lots 1 & 2 DP 1094055
63 Curlewin Lane, Boxers Creek
17033 Hume Highway, Boxers Creek

Base map source: NSW Department of lands SixViewer web site. Used with permission.

Scale: Not calculated



Base map source: Snelling P.A (compiler). 2003. Goulburn 8629 1:100 000 Geology - GIS Data Package. NSW Department of Mineral Resources, (published on CD-ROM)
Scale: Not calculated

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SITE PLAN – SOLID GEOLOGY
Proposed development
Lot 1 DP 1094055
63 Curlewin Lane, Towrang
17033 Hume Highway, Boxers Creek

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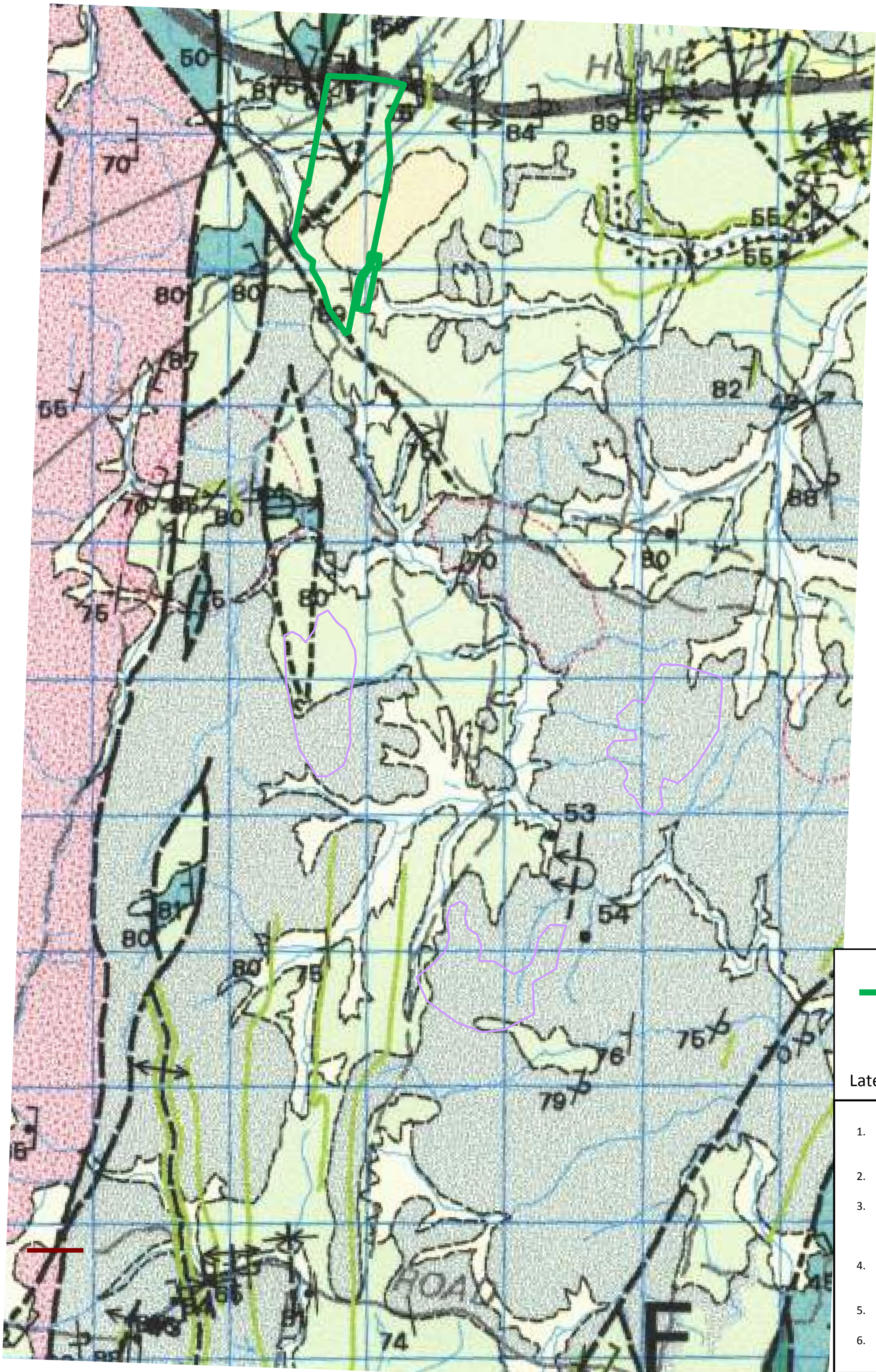

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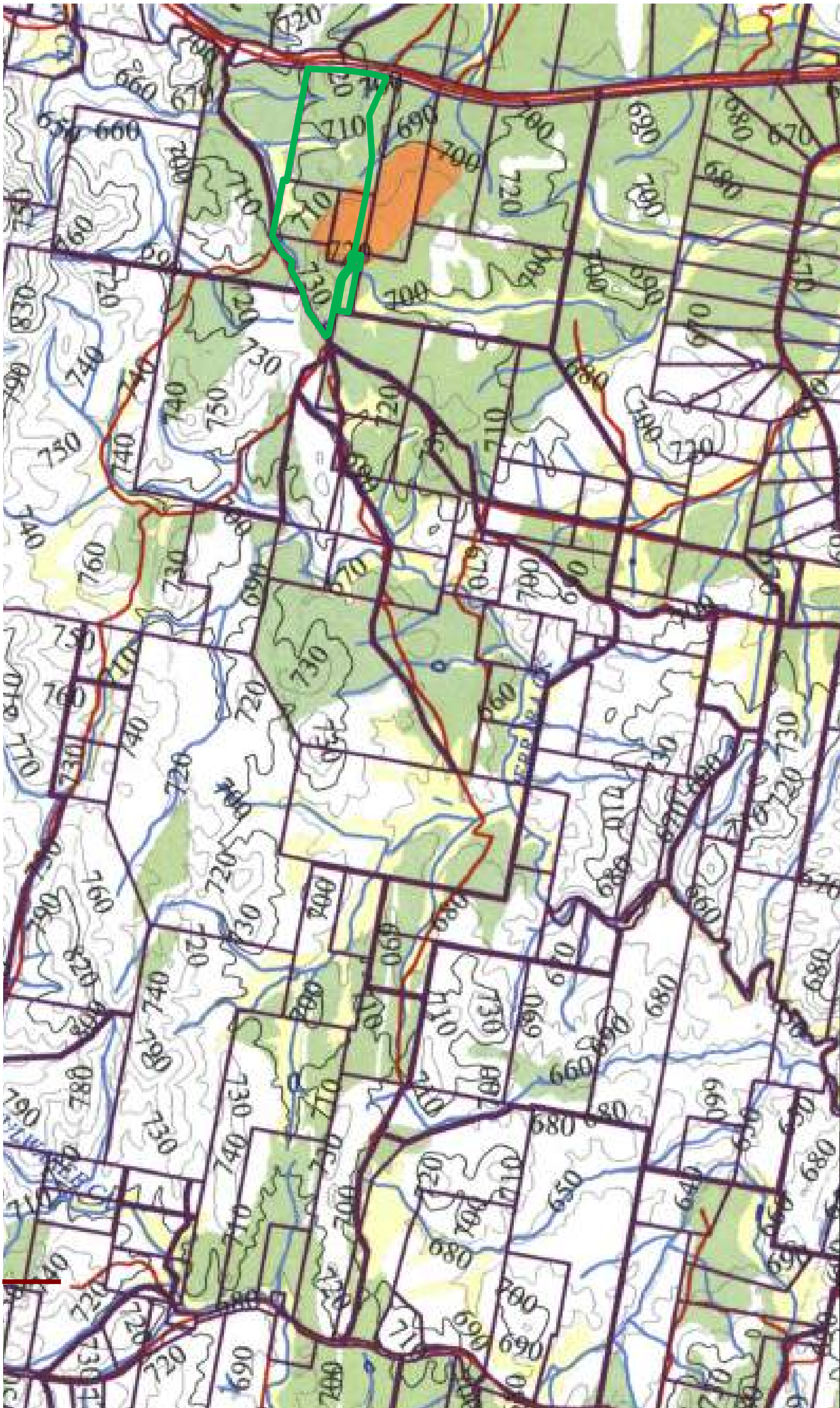
REGOLITH MAP
ARGYLE QUARRY
Lots 1 &2 DP 1094055
63 Curlewin Lane, Boxers Creek
17033 Hume Highway, Boxers Creek

Base map source: Goulburn 1:100,000 Regolith map.
Acknowledgment: This material has been reproduced from a draft hard copy of a map produced by the Department or Primary Industries (Division of Mineral Resources).
Scale: Not calculated



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CADASTRE & CAINOZOIC MAP
ARGYLE QUARRY
Lots 1 & 2 DP 1094055
63 Curlewin Lane, Boxers Creek
17033 Hume Highway, Boxers Creek

Base map source: Goulburn 1:100,000 Cadastre Cainozoic map.

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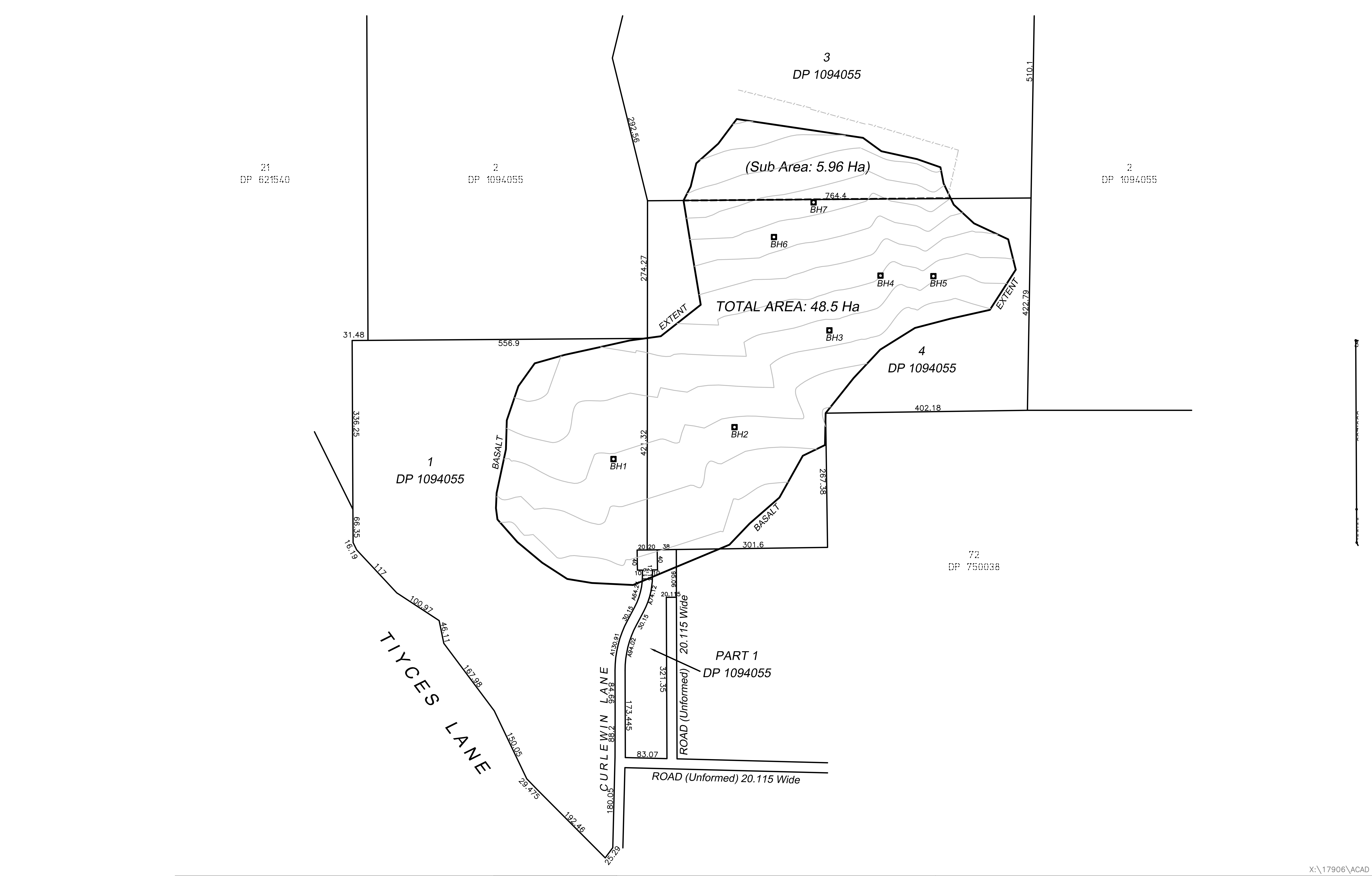
Scale: Not calculated



ISSUE	AMENDMENT	DRAWN	DATE
A	INITIAL ISSUE	IP	26.06.08
B	BORE HOLES ADDED	IP	01.07.08

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Peter MILLER

PROPOSED QUARRY
LOTS 1, 3 & 4 DP 1094055
TIYCES LANE, TOWRANG

LGA: GOULBURN MULWAREE

EXTENTS OF BASALT OUTCROP

SURVEYED: IP
DRAWN: IP
CHECKED:
ISSUE: B
DRAWING No. 17906–BAS

SCALE 1:5000 | DATUM – | DATE 20–06–2008

J. Geological Assessments:
a. Marian Vale Geological Assessment of Potential Construction Material Resources by Geos Mining.
b. Marian Vale Cored Drilling Assessment Report.

Unit 206, 20 Dale St, Brookvale 2100
Telephone: 61 2 9939 3233 Fax: 61 2 9939 3211
Email: geos@mineralgeos.com
Website: www.mineralgeos.com

Marian Vale Cored Drilling Assessment Report

Geos Mining project no 2134-2

**Project Commissioned by
Laterals Planning on behalf of
Millerview Constructions Pty Ltd**

**Greg MacRae
BSc, DipEd
Senior Geologist**

**Geos Mining
January 2007**

GJN Enterprises Pty Ltd (ABN 63 076 664 572) trading as Geos Mining

SUMMARY

A drilling program comprising seven cored drillholes at seven separate locations was undertaken at Marian Vale. The program was designed to assess the suitability of lithologies at these locations to be quarried as sources of coarse and fine aggregate products and brickmaking clay/shale.

Three drillholes, MVDDH1, MVDDH2 and MVDDH6, are considered to offer the best potential for extraction of coarse aggregate (MVDDH1 and MVDDH6) and structural clay/shale (MVDDH2 and MVDDH6).

Further geological assessment through geological mapping and drilling is recommended to further assess the potential resources at MVDDH1, MVDDH2, and MVDDH6.

Disclaimer

While every effort has been made, within the time constraints of this assignment, to ensure the accuracy of this report, Geos Mining accepts no liability for any error or omission. Geos Mining can take no responsibility if the conclusions of this report are based on incomplete or misleading data.

Geos Mining and the authors are independent of the project vendors and of Millerview Constructions, and have no financial interests in any associated companies. Geos Mining is being remunerated for this report on a standard fee for time basis, with no success incentives.

CONTENTS

FIGURES

TABLES

INTRODUCTION

The Geological Assessment Report for proposed quarrying at Marian Vale (MacRae 2006) indicated that cored drilling should be undertaken at a number of potential quarry sites on the property. Seven cored drillholes were drilled at Marian Vale (Figure 1).

Abbreviations

Symbol	Explanation	Symbol	Explanation
m	metre	m3	cubic metre
Mt	million tonnes	DDH	diamond drillhole

PREVIOUS WORK

Previous geological assessment work was undertaken by MacRae (2006), Allen (2006). This and other previous work at Marian Vale is reviewed in MacRae (2006).

SITE GEOLOGY

The site is mainly underlain by rocks of the Ordovician Adaminaby Group. A Tertiary basalt flow occurs in the north of the site (MacRae 2006). Six drillholes intersected the Ordovician sequence and one intersected the basalt.

Refer to the previous report (MacRae 2006) for a description of the different lithologies occurring at Marian Vale.

DRILLING

Objective

Seven cored drillholes were drilled at Marian Vale to:

- Assess the type and thickness of lithologies underlying the possible quarry sites; and,
- Assess other features such as fracturing and depth to and degree of weathering within the sequences drilled.

Table 1 shows location, grid references (AGD66 Zone 55) and depth of each drillhole. Figure 1 shows the location of drillholes and Figure 2 show the drillrig at MVDDH1. Drill logs are appended to the report.

Table 1: Drillhole data

Drillhole	Location	Depth	Drillhole Dip	amgE	amgN
MVDDH1	Grenada	30.90 m	60W	763334	6146570
MVDDH2	Moonshine Ridge	32.50 m	70E	762793	6146009
MVDDH3	East of Grenada	29.60 m	Vertical	763577	6146303
MVDDH4	Providence	29.98 m	60E	760698	6146622
MVDDH5	Robinsons	30.30 m	Vertical	760184	6145623
MVDDH6	Basalt Hill	26.50 m	Vertical	760963	6150279
MVDDH7	Ben Nevis	33.30 m	Vertical	761670	6144721

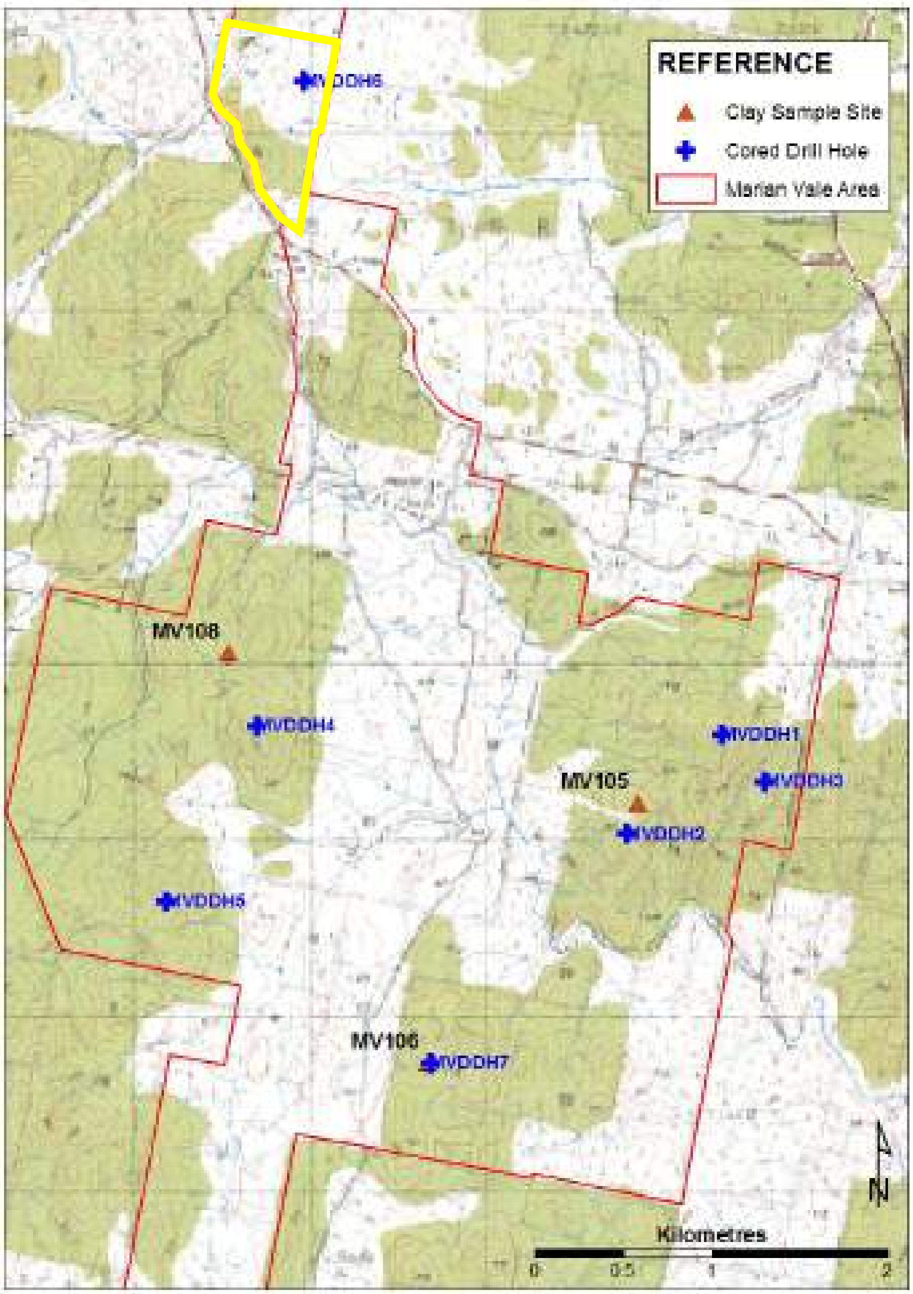

Figure 1: Location of drillholes and clay/shale sampling

Figure 2: Drilling rig at MVDDH1

Results

Seven fully cored drillholes were drilled at Marian Vale, six drillholes in the Adaminaby Group sequence and one drillhole in basalt.

Drillholes in the Adaminaby Group sequence were drilled at different orientations due to folding (Table 1) and all drillholes in this sequence successfully cut across bedding at moderate angles intersecting a range of lithologies within the Adaminaby Group. Features of turbiditic deposition were noted in all drillholes which enabled determination of bedding orientation. All drillholes except MVDDH4 intersected upright sequences.

The drillhole in the basalt was drilled vertically and penetrated through the basalt. Photos of drillholes MVDDH1, 2 and 6 are shown in Appendix 2.

The occurrence of strongly developed fracturing/jointing in all drillholes needs to be noted as the fracturing/jointing may present difficulties if blasting is used as part of quarrying.

Drillhole MVDDH1

The drillhole was drilled on a prominent hill named “Grenada” in the eastern part of the Marian Vale site. The sequence comprises silicified sandstone, unsilicified sandstone, siltstone, interbedded siltstone and sandstone, and claystone (see Appendix 1). Fracturing is well developed throughout the sequence. The sequence dips 70^{o} east.

The upper 13.44 m of the drillhole is dominated by strongly silicified quartz sandstone (96% of the 13.44m); the remainder of this sequence comprises thin claystone or fine-grained, unsilicified sandstone interbeds.

Based on one drillhole, this silicified sandstone unit has potential as a coarse aggregate resource. If blasting is used, the fracturing within the sequence may result in the production of some oversize blast material.

Further drilling of this silicified sandstone, to the east (up dip) as well to the north and south (along strike) of MVDDH1, is recommended to assess its extent.

Drillhole MVDDH2

The drillhole was drilled near “Moonshine Ridge” in the eastern part of the Marian Vale site, south of Grenada. The sequence comprises claystone, unsilicified sandstone, silicified sandstone, siltstone, interbedded siltstone and sandstone (see Appendix 1). The sequence dips about 50^{o} west.

The upper 10.0 m of the drillhole comprises two claystone and lesser siltstone zones separated by 3.45 m of unsilicified, reddish, iron-stained, sandstone. Excluding the sandstone unit, this section has potential as a source of brickmaking clay/shale. The dip of the sequence means that both claystone/siltstone zones are exposed at the surface.

This finer sequence below 10.0 m consists of 8.40 m of silicified sandstone interbedded with 1.36 m of siltstone/claystone in beds ranging in thickness from 0.15 to 0.60 cm.

Additional drilling to the east and west of MVDDH2 as well as along strike (north and south) is recommended to assess the extent of the clay/shale horizons as well as the underlying silicified sandstone horizon.

Drillhole MVDDH3

The drillhole was drilled east of Grenada in the eastern part of the Marian Vale site. The sequence comprises silicified sandstone, claystone, unsilicified sandstone, siltstone, interbedded siltstone and sandstone (see Appendix 1). The sequence dips 60^{o} west.

The sandstone in this sequence is only mildly silicified or not silicified at all;; the interbedded nature indicates this location has no resource significance.

Drillhole MVDDH4

The drillhole was drilled on “Providence” a prominent hill in the western part of the Marian Vale site. The sequence comprises silicified sandstone, claystone, unsilicified sandstone, siltstone, interbedded siltstone and sandstone (see Appendix 1). The sequence dips 80^{o} west and is overturned.

Strongly silicified sandstone and claystone are interbedded on the scale of a half to one metre in the upper 15m of the drillhole. Below this depth the sandstone is much less silicified. Selective extraction of the silicified sandstone and claystone in the upper part of MVDDH4 would be the likely means of quarrying this material.

Drillhole MVDDH5

The drillhole was drilled at “Robinsons” in the western part of the Marian Vale site. Outcrop at Robinsons is strongly silicified sandstone and bedding features were not observed. The drilled sequence comprises moderately silicified sandstone, siltstone, interbedded siltstone and claystone (see Appendix 1).

The upper part of 17.5m of the drilled sequence consists of moderately silicified sandstone. This is underlain by interbedded siltstone and claystone.

The upper part of this drillhole may have potential for coarse aggregate however, silicification is apparently not as well developed as in other sandstone units in other parts of the Marian Vale site.

Further geological assessment is recommended prior to possible further drilling.

Drillhole MVDDH6

This drillhole was drilled on a basalt hill known as Curlewin. The sequence intersected consisted of 19.55m of basalt and is underlain by 6.95m of clay. The basalt exhibits well developed horizontal joints as well as less common vertical to subvertical joints. The basalt appears to be uniform in lithology throughout the drillhole. Below the basalt laminated carbonaceous clay (4m) is underlain by pale to mid grey massive clay (3m).

Both the basalt and clay should be tested.

Further drilling to basement (ie, Palaeozoic sequence) is recommended to assess the basalt and clay as well as determining whether other lithologies (eg, sand and gravel) underlie the clay.

Extraction from south commencing at the base of the basalt unit would enable access to both the basalt and clay.

Drillhole MVDDH7

This drillhole was drilled near a prominent hill named Ben Nevis. The sequence drilled comprises silicified sandstone, claystone, interbedded sandstone and claystone, and mildly to unsilicified sandstone. The sequence dips 60 ^{o} northwest.

Silicified sandstone occurs in the upper 8m of the drillhole interbedded with claystone. Below this depth the sandstone is either unsilicified or mildly silicified.

Drilling below about 18m intersected deeply iron-stained and strongly fractured sandstone partly interbedded with siltstone and claystone.

The upper part of the sequence at this location may offer potential for clay/shale for brickmaking but has little potential for coarse aggregate.

CONCLUSIONS

- Drilling to determine coarse aggregate and structural clay/shale potential at seven sites at Marian vale was completed.
- Three drillholes, MVDDH1, MVDDH2 and MVDDH6, intersected sequences with sound potential for quarry development.
- MVDDH1 at Grenada intersected an interval of 13.44m of strongly silicified sandstone.
- MVDDH2 at Moonshine Ridge intersected two sequences of claystone with a combined intersection of 6.55m which is underlain by an interval of 7m of silicified sandstone.
- MVDDH6 at Curlewin intersected 19.55m of basalt underlain by 6.95m of clay.
- Fracturing/jointing is a significant feature of all drillholes and may have an influence on quarrying if blasting is used.
- Of the other drillholes, MVDDH4 and MVDDH5 intersected potential silicified sandstone whereas MVDDH7 intersected potential claystone.
- Drillhole MVDDH3 did not intersect any suitable lithologies.

RECOMMENDATIONS

- Further assessment by drilling and detailed mapping are recommended for the area around Grenada (MVDDH1), Moonshine Ridge (MVDDH2) and Curlewin (MVDDH6) to assess the extent of the potential resources at these sites.
- Assessment of geology in the vicinity of drillholes with lower potential intersections (eg, silicified sandstone in the upper part of MVDDH4 and MVDDH5, and claystone in the upper part of MVDDH7) should be undertaken to determine further drilling is warranted.
- Sampling of drillcore is recommended to determine the suitability of the material in MVDDH1, MVDDH2 and MVDDH6 for the intended uses.

REFERENCES

Allen D. 2006. Mining of construction material from Marian Vale – East of Goulburn. A preliminary feasibility assessment. Groundwater Imaging Pty Ltd, Report (unpublished).

MacRae G.P. 2006. Marian Vale geological assessment of potential construction material resources. Geos Mining project no 2134-1. Report for Laterals Planning.

APPENDIX 1 - Drill Logs

GEOS MINING DIAMOND DRILLING LOG SHEET

Project:	Marian Vale	Driller:	Macquarie Drilling	Date:	29/11/2006
Location:	*"Grenada"*	Rig:	Diamond	Start Time:	
Drillhole:	***MVDDH1***	Drill Orientation:	60W	Finish Time:	
Coords:	Datum: AGD66 Zone: 55 amgE: 763334 amgN: 6146570 (by GPS)	Logged:	Mike Lovesey & Greg MacRae (Geos Mining)	EOH:	30.9m
Height:	778m (by GPS)				

Metrage Drilled									
From	To	**Inter val**	Description	Grain Size	Colour	RQD	Structure	Angle	Sample
0.00	0.50	0.50	Augered; No core; Fractured sandstone						
0.50	4.58	4.08	Silicified sandstone with visible basal turbiditic flows; fractured to heavily fractured; iron staining on some fractures; 11cm graded (?) med to coarse sandstone at base of unit. (Core loss of 0.6cm between 2.5 and 4.1m).	Medium; minor fine sandstone	Grey; minor red-grey	0.50	Fractures	40^0; 60^0	
4.58	4.81	0.23	Claystone		Grey-cream				
4.81	5.71	0.90	Silicified sandstone; fractured to heavily fractured;	Medium; minor fine	Grey				
5.71	5.81	0.10	Claystone		Cream-grey				
5.81	7.60	1.79	Silicified sandstone; fractured to heavily fractured;	Medium	Grey to orange-grey	0.52	Fracture	60^0	
7.60	7.70	0.10	Claystone; crushed.		Grey				
7.70	8.03	0.33	Heavily fractured laminated fine sandstone/siltstone unit with minor qtz veins.	Fine	Grey	0.61	Fracture	65^0	
8.03	8.09	0.06	Claystone		Grey				
8.09	9.16	1.07	Silicified sandstone with Fe staining; very heavily fractured	Medium	Grey to greenish grey				
9.16	9.20	0.04	Crushed clayey siltstone		Grey				
9.20	12.45	3.25	Heavily fractured silicified sandstone	Medium; some coarse	Grey	0.68	Fracture	35^0	

Metrage Drilled			Description	Grain Size	Colour	RQD	Structure	Angle	Sample
From	To	**Inter val**							
12.45	13.44	0.99	Silicified sandstone	Medium	Grey	0.68	Fracture	35^0	
13.44	13.65	0.21	Claystone		Grey				
13.65	14.04	0.39	Laminated (cross laminated?) fine sandstone	Fine	Grey				
14.04	14.50	0.46	Fine sandstone (not silicified).	Fine	Grey				
14.50	15.33	0.83	Fine sandstone not silicified/laminated.	Fine	Grey				
15.33	15.41	0.08	Claystone		Grey				
15.41	16.86	1.45	Fine sandstone not silicified/laminated.	Fine	Grey				
16.86	17.50	0.64	Mildly silicified sandstone with Fe staining at base.	Medium	Pale grey				
17.50	17.73	0.23	Interbedded fine sandstone/siltstone	Fine	Grey				
17.73	18.37	0.64	Mildly silicified sandstone; significant Fe staining	Fine-medium	Grey				
18.37	18.67	0.30	Claystone		Grey				
18.67	19.13	0.46	Mildly silicified sandstone	Fine-medium	Grey				
19.13	20.50	1.37	Sandstone	Fine-medium	Grey				
20.50	22.70	2.20	Heavily fractured silicified sandstone with minor qtz veins. Some orange/brown clay between fractures. At 22.5m there is a light green leached material? Secondary Cu mineral?	Medium-coarse	Grey				
22.70	24.80	2.10	Silicified sandstone/siltstone. Heavily fractured and harder with coarser grains. More light green material/copper mineral? Some minor quartz veining.	Medium-coarse	Grey				
24.80	26.50	1.70	Silicified sandstone with gossanous quartz veins >10mm in parts. At 25.53 there are thin fractured claystone units. Extensive Fe staining (not just within fractures) between 26.3m and 26.5m	Medium-coarse	Grey				
26.50	29.10	2.60	Fine sandstone interbedded with crushed claystone material. At 27.4m there is 37cm of claystone/fine sandstone. Below there is fine sandstone/claystone to 29m. Very brittle around 29m and very high Fe staining at 28.4	Fine	Pale green/dark browny red				
29.10	29.90	0.80	Medium sandstone; some fine sandstone/siltstone with extensive Fe staining on fractures. Fractures parallel to bedding? Some dull earthy/off white patches with minor qtz veining.	Medium	Pale grey/pale green				
29.90	30.23	0.33	Silicified sandstone	Medium	Pale grey / pale green				

Metrage Drilled			Description	Grain Size	Colour	RQD	Structure	Angle	Sample
From	To	**Inter val**							
30.23	30.90	0.67	Medium grained sandstone	Medium	Pale grey / pale green				
			EOH 30.90						

GEOS MINING DIAMOND DRILLING LOG SHEET

Project:			Marian Vale	**Driller:**	Macquarie Drilling			**Date:**	01/12/2006	
Location:			Moonshine Ridge	**Rig:**	Diamond			**Start Time:**		
Drillhole:			***MVDDH2***	**Drill Orientation:**	70E			**Finish Time:**		
Coords:			Datum: AGD66 Zone: 55 amgE: 762793 amgN: 6146009 (by GPS)	**Logged:**	Mike Lovesey & Greg MacRae (Geos Mining)			**EOH:**	32.5m	
Height:			715m (by GPS)							
Metrage Drilled										
From	To	**Inter val**	Description	Grain Size	Colour	RQD	Structure	Angle	Sample	
0.00	2.00	2.00	Augered; No core; Siltstone/claystone							
2.00	2.65	0.65	Very fine fractured siltstone/claystone with some iron staining		Grey/green					
2.65	3.00	0.35	Coarser and harder light grey shale material with some mica. Hardness increases with depth		Pale grey					
3.00	3.50	0.50	Harder shale/sandstone not silicified; fractured		Pale green/grey					
3.50	3.65	0.15	Very soft fine grained siltstone/claystone		Pale green					
3.65	3.96	0.31	Coarser sandstone not silicified and heavily fractured with some iron staining		Grey/pale green					
3.96	4.00	0.04	Very fine and brittle clay material/soft siltstone		Pale green					
4.00	4.20	0.20	Soft siltstone/claystone with some iron staining		Orange/grey					
4.20	4.70	0.50	Siltstone/shale with iron staining becomes increasingly coarse grained with depth		Green/pink					
4.70	8.15	3.45	Pink sandstone not silicified very brittle coarse texture and less fractures	Medium-coarse	Pink/purple					
8.15	8.25	0.10	Very fine soft clay material		Green					
8.25	8.45	0.20	Siltstone/claystone with some mica		Pink/green					
8.45	9.40	0.95	Siltstone/Claystone		Pale green					
9.40	9.50	0.10	Heavily crushed fine siltstone material	Very fine	Green					
9.50	10.00	0.50	Claystone becoming increasingly coarse with depth		Grey/green					
10.00	11.17	1.17	Silicified sandstone suitable for aggregate heavily iron stained	Coarse	Pale green					

Metrage Drilled			Description	Grain Size	Colour	RQD	Structure	Angle	Sample
From	To	**Inter val**							
11.17	11.50	0.33	Soft siltstone		Grey				
11.50	12.72	1.22	Silicified sandstone suitable for aggregate heavily iron stained and fractured	Medium-coarse	Grey				
12.72	13.00	0.28	Softer sandstone less silicified	Medium	Grey				
13.00	13.60	0.60	Siltstone/Claystone with minor quartz veining		Grey				
13.60	16.65	3.05	Silicified sandstone suitable for aggregate. Extensive quartz veining up to 5mm thickness	Medium-coarse	Pale grey				
16.65	16.80	0.15	Very fine siltstone/claystone bed very brittle interbedded with sandstone		Grey				
16.80	18.40	1.60	Hard silicified iron stained sandstone suitable for aggregate	Medium-coarse	Grey/red				
18.40	18.50	0.10	Soft siltstone bed very brittle		Green				
18.50	18.60	0.10	Silicified sandstone interbedded with siltstone.	Medium	Grey				
18.60	18.80	0.20	Fine siltstone/claystone		Pale grey				
18.80	18.98	0.18	Silicified sandstone	Fine-medium	Grey				
18.98	19.05	0.07	Fine siltstone/shale		Pale grey				
19.05	19.65	0.60	Silicified sandstone	Medium-coarse	Grey				
19.65	20.10	0.45	Fine siltstone/shale		Pale grey				
20.10	21.35	1.25	Silicified sandstone	Medium-coarse	Grey				
21.35	21.70	0.35	Siltstone/shale laminated; interbedded		Pale grey/green				
21.70	22.05	0.35	Mildly silicified sandstone	Fine-medium	Grey				
22.05	22.20	0.15	Laminated fine siltstone/shale		Grey/green				
22.20	22.60	0.40	Mildly silicified sandstone	Fine-medium	Tan				
22.60	22.95	0.35	Heavily fractured sandstone interbedded with laminated shale/sandstone						
22.95	23.70	0.75	Mildly silicified fractured sandstone	Fine-medium	Grey/brown				
23.70	23.85	0.15	laminated siltstone/claystone						
23.85	24.05	0.20	Mildly silicified sandstone	Medium	Tan				

Metrage Drilled			Description	Grain Size	Colour	RQD	Structure	Angle	Sample
From	To	**Inter val**							
24.05	24.22	0.17	Fine laminated siltstone		green/grey				
24.22	24.50	0.28	Mildly silicified sandstone	Medium	Tan				
24.50	24.63	0.13	Fine laminated siltstone		grey/green				
24.63	25.03	0.40	Fine to medium iron stained sandstone	Medium-coarse	grey/red				
25.03	27.38	2.35	Laminated siltstone/shale		Buff				
27.38	32.50	5.12	Interbedded laminated siltstone/shale with fine to medium mildly silicified sandstone	Fine-medium	Buff				
			EOH 32.50						

GEOS MINING DIAMOND DRILLING LOG SHEET

Project:	Marian Vale	**Driller:**	Macquarie Drilling	**Date:**	07/12/2006
Location:	East of Grenada	**Rig:**	Diamond	**Start Time:**	
Drillhole:	***MVDDH3***	**Drill Orientation:**	vertical	**Finish Time:**	
Coords:	Datum: AGD66 Zone: 55 amgE: 763577 amgN: 6146303 (by GPS)	**Logged:**	Mike Lovesey (Geos Mining)	**EOH:**	29.6m
Height:	707m (by GPS)				

Metrage Drilled			Description	Grain Size	Colour	RQD	Structure	Angle	Sample
From	**To**	**Inter val**							
0	1.60	1.60	Augered; No Core; Sandstone						
1.60	2.33	0.73	Mildly silicified fine to medium fractured sandstone with minor clay partings 1 to 2 mm thickness	Fine-medium	grey				
2.33	2.53	0.20	Fractured claystone						
2.53	3.13	0.60	Core Loss (60cm)						
3.13	3.61	0.48	Fractured sandstone						
3.61	3.71	0.10	Fractured claystone						
3.71	4.79	1.08	Fractured sandstone with minor 2cm clay bed with iron staining	Fine	grey/red	0.44		60^{0}	
4.79	5.21	0.42	Claystone pale to mid grey		mid grey				
5.21	6.51	1.30	Sandstone						
6.51	7.59	1.08	Laminated claystone	Fine	pale grey				
7.59	11.13	3.54	Mildly fractured fine to medium sandstone			0.68		60^{0}	
11.13	11.26	0.13	Very fractured claystone						
11.26	15.24	3.98	Sandstone			0.43		70^{0}	
15.24	15.32	0.08	Claystone		pale grey				
15.32	16.00	0.68	Core Loss						
16.00	16.20	0.20	Laminated fine sandstone/siltstone	Fine-medium	mid grey				
16.20	16.50	0.30	Pervasively quartz veined silicified sandstone						
16.50	18.60	2.10	Silicified sandstone with quartz veining and micro faulting near base	Fine-medium	grey/light grey	0.35	Fracture	80^{0}; 35^{0}	

Metrage Drilled			Description	Grain Size	Colour	RQD	Structure	Angle	Sample
From	To	Interval							
18.60	19.73	1.13	Grey claystone; fractured		grey				
19.73	20.13	0.40	Fine laminated sandstone	Fine	grey				
20.13	22.66	2.53	Claystone interbedded with minor sandstone (up to 10cm)	Fine-medium	grey/dark grey				
22.66	23.52	0.86	Laminated sandstone with a 3cm quartz vein at the top	Fine-medium		0.43			
23.52	25.49	1.97	Laminated mid grey/pale buff siltstone/claystone	Fine	mid grey				
25.49	29.60	4.11	Interbedded sandstone and siltstone	Fine-medium	dark grey				
			EOH 29.60						

GEOS MINING DIAMOND DRILLING LOG SHEET

Project:	Marian Vale	**Driller:**	Macquarie Drilling	**Date:**	13/12/2006
Location:	Providence	**Rig:**	Diamond	**Start Time:**	
Drillhole:	***MVDDH4***	**Drill Orientation:**	60E	**Finish Time:**	
Coords:	Datum: AGD66 Zone: 55 amgE: 760698 amgN: 6146622 (by GPS)	**Logged:**	Greg MacRae (Geos Mining)	**EOH:**	29.98m
Height:	707m (by GPS)				

Metrage Drilled			**Description**	**Grain Size**	**Colour**	**RQD**	**Structure**	**Angle**	**Sample**
From	**To**	**Inter val**							
0	2.20	2.20	Augered; No Core; Claystone						
2.20	2.73	0.53	Claystone						
2.73	3.70	0.97	Strongly silicified sandstone with red-brown iron staining	Fine-medium	Pale buff-grey to red-brown	0.55	bedding	35^0	
3.70	3.82	0.12	Claystone		Buff				
3.82	4.45	0.63	Sandstone; strongly silicified red-yellow iron stained on fractures	Medium	Grey	0.29			
4.45	4.91	0.46	Claystone; fine mica on bedding planes; red-brown iron stained in part		Buff				
4.91	6.14	1.23	Strongly silicified sandstone; red-brown iron stained; quartz-healed fractures	Medium	Grey	0.59	bedding; fracture	20^0; 60^0	
6.14	6.31	0.17	Claystone		Buff				
6.31	6.91	0.60	Strongly silicified fine-medium grained sandstone	Fine-medium	Grey				
6.91	7.59	0.68	Claystone with silt to very fine sand grains in matrix		Buff				
7.59	7.91	0.32	Sandstone; graded coarse to fine (indicates sequence overturned to west)	Coarse-fine	Grey		bedding; fractures	10^0; 45^0	
7.91	8.37	0.46	Claystone		Buff				
8.37	8.55	0.18	Core loss						
8.55	10.80	2.25	Silicified sandstone; minor thin claystone interbeds; iron stained fractures	Medium-coarse	Grey	0.57	bedding; fracture	20^0; 70^0	
10.80	11.49	0.69	Fine-grained sandstone unsilicified with minor claystone interbeds	Fine	Pale grey				

Metrage Drilled			Description	Grain Size	Colour	RQD	Structure	Angle	Sample
From	To	Inter val							
11.49	11.70	0.21	Claystone		Grey to mauve				
11.70	12.20	0.50	Fine-grained sandstone to siltstone with mauve staining	Fine	Grey				
12.20	13.07	0.87	Claystone with mauve staining on some bedding planes		Grey				
13.07	13.83	0.76	Core loss						
13.83	14.19	0.36	Claystone						
14.19	14.79	0.60	Silicified sandstone	Very fine-fine	Grey				
14.79	15.03	0.24	Claystone						
15.03	15.87	0.84	Mildly silicified laminated and cross laminated fine sandstone	Fine	Grey				
15.87	16.30	0.43	Claystone						
16.30	16.85	0.55	Silty fine sandstone; laminated	Fine	Grey				
16.85	17.43	0.58	Massive fine sandstone	Fine	Grey				
17.43	17.76	0.33	Claystone						
17.76	18.08	0.32	Grey unsilicified sandstone		Grey				
18.08	18.40	0.32	Core loss						
18.40	19.66	1.26	Interbedded silty fine sandstone and claystone						
19.66	21.09	1.43	Clayey fine to medium grained sandstone	Fine-medium					
21.09	21.27	0.18	Claystone						
21.27	21.49	0.22	Core loss						
21.49	22.09	0.60	Claystone						
22.09	24.13	2.04	Unsilicified sandstone with minor claystone interbeds						
24.13	26.30	2.17	Thickly interbedded claystone and sandstone; not silicified; beds 20-40cm thick						
26.30	26.75	0.45	Core loss						
26.75	29.98	3.23	Thickly interbedded claystone and sandstone; beds 20-40cm thick (includes core loss of 0.24cm near base)		Grey		Bedding	15	
			EOH 32.50						

GEOS MINING DIAMOND DRILLING LOG SHEET

Project:			Marian Vale	**Driller:**	Macquarie Drilling			**Date:**	15/12/2006
Location:			Robinsons	**Rig:**	Diamond			**Start Time:**	
Drillhole:			***MVDDH5***	**Drill Orientation:**	vertical			**Finish Time:**	
Coords:			Datum: AGD66 Zone: 55 amgE: 760184 amgN: 6145623 (by GPS)	**Logged:**	Mike Lovesey (Geos Mining)			**EOH:**	30.3m
Height:			746m (by GPS)						
Metrage Drilled			**Description**	**Grain Size**	**Colour**	**RQD**	**Structure**	**Angle**	**Sample**
From	**To**	**Inter val**							
0.00	1.15	1.15	Augered						
1.15	1.70	0.55	Coarse sandstone, heavily fractured	Coarse	Orange / white				
1.70	4.48	2.78	Mildly silicified fine sandstone, heavily fractured with Fe staining and minor quartz veining (<5mm)	Medium-coarse	Grey / purple				
4.48	4.88	0.40	Core loss						
4.88	17.50	12.62	Mildly silicified fine sandstone, heavily fractured with Fe staining and minor quartz veining (<5mm)	Medium-coarse	Grey / purple				
17.50	21.20	3.70	Fine laminated siltstone/shale, heavily fractured, brittle material	Very fine	Green / grey				
21.20	30.30	9.10	Fine siltstone/medium grey to brown claystone material, laminated with visible turbidite sequences/micro folds. Soft, significant Fe staining particularly between 24 to 26 metres. Visible bedding between 28 to 30.3 metres (laminite)	Fine	Grey / brown				
			EOH 30.30						

GEOS MINING DIAMOND DRILLING LOG SHEET

Project:			Marian Vale	**Driller:**	Macquarie Drilling				**Date:**	19/12/2006
Location:			Mt Curlewin	**Rig:**	Diamond				**Start Time:**	
Drillhole:			***MVDDH6***	**Drill Orientation:**	vertical				**Finish Time:**	
Coords:			Datum: AGD66 Zone: 55 amgE: 760963 amgN: 6150279 (by GPS)	**Logged:**	Greg MacRae (Geos Mining)				**EOH:**	26.5m
Height:			737m (by GPS)							
Metrage Drilled										
From	**To**	**Interval**	**Description**	**Grain Size**	**Colour**	**RQD**	**Structure**	**Angle**	**Sample**	
0.00	2.00	2.00	Augered; no core; basalt soil and deeply weathered basalt							
2.00	19.55	17.55	Basalt, crystalline, grain size averages about 1mm; well developed horizontal fracturing ranging from 1 to 5cm thick. Less commonly vertical to sub-vertical fractures about 40cm long. Weathering strongly developed along vertical fractures from 6.5 to 6.8m depth and from 7.6 to 8.0 cm depth. Iron staining common on both horizontal and vertical fractures. Basal 30cm of unit (above underlying clay) strongly weathered.	~1mm average	Dark grey	very low: ~0.02	fractures	0, 50, 80, 90^0		
19.55	23.51	4.04	Black laminated clay; carbonaceous with grey to pale grey interbeds ranging from 1-2cm up to 14cm thick.		Black to grey					
23.51	23.55	0.04	Clayey yellow sand	Fine-medium	Yellow					
23.55	26.50	2.95	Pale to mid grey and buff featureless clay (includes 80cm core loss from 24.05-24.85m depth)		Grey to buff					
			EOH 26.50							

GEOS MINING DIAMOND DRILLING LOG SHEET

Project:	Marian Vale	**Driller:**	Macquarie Drilling	**Date:**	21/12/2006
Location:	Marian Vale South ("Ben Nevis")	**Rig:**	Diamond	**Start Time:**	
Drillhole:	***MVDDH7***	**Drill Orientation:**	vertical	**Finish Time:**	
Coords:	Datum: AGD66 Zone: 55 amgE: 761670 amgN: 6144721 (by GPS)	**Logged:**	Greg MacRae (Geos Mining)	**EOH:**	33.00
Height:	m (by GPS)				

Metrage Drilled									
From	**To**	**Interval**	**Description**	**Grain Size**	**Colour**	**RQD**	**Structure**	**Angle**	**Sample**
0.00	1.00	1.00	Augered; no core; Sandstone						
1.00	2.60	1.60	Sandstone; silicified fractured bedded; iron staining on fractures		greeny grey		bedding fracture	30; 90, 60	
2.60	5.00	2.40	Claystone to silty claystone; core extremely broken; two core losses of 35cm and 10cm within this unit.		greeny grey and grey				
5.00	6.80	1.80	Silicified sandstone; quartz veined and fractured; iron staining on fractures.		grey	0.39	fracture	50	
6.80	7.40	0.60	Claystone; iron stained; 90^0 jointing				joint	90	
7.40	8.12	0.72	Silicified fine-grained sandstone	fine		0.56	fracture	50	
8.12	8.22	0.10	Claystone; grey		grey				
8.22	12.90	4.68	Fine to medium grained sandstone; unsilicified	fine-medium	grey		bedding	45	
12.90	15.70	2.80	Laminated and interbedded silty sandstone and claystone				bedding	45	
15.70	17.60	1.90	Fine sandstone; mildly silicifed. Minor claystone interbeds becoming iron-stained towards and at the base	fine					

Metrage Drilled			Description	Grain Size	Colour	RQD	Structure	Angle	Sample
From	To	Interval							
17.60	18.25	0.65	Mauve to buff claystone		mauve to buff				
18.25	18.85	0.60	Medium to coarse sandstone; strongly yellow-brown iron-stained and strongly fractured	medium-coarse	yellow-brown		fractures	90, 70	
18.85	20.90	2.05	Mauve to grey-green claystone						
20.90	27.30	6.40	Unsilicified orange-brown to buff weathered sandstone; iron staining along fractures		orange-brown to buff				
27.30	28.28	0.98	Interbedded grey siltstone and grey-buff sandstone		grey to grey buff				
28.28	33.00	4.72	Interbedded orange-brown sandstone and grey to buff silty claystone		orange-brown; grey; buff		bedding	45	
			EOH 33.00						

APPENDIX 2 – Drillcore Photos

Drillhole MVDDH1

Drillhole MVDDH2

Drillhole MVDDH6

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Marian Vale Geological Assessment of Potential Construction Material Resources

Geos Mining project no 2134-1

**Project Commissioned by
Laterals Planning on behalf of
Millerview Constructions Pty Ltd**

**Greg MacRae
Senior Geologist**

**Geos Mining
December 2006**

SUMMARY

An assessment of the potential of sandstone for use as coarse aggregate and siltstone/claystone for use as structural clay/shale was undertaken at Marian Vale, east of Goulburn for Laterals Planning.

A review of the site geology at Marian Vale indicates that the proposed coarse aggregate and clay/shale quarry sites are in Ordovician Adaminaby Group rocks.

Strongly silicified sandstone units within the Adaminaby Group on two prominent hills ("Grenada" and "Providence") and in other parts of the Marian Vale site have potential as quarry sites for coarse aggregate. However, the interbedded nature of the sequence at Marian Vale indicates that quarrying of different lithologies for differing end uses would require selective extraction.

Siltstone/claystone with up to 26% kaolinite has been identified as potentially suitable for use as structural clay/shale for brick manufacture. Three samples obtained for ceramic testing fired pale beige (2 samples) to pink (1 sample) in colour and are considered suitable for brick manufacture.

Disclaimer

While every effort has been made, within the time constraints of this assignment, to ensure the accuracy of this report, Geos Mining accepts no liability for any error or omission. Geos Mining can take no responsibility if the conclusions of this report are based on incomplete or misleading data.

Geos Mining and the authors are independent of Millerview Constructions, and have no financial interests in any associated companies. Geos Mining is being remunerated for this report on a standard fee for time basis, with no success incentives.

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FIGURES

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INTRODUCTION

This study aims to further assess the suitability of rocks in the Marian Vale subdivision for use as coarse aggregate, brick-making clay, and other quarry materials.

Background

A Part 3A Submission has been prepared by Laterals Planning for Millerview Constructions relating to the development of quarrying operations as well as brick, ceramics and concrete products manufacturing facilities at Marian Vale has been provided to the Department of Planning (Laterals Planning 2006).

Millerview Constructions has undertaken an extensive exploration drilling program across the site with initial drilling commencing in 2005. The drilling program which included holes up to a depth of 150 m was primarily for water but did identify material potentially suitable for quarrying. Drilling and limited testing indicated that significant quantities of material existed with potential for use in road construction, as coarse aggregate and sand products, for use in making bricks and ceramics and for concrete products (Laterals Planning 2006).

Abbreviations

Symbol	Explanation	Symbol	Explanation
m	metre	m3	cubic metre
Mt	million tonnes		

PREVIOUS WORK

Previous geological assessment work was undertaken by Allen (2006). Water bore drilling was undertaken by Hydroilex (Lee 2005). Petrographic assessment (Geochempet 2005), clay mineralogy analyses (Ward and Zhongsheng 2005) and aggregate testing (Boral Resources (NSW) Pty Ltd 2005) have also been undertaken.

The report of Allen (2006) has been reviewed and is generally a well considered assessment of the potential of the Marian Vale site for the development of construction materials operations. The report concludes (pp 32-33) that:

- the silicified sandstone units could only be mined “with large stripping ratios as they exist only in near vertical bands typically less than 3m thick”;
- the most suitable areas of silicified sandstone is in the east of the Marian Vale property;
- silicified sandstones in the west are likely to be more difficult to quarry due to faulting and fault-related deformation;

- basalt in the north of the site has potential as a source of coarse aggregate and testing of this rock type was recommended;
- inclined drillholes would be necessary to accurately assess the geology of possible quarry locations; and,
- the Adaminaby Group is a potential source of clay and construction sand.

Whilst most of the conclusions are generally appropriate, this author disagrees with the assessment that construction sand can be produced from crushing of sandstone units. Minor amounts of construction sand would be produced as a by-product but production of significant amounts of construction sand from the silicified sandstone is likely to be costly due to the hardness of the silicified sandstone.

The report by Lee (2005) provides only limited new geological data as the bore holes were not drilled in any of the proposed quarry sites. The drill logs are too simplified to be of any use.

Petrographic descriptions (Geochempet 2005) provide useful information on the composition of the sandstone units. Clay analyses by Ward and Zhengsheng (2005) provide data on clay mineralogy of potential brick clay sources. Boral Resources (NSW) Pty Ltd (2005) undertook aggregate testing of sandstone samples from Marian Vale.

SITE GEOLOGY

Geologically, the Marian Vale subdivision only has a limited number of rock types being, sandstone, siltstone, claystone, carbonaceous siltstone, basalt and alluvium. Rocks form part of the Adaminaby Group and Bendoc Groups as well as unnamed Tertiary and Quaternary units. The rocks are folded and faulted. The geology of the area (Snelling 2003) is shown in Figure 1 and summarised in Table 1.

Table 1: Summary of geology (after Snelling 2003)

Era	Age	Group	Formation	Lithology
Cainozoic	Quaternary	Ungrouped	Unnamed (Qa)	Alluvium, eluvium, colluvium
	Tertiary	Ungrouped	Unnamed (Teb)	Basalt, gabbro
Palaeozoic	Silurian	Ungrouped	Jerrara Formation (Sj)	Massive to laminated siltstone with minor black shale
	Ordovician	Adaminaby Group	Undifferentiated sequence (Oa)	Sandstone and siltstone/claystone
			Nattery Chert (Oan)	Chert
		Bendoc Group	Warbisco Shale (Obw)	Carbonaceous siltstone/claystone
			Bumballa Formation (Obb)	Dark grey to black siltstone, fine to coarse sandstone
			Unnamed sequence (Obs)	Siltstone/claystone

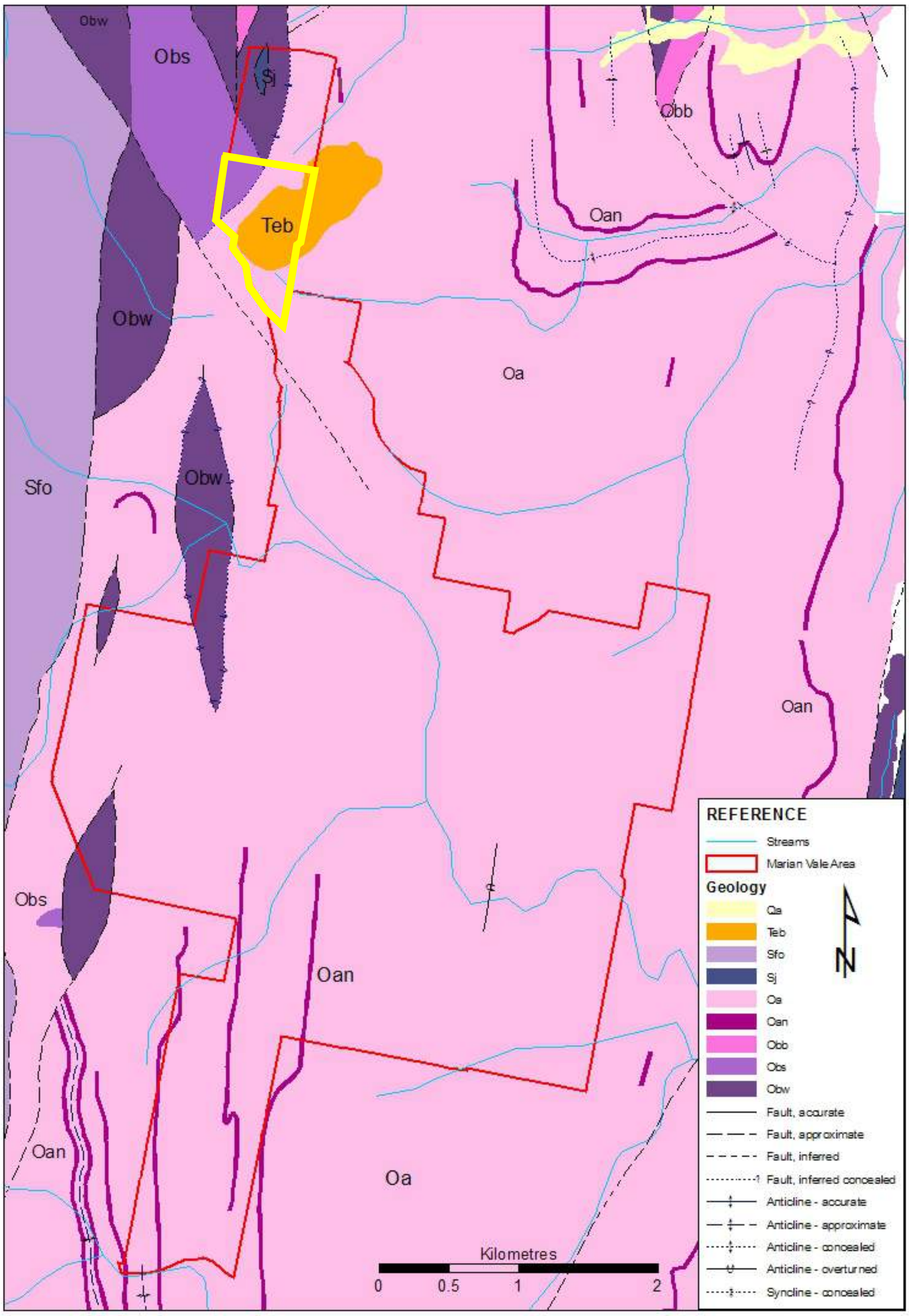

Figure 1: Solid geology of the Marian Vale area (data from Snelling 2003)

Lithology

Adaminaby Group

The area is mainly underlain by Ordovician Adaminaby Group (Oa) which is turbiditic fine- to coarse-grained mica-quartz (feldspar) sandstone interbedded with siltstone and rarely discontinuous chert horizons. Sandstone beds are typically graded with ripple cross lamination prominent in fine-grained sandstone.

The interbedded nature is a result of deposition of the Adaminaby Group sequence as turbidite flows in a deep marine environment. Turbidites typically form a graded bed ranging in grainsize from medium to coarse-grained sandstone at the base to siltstone at the top (Figure 1) to produce multiple, stacked sandstone and siltstone/claystone beds. Thickness of sandstone beds range up to about 3 m (Allen 2006) but tend to be about 1 m in thickness.

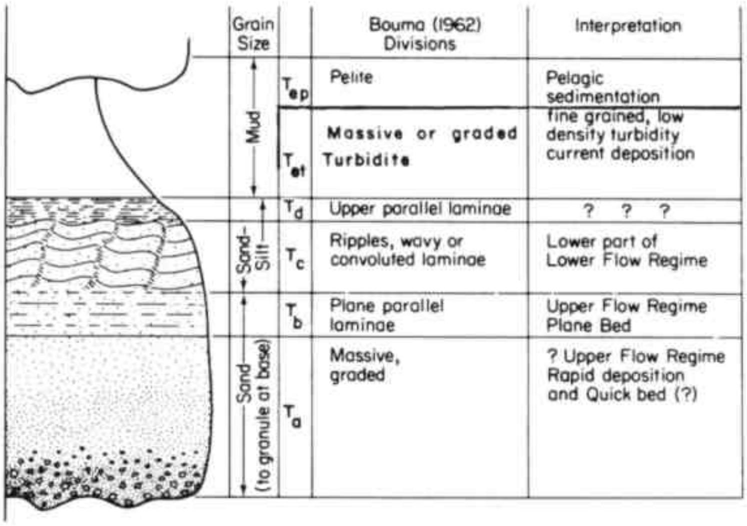

Figure 2: Classical turbidite unit (After Bouma 1962).

Lithologically, the sandstone is typically medium-grained, graded, and quartz-rich. The development of strongly siliceous "quartzite" horizons is probably related to diagenetic and regional metamorphic processes. Such quartz-rich,, strongly silicified sandstone units may have potential to produce coarse aggregate.

Siltstone/claystone units within the Adaminaby Group are typically kaolinitic and have been used within the region in the manufacture of bricks. Some of these siltstone/claystone units may be low in plasticity and these would require mixing with more plastic clay to produce material suitable for brick manufacture. The plasticities of the samples tested (see p13 for details) are acceptable without further blending.

The Nattery Chert (Oan) is a thin chert horizon and has little potential for use as a construction material (Allen 2006).

Bendoc Group

The Ordovician Warbisco Shale (Obw) which comprises black, laminated carbonaceous shale with minor quartzose sandstone and is in fault contact with the Adaminaby Group sequence. The black carbonaceous shale has potential as a source of roadbase material. Nearby to the north this material is used for roadbase at Divall's Carrick Hill quarry.

Jerrara Formation

The Jerrara Formation is a thinly-bedded massive to laminated siltstone unit with minor graptolitic black shale horizons. It outcrops in a limited area in the north of the Marian Vale site.

Tertiary Unit

A Tertiary alkali basalt flow (Teb) overlies Ordovician rocks in the northern part of the Marian Vale subdivision. This unit is up to about 25 m thick. There is potential to develop this basalt as a source of coarse aggregate.

Quaternary Units

Quaternary alluvium (Qa) occurs along drainage lines and colluvial and eluvial material (not shown on map) is developed on the hillsides.

Structure

Folding and faulting are evident in the older rock units at Marian Vale. The Palaeozoic sequence is folded as indicated by steep to vertical dips (Allen 2006) within the site. In places two periods of folding have been identified (see Snelling 2003). Distance between fold axes varies from about 80 m to about 420 m (Snelling 2003).

Faulting is evident in the area (Allen 2006; Snelling 2003).

SAMPLING PROGRAM

Three siltstone/claystone samples were collected by this author for ceramic testing by University of Technology, Sydney. Kaolinite content of the siltstone/claystone at Marian Vale is up to 27% (Ward and Zhengsheng 2005). Sample descriptions and grid references are in Table 2.

Table 2: Ceramic testing sample data

Sample No	Description	amgE	amgN
MV105	Pale grey siltstone/ claystone with moderate red iron staining	762858	6146187
MV106	Pale grey siltstone/ claystone with minor red iron staining	761672	6144716
MV108	Pale grey siltstone/ claystone with minor red iron staining	760541	6147041

Samples collected by Lee (2005) were provided to Boral Materials Testing Laboratory for aggregate testing. Table 3 summarises results of aggregate and mineralogical testing and includes location data.

Samples were collected by Allen (2006) but not tested. These samples have been examined by this author.

Table 3: Sample testing data for previous samples

Sample Nos	Rock Type	mgaE	mgaN	Test	Pertinent Results	Ref
1 / Lot 8	siltstone/ claystone	762970	6146370	Clay mineralogy	Kaolinite 19.4%	Ward & Zhengsheng 2005
2 / Lot 17	siltstone/ claystone	761850	6145170	Clay mineralogy	Kaolinite 19.2%	Ward & Zhengsheng 2005
3 / Lot 17	siltstone/ claystone	761790	6144910	Clay mineralogy	Kaolinite 14.1%	Ward & Zhengsheng 2005
4 / Lot 18	siltstone/ claystone	761180	6144955	Clay mineralogy	Kaolinite 22.4%	Ward & Zhengsheng 2005
5 / Lot 18	siltstone/ claystone	761190	6144930	Clay mineralogy	**Kaolinite 26.9%**	Ward & Zhengsheng 2005
6 / Lot 30 Quarry	sandstone	760200	6146700	Calif Bearing Ratio 2.5 mm penetration	CBF 2.5 = 10	Boral 2005
6 / Lot 30 Quarry	sandstone	760200	6146700	Calif Bearing Ratio 5 mm penetration	CBF 5 = 14	Boral 2005
6 / Lot 30 Quarry	siltstone/ claystone?	760200	6147240	Clay mineralogy	Kaolinite 19.0%	Ward & Zhengsheng 2005
7 / Lot 37 Hat Hill	sandstone?	760650	6147270	Clay mineralogy	Kaolinite 10.4%	Ward & Zhengsheng 2005
7 / Lot 37 Hat Hill	sandstone?	760650	6147270	Calif Bearing Ratio 2.5 mm penetration LA Grading B % Loss	CBF 2.5 = 70 LA = 21%	Boral 2005
7 / Lot 37 Hat Hill	sandstone?	760650	6147270	Calif Bearing Ratio 5 mm penetration LA Grading B % Loss	CBF 5 = 80 LA = 21%	Boral 2005
8 / Lot 37W Hat Hill West	siltstone/ claystone?	760500	6147050	Clay mineralogy	Kaolinite 19.0%	Ward & Zhengsheng 2005
9 / 57429 – Providence	sandstone	760820	6246780	Calif Bearing Ratio 5 mm penetration LA Grading B % Loss	CBF 5 = 14 LA = 21%	Boral 2005
10 / 57430 – Grenada Central (Lookout)	sandstone	763500	6146800	Calif Bearing Ratio 5 mm penetration LA Grading B % Loss	CBF 5 = LA = 20%	Boral 2005
11 / 57431 – Grenada South	sandstone	763210	6146440	Calif Bearing Ratio 5 mm penetration LA Grading B % Loss	CBF 5 = LA = 23%	Boral 2005
12 / 58106 Grenada West	sandstone?	763150	6146660	Grading	Grading	Boral 2005
13 / 58107 Grenada North	sandstone?	763320	6147240	Grading	Grading	Boral 2005

SUITABILITY OF SITE MATERIALS

Coarse Aggregate

Adaminaby Group

The interbedded nature of the Adaminaby Group sequence presents problems for quarry operation as winning of suitable sandstone units would probably require selective extraction. Although testing has indicated that parts of particular sandstone units may be suitable for use as coarse aggregate, it has not been established whether all lithologies in the sequence are suitable. That is, the variation in quality along strike and down dip needs to be determined. Folding of the sequence adds further complications in relation to quarry development.

Nonetheless, there may be some areas within the Marian Vale site where sandstone dominates the Adaminaby Group sequence. If such an area or areas was found, this could mean that bulk extraction would be possible. However, this would require detailed mapping of the site including identification of structural features such as folding and faulting.

The interbedded nature of the Adaminaby Group is in contrast to a typical quarry operation where the target material is quite uniform in lithology over the quarried area and, therefore, can be extracted in bulk by blasting (see notes in Appendix 1).

Tertiary Basalt

The Tertiary basalt unit has been suggested as a possible alternative coarse aggregate quarry site rather than the silicified sandstone of the Adaminaby Group. However, the proximity of the basalt to the Hume Highway and to a number of residences means that quarry development may be hampered by external constraints due to its location. No work has been undertaken on the basalt for this report.

Construction Sand

Adaminaby Group

The possibility of producing construction sand by crushing of the Adaminaby Group quartzite is unlikely. Production of construction sand from sandstone is dependent on the sandstone being "friable" which results from deep weathering and produces rippable sandstone.

The sandstone onsite varies from hard to weathered but none of the sandstone is "friable". Any construction sand produced from crushing of sandstone is unlikely to be suitable for applications requiring more stringent quality control.

Elsewhere in the region Boral Resources (NSW) Pty Ltd produce construction sand from ripping of friable Hawkesbury Sandstone which is significantly younger than the Adaminaby Group and has undergone deep weathering during the Tertiary. This process of obtaining construction sand from friable sandstone is substantially different to any process which could be used at Marian Vale to produce construction sand from rocks of the Adaminaby Group.

It s likely that the only possible source of construction sand at Marian Vale is likely to be as a minor by-product of crushing of sandstone in the production of coarse aggregate.

Brick Clay/Shale

Siltstone/claystone material within the Adaminaby Group has been used in the near vicinity of the Marian Vale site for the production of ceramic products including dry pressed bricks (Ray et al. 2003) and floor tiles (MacRae 2001).

Testing of mineralogy (Table 2) indicates that the siltstone/claystone contains 14 to 27% kaolinite.

Ceramic testing undertaken assessed the following parameters:

- dry strength;
- fired colour
- linear drying shrinkage;
- mass loss on firing;
- tendency to crack; and,
- plasticity index;

Three siltstone/claystone samples were tested and found to able to produce for bricks. Details of testing results are in Ray and Guerbois (2006). Sample descriptions are in Table 2 and locations are shown Figure 3. The colour variation of the samples is shown in Figure 4 and descriptions by Ray & Guerbois (2006) are shown in table 4 below:

Table 4: Colour variation described by Ray & Guerbois (2006) of siltstone/claystone samples tested

Sample	950°C	1000°C	1050°C	1100°C	1200°C
MV 105	Pink	Pink	Pink	Darker Pink	Grey
MV 106	Beige	Beige	Darker Beige	Dark Beige	Greenish Grey
MV 108	Beige	Beige	Darker Beige	Light Brown	Dark Grey

These colours are equivalent to the following colours on the standard Munsell soil colour charts (table 5):

Table 5:Standard Munsell colours of siltstone/claystone samples tested

Sample	950°C	1000 °C	1050 °C	1100 °C	1200 °C
105	7.5YR 8/3	7.5YR 8/3	7.5YR 8/3	10YR 8/2	2.5Y 7/2
106	7.5YR 8/2	10YR 8/2	10YR 8/2	10YR 8/3	2.5Y 7/3
108	7.5YR 8/2	5YR 8/1	7.5YR 8/3	10YR 7/4	10YR 6/3

Plasticity testing results are summarised in table 6 below:

Table 6: Plasticity data of siltstone/claystone samples tested

Sample No	MV 105	MV 106	MV 108
Liquid Limit	28	27	37
Plastic Limit	21	19	22
Plasticity Index	7	8	15

Some observations on the testing results are:

- MV106 and MV108 fire to a pale colour described by Ray & Guerbois (2006) as beige.
- MV105 has a higher iron content as indicated by the pink colour (Figure 4) and unless blended it may be difficult to get a consistent colour, as it appears to be close to the critical iron content where colour may change significantly with minor change in iron content (S. Border pers. comm.). Colour consistency is one of the most critical features in brickmaking, especially for a dry press type plant.
- Both samples MV106 and MV108 bloat slightly at 950ºC and have slightly high firing shrinkages. These factors need to be considered when using this material.
- MV106 has a relatively high drying shrinkage.
- MV108 is more plastic than the other two samples. However, the plasticity indices of the samples are comparable to those measured for Bringelly Shale in areas where brick making clays have been extracted (Herbert 1979).

Additional testing is recommended at Marian Vale to further assess the potential of the clay/shale for use in brickmaking.

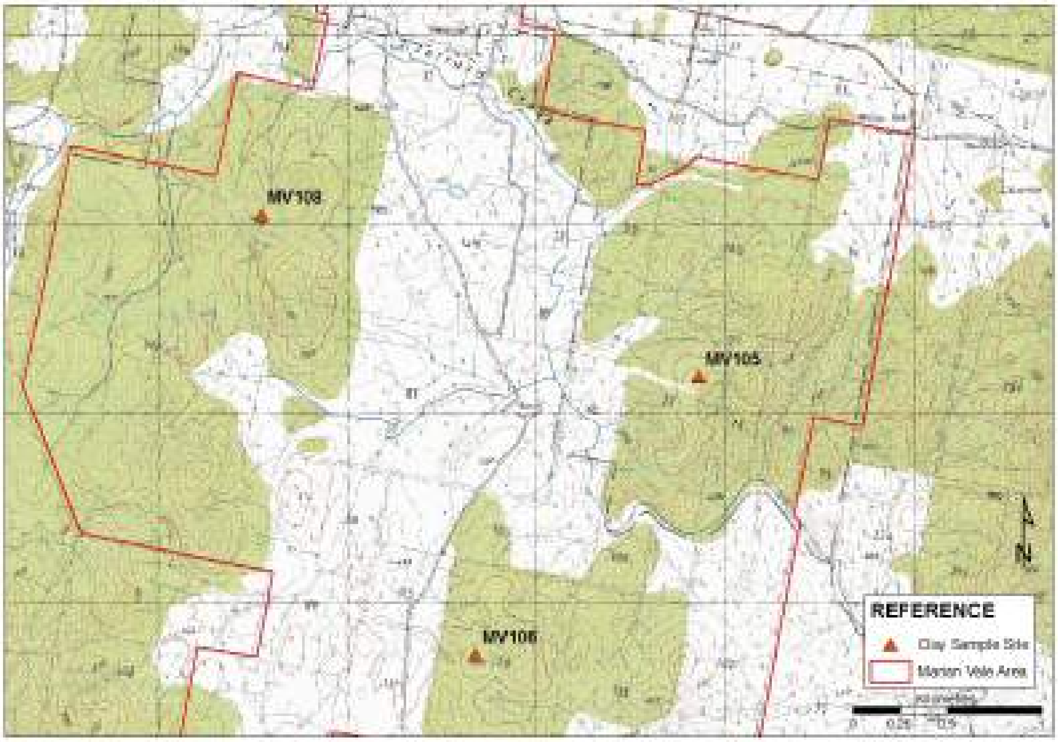

Figure 3: Location of clay/shale samples

Figure 4: Briquette colours

CONCLUSIONS

- Silicified quartz-rich sandstone within the Adaminaby Group is suitable for use as a source of coarse aggregate;

- The interbedded nature of the Adaminaby Group means that, apart from the silicified sandstone, about 30 to 50% (or possibly more) of the sequence may not be suitable as coarse aggregate and would be either waste or by-product material;

- Alternative quarry strategies such as selective extraction to separate different materials would be necessary to reduce throughput of unusable material in the processing path for coarse aggregate production;

- Crushing of coarse aggregate is unlikely to produce large volumes of construction sand due to the hardness of the source material;

- Ceramic testing on three samples of siltstone/claystone at Marian Vale found that this material has potential for use in brick manufacture.

RECOMMENDATIONS

- Development of a coarse aggregate quarry will be challenging because of variable geological parameters;
- Further detailed geological assessment of the proposed quarry sites is required to assess the feasibility of quarry development;
- A diamond drilling program of up to three drillholes at Grenada and three drillholes at Providence is considered necessary to assess subsurface lithologies at these sites;
- Follow-up percussion drilling is advised if quarry development is proposed; and,
- Further testing of siltstone/claystone for ceramic properties is recommended to further assess the suitability of the material for brick making and to determine requirements of blending materials.

REFERENCES

Allen D. 2006. Mining of construction material from Marian Vale – East of Goulburn. A preliminary feasibility assessment. Groundwater Imaging Pty Ltd, Report (unpublished).

Boral Resources (NSW) Pty Ltd. 2005. Materials Testing Reports for Peter Miller. Boral Materials Testing Services Reports (unpublished).

Bouma A.H. 1962. *Sedimentology of some Flysch Deposits: A Graphic Approach to Facies Interpretation*, Elsevier, Amsterdam.

Geochempet Services, 2005, Petrographic reports on three rock spalls samples (57429, 57430 and 57431).

Laterals Planning, 2006. Project Application - Part 3a. Proposal for a Quarry, Brickworks, Building Products Manufacturing, Ceramic Products Manufacturing, and Concrete Products Manufacturing, "Marian Vale". Laterals Planning, Report Reference No. 5030.

Lee J. 2005. Summary of Preliminary Results of 2005 Drilling Results and Aquifer Testing Programme 'Marian Vale' Tiyces Lane, Goulburn for Millerview Constructions Pty. Ltd. Hydroilex Report HG.05.11.23 (unpublished).

MacRae G.P. 2001. Structural Clay/Shale Resources of the Sydney Region. Geological Survey of New South Wales, Report GS2001/038.

Ray A. & Guerbois J-P. 2006. MRDL Clay Test. AccessUTS Project No. C06/61016.

Ray H.N. MacRae G.P. & Cain L. 2003. Industrial Minerals Database, Version 2. Geological Survey of New South Wales, Database on CD-ROM.

Snelling P.A (compiler). 2003. Goulburn 8629 1:100 000 Geology - GIS Data Package. NSW Department of Mineral Resources, (published on CD-ROM)

Ward C.R. & Zhongsheng L. 2005. Mineralogy of Rock Samples for Hydroilex. UNSW Geological Analysis Report (unpublished).

APPENDIX 1: KNOWN QUARRIES AND RESOURCES IN THE REGION

There are many established quarries within the region which mainly supply local markets in the Goulburn district. Relevant quarries are listed in Table 7 and their locations are shown in Figure 5. Numerous other small Council quarries occur throughout the region but are not shown on the accompanying figure.

Table 7: Known quarries and resources in the region

QUARRY	OPERATOR	COMMODITY	ANNUAL PRODUCTION	GEOLOGY	MARKET
Paddys River, east of Marulan	Bowral Bricks	Brick clay	6 000 t	Ordovician siltstone	Local / regional use in brick manufacture
Shelleys Flat area, east of Goulburn	Austral Bricks	Ceramic clay	4 000 t	Ordovician siltstone	Export to Sydney as component in ceramic tile / brick manufacture
Minda Clay Pit	Hallinan Haulage	Brick clay	5 000 t	Tertiary clay	Export to Sydney as component in ceramic tile / brick manufacture
Bunnygalore Pit	Bowral Bricks	Brick clay	10 000 t	Permian shale	Export to Sydney as component in ceramic tile / brick manufacture
Barina, Collector	Barina Quarries	Coarse aggregate	40 000 t	Silurian quartzite	Local concrete production and roadmaking
Marulan South Proposal	Boral	Coarse aggregate	5 Mt (Proposed)	Devonian granitoid	Primarily export to Sydney for concrete / roadmaking
Ginnagulla Quarry	Boral	Coarse aggregate	160 000 t	Silurian felsic volcanics	Local / regional concrete production and roadmaking
Johnniefelds, Marulan	Readymix	Coarse aggregate	190 000 t	Devonian felsic volcanics	Local / regional concrete production and roadmaking
Lynwood, Marulan	Readymix	Coarse aggregate	5 Mt (Proposed)	Devonian felsic volcanics	Primarily export to Sydney for concrete / roadmaking
Bogo Quarry	TRN	Coarse aggregate	100 000 t	Devonian felsic volcanics	Local / regional concrete production and roadmaking
Exeter Quarry	Malcolm Holdings	Coarse aggregate	168 000 t	Tertiary basalt	Local / regional concrete production and roadmaking
Currandooley Sand Pit	Tobiway	Construction sand	220 000 t	Quaternary alluvium	Local / regional concrete production, Canberra and surrounding area
Bungendore Sand Pit	Readymix	Construction sand	110 000 t	Quaternary alluvium	Local / regional concrete production, Canberra and surrounding area
Penrose Sand Quarry	Boral	Construction sand	270 000 t	Triassic friable sandstone	Local / regional concrete production
Yass River Road	GC Schmidt	Road base	100 000 t	Ordovician shale	Local roadmaking and fill material
Carrick Hill, east of Goulburn	Divall	Road base	90 000 t	Ordovician carbonaceous siltstone	Local roadmaking and fill material

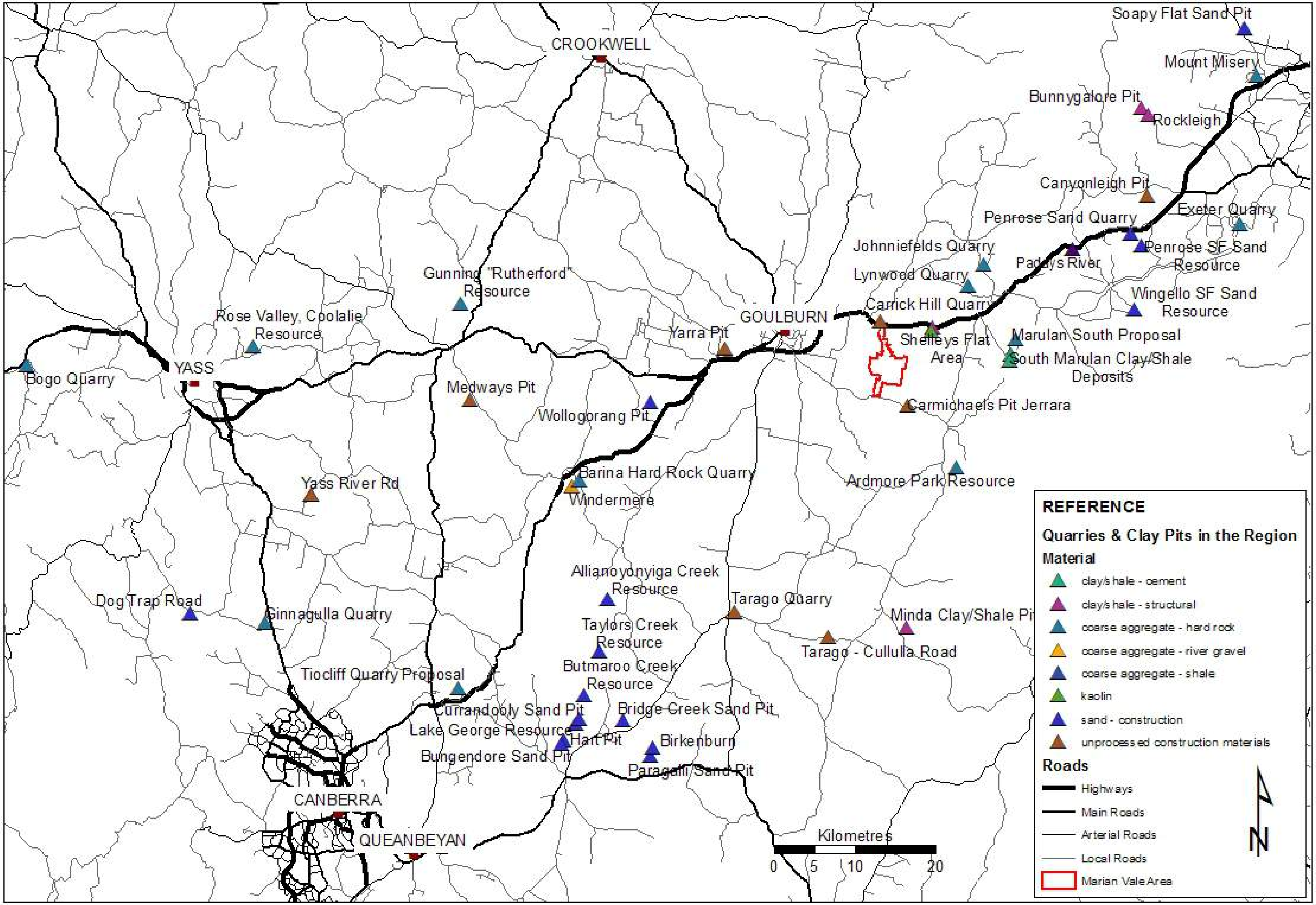

Figure 5: Competing quarries within the Goulburn region Note: Not all sites on this map are listed in Table 4

APPENDIX 2: QUARRY RESOURCE PARAMETERS

Given that environmental and market requirements have been met, optimum quarry operations need to be able to access a large mass of homogeneous material of suitable quality to generate the required products. Typically, coarse aggregate quarries use igneous materials such as volcanics or intrusives such as rhyolite or granite.

The mass of homogeneous material to be quarried is ideally uniform in three dimensions and at least about 100^3 m or 1 000 000 m^3. This is the equivalent of about 2.5 Mt in-ground resource.

The sandstone material at Marian Vale does not meet this minimum requirement for a coarse aggregate quarry. Allen (2006) has indicated that the sandstone units are variable in quality (ie, soundness) along strike and, perhaps, down dip. That is, they are not known to be homogeneous in any dimension.

APPENDIX 3: BRICKWORKS DEVELOPMENT

Generally, although it may be feasible to develop a brickworks on the Marian Vale site, there are a number of factors which will need to be thoroughly assessed prior to such a development.

The siltstone/claystone material on the site may be suitable for use in brick manufacture but it is highly unlikely that this material would be capable of providing a suitable source of all brick making components. It is probable that another source of more plastic material would be needed to enable the brickmaking process to occur.

The strong trend in the brick manufacturing industry is for consolidation of operations. The vast majority of bricks produced in NSW come from the Sydney region (including Bowral), although there are some regional brickworks such as in Albury. The major brick manufacturing companies (Austral, Boral and PGH) dominate the industry and transport bricks throughout NSW and interstate.

A new brickworks at Marian Vale would be competing with major companies in a strongly competitive market. It would be prudent to assess the likelihood of success of a new brick manufacturing operation in such a market.

K. Mining of Construction Material from Marian Vale – A preliminary feasibility assessment prepared by Groundwater Imaging.

Mining of Construction Material from Marian Vale – East of Goulburn. A preliminary feasibility assessment.

September 2006

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Introduction

Marian Vale is a property 10 km east of Goulburn and south of the highway. An assessment of the potential of the property for mining of construction materials has been sought. The highway and nearby railway provide excellent access to Sydney markets which are suffering dwindling supply (Pienmunne, 2002).

The client has proposed:

- that hard metasandstone on the property could be mined for use as coarse aggregate;
- that soft metasandstone on the property could be crushed to manufacture sand; and
- that clays on the property are suitable for brick manufacture at a proposed on-site brick works.

Tertiary Basalt was discovered on the site via a literature search by the author and is proposed as a more appropriate source of coarse aggregate. Summary of the resources is as follows.

Reports to date assessing the potential of quarrying on Marian Vale have focused on rock sample analysis whereas this report is focused on the distribution, orientation and extent of suitable rock.

Tertiary Basalt coarse aggregate source

The presence of a Tertiary alkali basalt on the northern part of the property offers a potential opportunity to quarry coarse aggregate that should not be ignored. The basalt appears to be ideal for coarse aggregate production. Presence of Gabbro amongst the basalt (probably as dykes) suggests that the site is a volcanic source rather than just a flow. This means that there is potential for deep quarrying. The gabbro weathers rapidly and breaks up into reactive grains when crushed lightly and would need to be sieved out of the Basalt using a course sieve during the crushing process. The basalt is visible from a number of adjacent properties and only a portion of it is on Marian Vale. Purchase of adjacent property containing the remainder of the deposit is recommended should sample testing prove the resource is suitable for coarse aggregate. The Basalt/Gabbro appears to cover an area of 40 hectares and is expected to be at least 40m thick. If 80% of it is Basalt then at least 40 million tonnes of coarse aggregate, worth about $400 million dollars, could be quarried from the site.

Other coarse aggregate sources

On the main part of Marian Vale, the rock is almost entirely of the Ordovician Adaminaby Group – turbiditic quartz-mica sandstone and siltstone. Bands of the sandstone that contain a high proportion of quartz are hard and durable due to fusing of the quartz grains by metamorphism. Where the proportion of quartz drops off the sandstone becomes supported by mica and quickly becomes much softer. The hard bands are typically vertical and outcrop at the surface. Mining of the bands, typically less than 3 metres thick, alone is not feasible – they must be extracted along with adjacent rock and therefore a stripping ratio of 5 to 1 is anticipated at sites where there are the highest concentrations of hard bands. Sorting of coarse aggregate from softer material during crushing and sieving may well not be feasible as some rock of intermediate hardness is likely to crush into aggregate of dimensions the same as the hard rock. It is not anticipated that the rock becomes significantly harder with depth as the rock shows little evidence of weathering near the surface.

Hard metasandstone (sandstone hardened by metamorphism) bands have been mapped across the property. Concentrations of bands on the east of the property seem most prospective. Principally on the west of the property, hard bands of Nattery Chert (very fine grained siliceous rock) also exist. Chert from these bands broke up into fine particles when hit by a sledge hammer and therefore the chert does not appear to be suitable for use as coarse aggregate. The chert bands typically are flanked by siltstone and shale. Faulting in the west part of Marian Vale has resulted in very localized hardening of some metasandstone bands as well as fracturing of most of those bands by quartz veinlets. The fractured metasandstone also broke up into fine particles when hit by a sledge hammer and is therefore also deemed unsuitable for use in the manufacture of coarse aggregate.

Manufactured sand sources

The softer metasandstone of the Adaminaby Group is believed to be suitable for the manufacture of sand. Because it is made up almost entirely of quartz grains and sericite (fine grained randomly-oriented muscovite mica), when crushed it will convert to quartz sand grains and sericite clay dust. Such sandstone extends across almost the whole property. The west side of the property has components of Warbisco shale (Strongly foliated black carbonaceous shale), faults and associated localized metamorphism and chert bands that all may complicate manufacture of consistent quality sand. The central and eastern parts of the property seem to be much more consistent in lithology and structure and are therefore likely to be better for sand manufacture. Quarrying may target hard metasandstone bands so as to also produce coarse aggregate or may avoid such bands so as to target consistent soft metasandstone that can easily be crushed to form consistent quality sand. As hard blocky metasandstone concentrates on the surface of the ground as erosion removes the softer metasandstone and siltstone, clear geological mapping of the softer lithologies was not possible. Inclined drill holes would prove up the softer lithologies.

Clay sources

Brick and tile manufacture is best conducted using clay that contains little moisture and does not expand much when it absorbs water. The Adaminaby Group rock of Marian Vale is made of quartz and mica believed to be almost all sericite – (very fine grained randomly orientated muscovite (Ward, 2006,). Muscovite is the common clay mineral with the highest metamorphic grade which means that it contains the least moisture and does not suffer expansion problems. Clay sourced from the Adaminaby group rock is therefore potentially of the best possible quality for brick and ceramic manufacture – confirmation by a brick and ceramic manufacture expert is still required. As the Adaminaby group is turbiditic, it has a large range of particle sizes and there is a good possibility that a good proportion of clay may be separated from sand during sand manufacture. As the Group is layered, layers of shale may also be converted directly to a clay resource. Clay sources could not be identified by surface mapping as they have no exposure. Rather, inclined drilling and or investigative quarrying would be necessary. Again, the central and eastern parts of the Marian Vale property are likely to produce material of most consistency; however; the western side of the property appears to contain more shale. Faulted pods of Warbisco Shale occur in the west part of the property and this shale has potential to have very different clay mineralogy. The description on the geological map indicates that this shale is carbonaceous – this could complicate brick and tile manufacture. Major pods of inferred Warbisco shale are mapped on the Goulburn 1:100 000 geological map but additional geological mapping revealed that much more Warbisco Shale is potentially present on the west side of Marian Vale than is mapped. The shale does not outcrop in most locations and therefore is difficult to identify. Great care must also be taken when considering the significance of clay sampled from fault zones on the west side of Marian Vale as such clay is highly altered. Excavation on one of the faults revealed alteration minerals including talc and possibly serpentine. Such samples are interesting but are not representative of the general rock mass.

A good start on research of information on brick and refractory clays is available from http://answers.google.com/answers/threadview?id=609673 .

Literature review

An interview with two of the NSW Geological Survey team (M.M. Scott and O.D. Thomas) that mapped the Goulburn sheet in recent years was arranged at Orange. Because they have just reviewed most relevant literature, further searching was not necessary. Discussion of relevant geology has led to many of the conclusions of this report. Map and digital products were also obtained at that meeting and they strongly encouraged investigation of the Tertiary Basalt. They also provided draft notes on Goulburn industrial minerals and rock (Macrae, 2006). The author, Greg Macrae has left the Geological Survey and he is being pursued as a potential consultant by Laterals Planning.

Macrae's notes accompany paper copies of this report and are certainly worth reading. They reveal present and potential competing quarries and detail the rock type sourced at each of them. Of particular note are:

1. 'A proposal for a "super" quarry (centred on GR771413/6154683) in the Joaramin Ignimbrite west of Marulan is being prepared by Readymix Holding Pty. Ltd.'; and
2. 'Another quarry, planned for Ardmore Park south of Bungonia (GR770263/6133958), and containing resources of about 15 Mt of Teriary basalt, is proposed to supply Sydney, local and regional markets.' It is proposed that 7 Mt of construction sand will also be extracted from Ardmore Park.

The principal rock unit at Marian Vale, the Adaminaby Group is not considered prospective as a source of coarse aggregate by Macrae, only as a source of unprocessed construction material. The Warbisco Shale (a black shale), present in lenses on the west of Marian Vale is mined in Divall's quarry north of Marian Vale. Macrae (2006) states that 'Empirical evidence indicates the black shales produce a well-bound covering on dirt roads without becoming slippery when wet.'

The client has obtained testing of numerous samples of rock from the property and reports on the tests are listed in the reference list. Localities of the samples are not clearly given in any of the reports. Reports on mineralogy of clay samples, petrology of rock spall samples, and NATA geotechnical properties of rock samples were all obtained. Water bores have been drilled in fracture zones of the central valley and a draft report detailing that program also is available. Readers of this report should also familiarize themselves with the other reports on the property.

Rock samples

Thirty eight rock samples were collected principally from potential coarse aggregate sources. Two photos suggest the diversity of the more important samples.

All details of the samples, their co-ordinates and outcrop descriptions are given in Table 1. They are located on various maps that follow.

Figure 1 Rock samples from left to right are gabbro (site 36 – backhoe pit), Basalt (site 36 – backhoe pit), quartz vein ridden metasandstone (site ?), Shale flecs (site 30 – western boundary), metasandstone and shale hardened by faulting along with fault plane minerals such as talc (site 32 – bulk sample site), hard metasandstone (site 4 - lookout), Chert and shale (site 25 – quarry), soft metasandstone (site 38).

Figure 2 Basalt (hard durable fine grained rock – 'blue metal') and Gabbro (weathered coarse grained rock) from sample site 36. No gabbro was evident at the surface as it has been weathered away. This sample was collected from 2m metres down in the backhoe pit.

Table 1 Rock sample details

Site	Site Description	Rock Description	Outcrop Description	Easting	Northing	Dip	Strike
1	Where Ck crosses MV road	Hard Blocky metasandstone	near vertical group of bands 50m wide and 200m long	761840	6147680	20W to vert	350
2	On road to lookout, adjacent to creek	Hard Blocky metasandstone	3m thick band extends north but is stopped at the creek to the south. Similar bands with lesser exposure exist to the NW.	762290	6147100	45W	0
3	Saddle on road to lookout	Hard Blocky metasandstone	1m thick bands but >100m subcrop exists to west. To the east similar rock exists but only as float.	763281	6146681	vert	20
4	Lookout	Hard Blocky metasandstone	Outcrop removed by excavation left mainly floaters - subsoil contained much less hard rock than that present on the surface	763339	6146540	vert	0
5	East of lookout on steep slope	Hard Blocky metasandstone	band on steep side of hill	763408	6146506	vert	0
6	Fork in track on low ridge east of lookout	minor indurated shale and Hard Blocky metasandstone	band forms the low ridge	763569	6146288	vert	0
7	Spur east of 2 creeks east of lookout	Hard Blocky metasandstone	multiple bands >3m thick and with 100's of metres of strike length. A 30m length east of another gully has a strike perpendicular to the other bands indicating severe deformation.	763695	6146314	60W	30
8	100m east of lookout	scant metasiltstone among blocky metasandstone		763439	6146540	vert	0
9	West side of Basalt Mound - Cul-de-sac	Basalt	Float on west flank of basalt mesa.	761006	6150065	flat	0
10	East west road along fence - adjacent to a	Hard Blocky metasandstone	Multiple bands <3m thick extending along ridge. Another band exists about 50m west and has 100s of	761710	6145218	vert	0

	water tank on a hill		metres of strike length				
11	adjacent to site 10. Where ripping for pipe installation disturbed subsoil.	Soft Blocky metasandstone	Subsoil rock not evident at the surface	761736	6145265	vert	0
12	Hillside	Hard Blocky metasandstone	bands <2m wide along with friable siltstone. Packages of bands are up to 15m wide.	761583	6145032	vert	0
13	Fence	Hard Blocky metasandstone	wide package of bands extends at least 100m north and 100m south.	761497	6144844	vert	0
14	Backhoe pit	Mixed lenses of metasiltstone and hard blocky metasandstone	bands	761682	6144731	vert	0
15	150m NW of farm dam	Scarce hard blocky metasandstone float - principally soil at surface.	proportion of float indicates that hard bands are present but are thin and scarce in this area.	761702	6144578	vert	0
16	Ridge top	Hard Blocky metasandstone	package of bands at least 100m wide extends at least 100m north and south	761902	6144700	vert	0
17	no sample - soil	Scarce hard blocky metasandstone float - principally soil at surface.	proportion of float indicates that hard bands are present but are thin and scarce in this area.	762071	6144879	vert	0
18	creek	ONLY soil exists at surface	zone around creek divides packages of hard blocky metasandstone.	762121	6144784	vert	0
19	east ridge	Hard Blocky metasandstone	Package of very hard bands. No outcrop or float exists to the east!	762215	6144699	vert	20
20	low ridge	vien ridden hard blocky metasandstone	Single band 3m wide extends about 100m north and south	762343	6145040	vert	0
21	no sample - spur on west side of dam	Hard Blocky metasandstone	Isolated band 50m long and 2m wide with shale to the east and soil only to the west.	762139	6145151	30W	0

22	Bungonia road cutting	Chert	Band 2m thick in road cutting hosted in shale. Difficult to trace on the ground.	759890	6142576	80W	0
23		Chert	Band hosted in shale/soft metasandstone	760353	6146591	vert	0
24		Soft Blocky metasandstone	subcrop and soil	760400	6146580	vert	0
25	Quarry	Chert, soft and hard blocky metasandstone and indurated shale	may include a fault plane with altered rocks to the sides, vein ridden	760217	6146683	vert	0
26	SW of quarry	vein ridden blocky metasandstone - breaks up	band	760118	6146559	vert	0
27	SW of quarry	quartz vein band, 80% veins hosted in metasandstone and indurated shale	probably a major fold axis/fault combination where pressurized hydrothermal fluids could easily enter	760180	6146316	vert	0
28	10m east of bore in creek	Chert	band 2m wide extends up spur to north but is faulted by the creek to the south. Cuttings left at the bore are a combination of unweathered metasandstone, shale and vein quartz. They are obviously a good indication of the properties of the deeper unweathered rock.	760285	6146186	vert	0
29	no sample	quartz vein band, 80% veins hosted in metasandstone and indurated shale	probably a major fold axis/fault combination where pressurized hydrothermal fluids could easily enter	760174	6146148	vert	0
30	Western boundary. All along road from quarry	scant evidence of shale in topsoil	soil with small flecks of shale floater extend along the entire length of the road from the quarry.	759304	6145958	vert	0
31	Hill top on western boundary. No sample	quartz vein mass, 80% veins hosted in indurated shale	scant evidence in topsoil of shale extends from site 30 through site 31 and on to the NW corner of the property.	759436	6146988	vert	0

32	Bulk sample site	Chloritically altered hard blocky metasandsotne, soft blocky metasandstone and white shale flank fault plane minerals - talc, Serpentine? and possibly oxidized traces of copper mineralization	Major fault plain (greasy minerals 20 cm thick) and adjacent alteration zones	760548	6147053	80W	340
33	Backhoe pit on top of hill	White altered shale and talc	Shale altered and hardenned by faulting	760721	6147073	50-80N	260
34		Fissured, moderately indurated metasandstone	bands	760700	6147080	vert	0
35	fence intersection of NS ridge - forest to south	Fissured, moderately indurated metasandstone	north end of bands. Fragments in soil to the east	760741	6147298	vert	0
36	New backhoe pit - Top of basalt mesa about 60m west of driveway off new road	500mm topsoil over 1.9 m exposed subsoil and basalt pillars and gabbro veins	600mm diameter hexagonal basalt pillars (probably invaded by) gabbro veins which make up at least 10% of the rockmass in the pit (maybe more as the gabbro easily breaks up and converts to soil.	760956	6150285	flat	0
37	Top of prominent hill	Shale and metasandstone altered by faulting.	Fault with associated hard rock band plus one extra band of hard blocky metasandstone	760650	6146500	vert	0
38	long EW spur - typical of entire central valley	soft metasandstone	float found consistently! across the entire central valley and flanking spurs	762800	6146500	vert	0
39	plain ground	Shale to west, Soft Blocky metasandstone to east	little outcrop	760120	6147250	vert	0
40	Valley west of basalt with fence and gate	major magnetic anomaly (strike only estimated)	2 prominent magnetic anomalies just west of the basalt mesa suggests feeder mineralization (possibly gabbro) extends to depth	760810	6150100	unknown	300
41	North side of basalt mesa	basalt	north side of mesa - confined magnetic anomaly indicates edge of basalt	761000	6150440	flat	70

Mapping

Rock sample locations are presented on various maps that follow. Geological mapping was conducted while collecting the samples and conducting magnetic traverses.

Photos of some of the outcrops follow.

Figure 3 The Basalt mesa. Site 9.

Figure 4 Water bore - site 28. A hard fissured meta-sandstone band is in the background where it forms a spur. Rock chips from the bore give important evidence of the nature and consistency of meta-sandstone/siltstone found in the bore hole along with vein quartz remains.

Figure 5 Road base quarry - site 25 revealing deep weathering in chert, soft and hard vein ridden metasandstone and indurated shale. The quarry seems to be in a fault zone associated with the Towrang Fault. Because the quarry has been formed by ripping with bulldozer tines evidence of rock structure has been destroyed.

Figure 6 Site 10b looking south along the outcrop of a distinct hard metasandstone band.

Figure 7 Site 14 Outcrop of hard blocky metasandstone.

Figure 8 The backhoe pit at site 14 which reveals soft metasiltstone that is not evident at the surface.

Figure 9 Site 32 Greenish colour on hard blocky metasandstone in the forground is probably chloritic and is only present around the faults. Highly altered shale (now white) and soft white blocky metasandstone is present in the vicinity of the fault. Greasy minerals including talc, and probably serpentine are on the actual fault plane.

Figure 10 A highway cutting north of Marian Vale clearly shows the near vertical layering of rock in the area along with a near non-existent soil profile also common in the area. This site has been classified by NSW Geological Survey as Warbisco Shale. It is presented here because it is a good example of structure and weathering similar to that that cannot be observed under Marian Vale.

Hard blocky metasandstone is present in unrepresentative proportion at the surface. Figure 11 attempts to explain why this is.

Figure 11 A schematic section showing a hard metasandstone band and the way it weathers to form floaters across the ground surface.

The following maps present locations of rock samples collected, NSW Geological Survey mapping results and mapping conducted as part of this report.

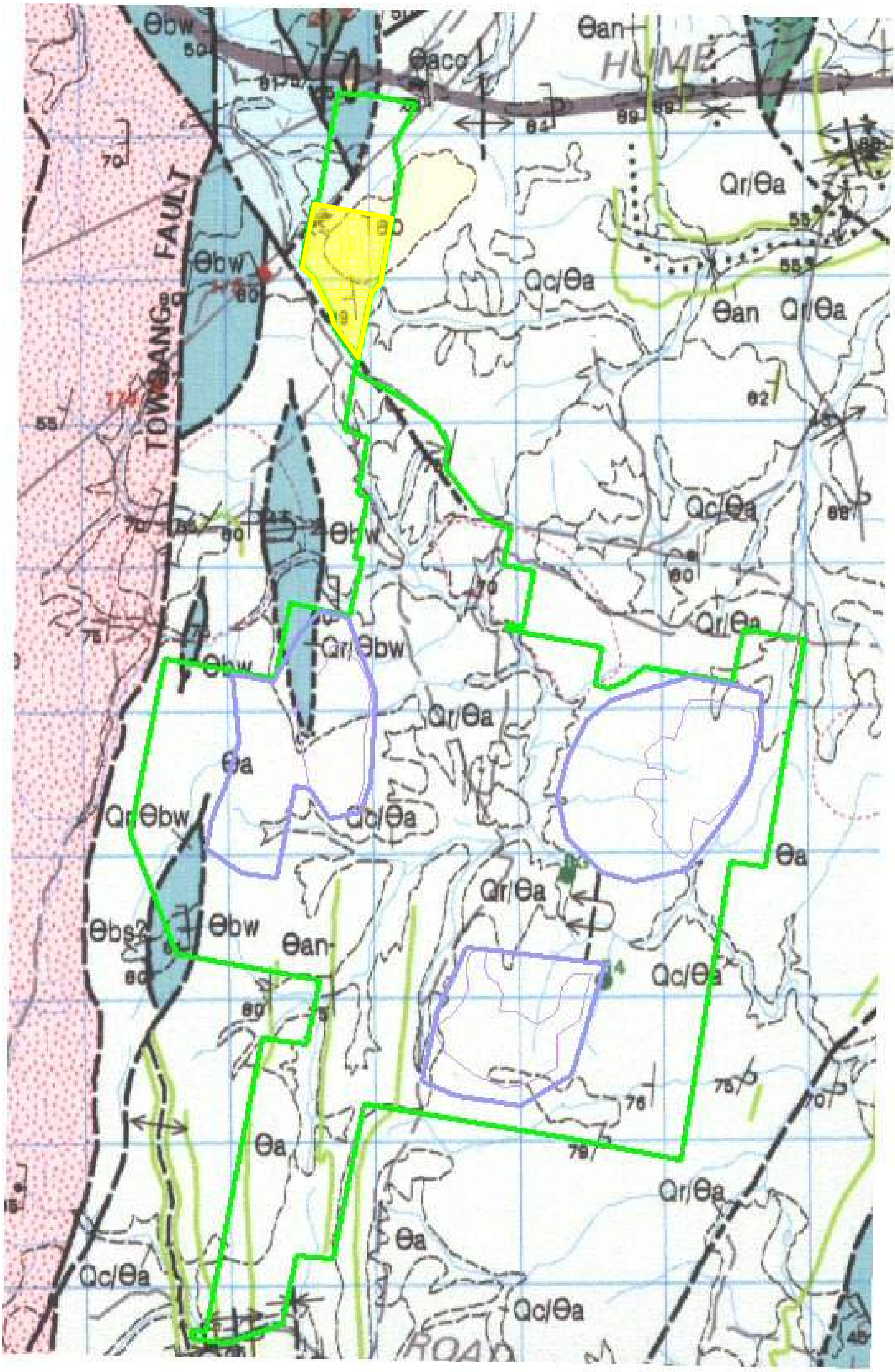


Figure 12 An exerpt from the NSW Geological Survey Goulburn 1:100000 geological map.

Relevant rock units given on Figure 12, in order of significance, not age, are:

- θa – Adaminaby Group (undifferentiated) – Turbiditic fine- to coarse-grained mica-quartz (± feldspar) sandstone and siltstone. Rare discontinuous chert units. Sandstone beds typically display graded bedding and ripple cross lamination is prominent in fine-grained sandstone. Siltstone and shale display horizontal lamination.
- θan – Nattery Chert – Thin bedded to laminated radiolarian and conodont bearing chert, variably cherty siltstone and mudstone, minor graded and cross-laminated fine grained quartzose sandstone.
- θbw – Warbisco Shale – Strongly foliated black laminated carbonaceous shale.

The following map key is relevant to all the remaining maps.

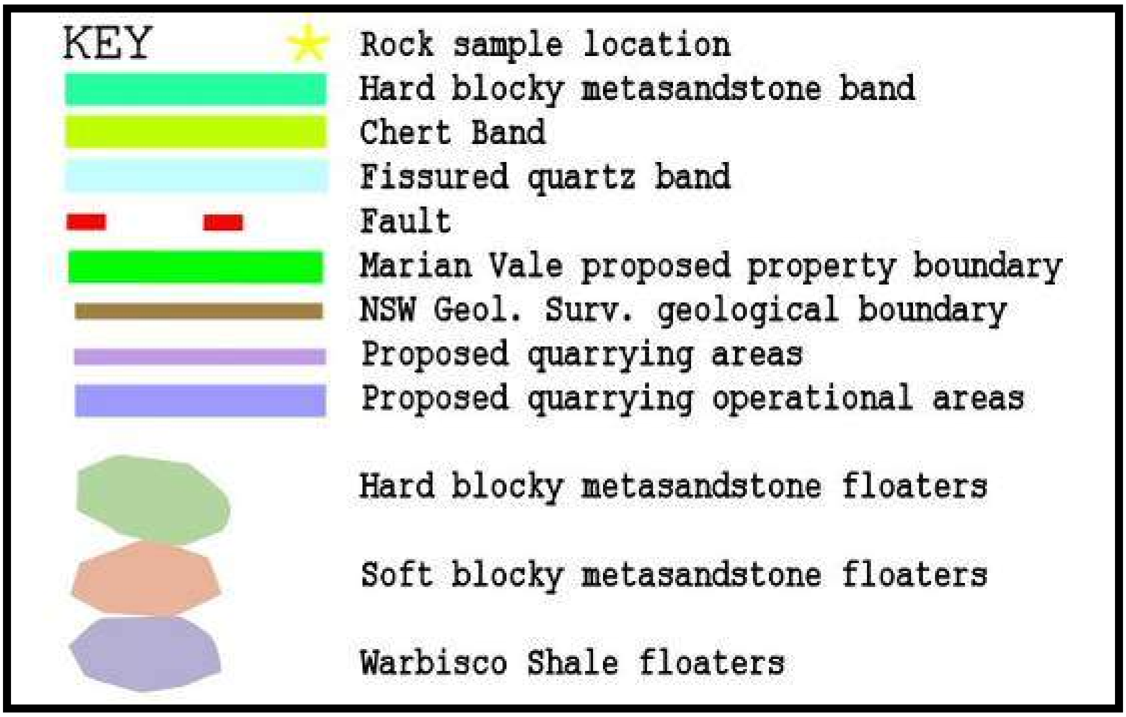


Figure 13 A Key to the maps in this report.

Areas mapped are extrapolated away from the rock sample sites, magnetic traverses and other sources of evidence. Extrapolated mapping is less reliable than mapping in the vicinity of sources of evidence. Never the less, areas mapped as having soft blocky metasandstone floaters are areas where manufactured sand and clay are likely to be derived whereas areas mapped as having hard blocky metasandstone floaters are deemed to be suitable for sand manufacture (with higher crushing energy requirements) and possibly coarse aggregate manufacture. Areas mapped as Warbisco shale are deemed to be similar to Divall's roadbase quarry. Unclassified areas on the west Marian Vale map are deemed to contain extensive faulting, soft metasandstone, siltstone and shale of the Adaminaby group and Warbisco Shale. They cannot be mapped due to lack of surface evidence.

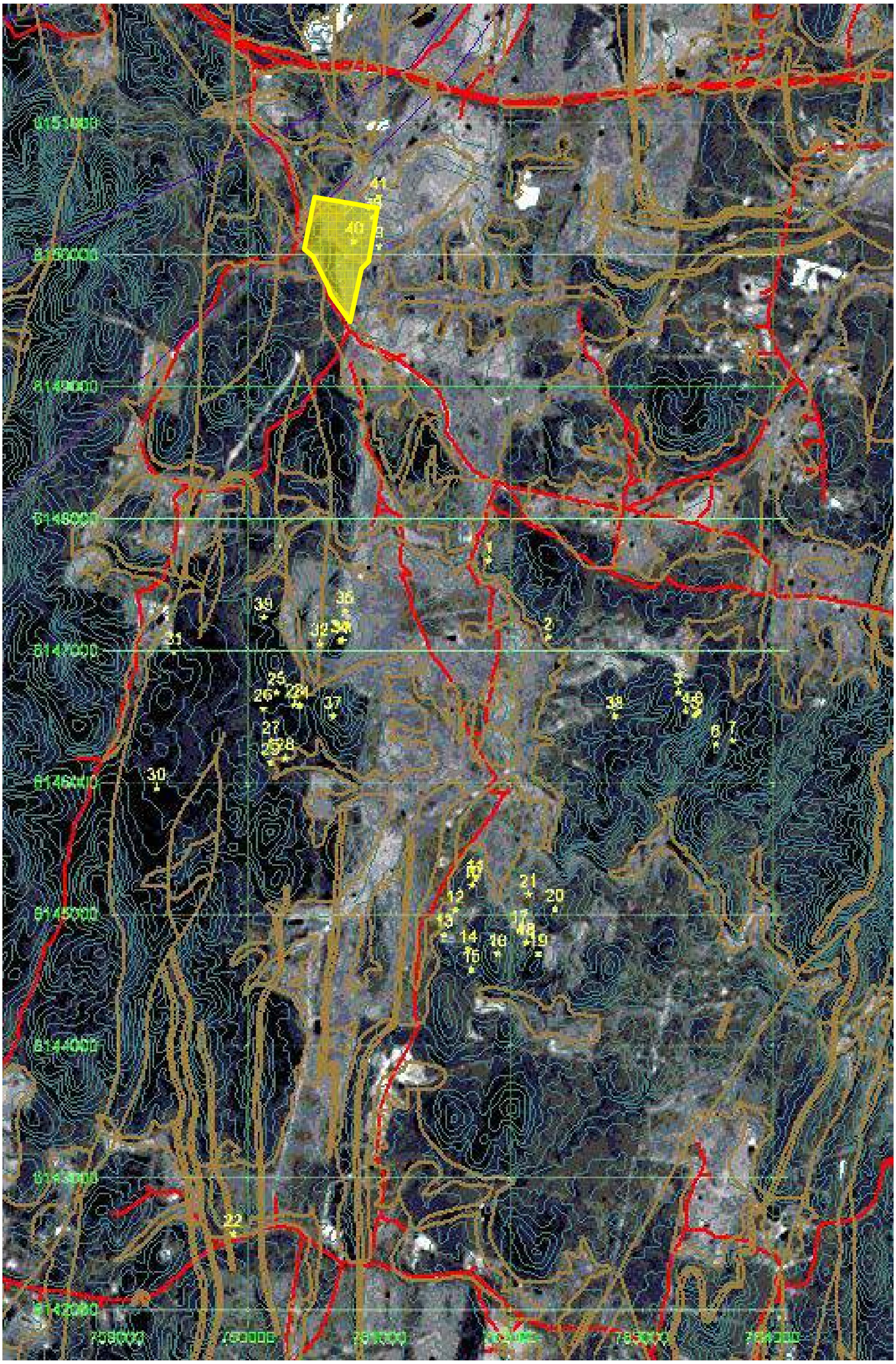


Figure 14 An overview of rock sample locations (in AGD66 coordinates), and NSW Geological Survey boundaries, contours roads and landsat (NSW Geol. surv. , 2003)

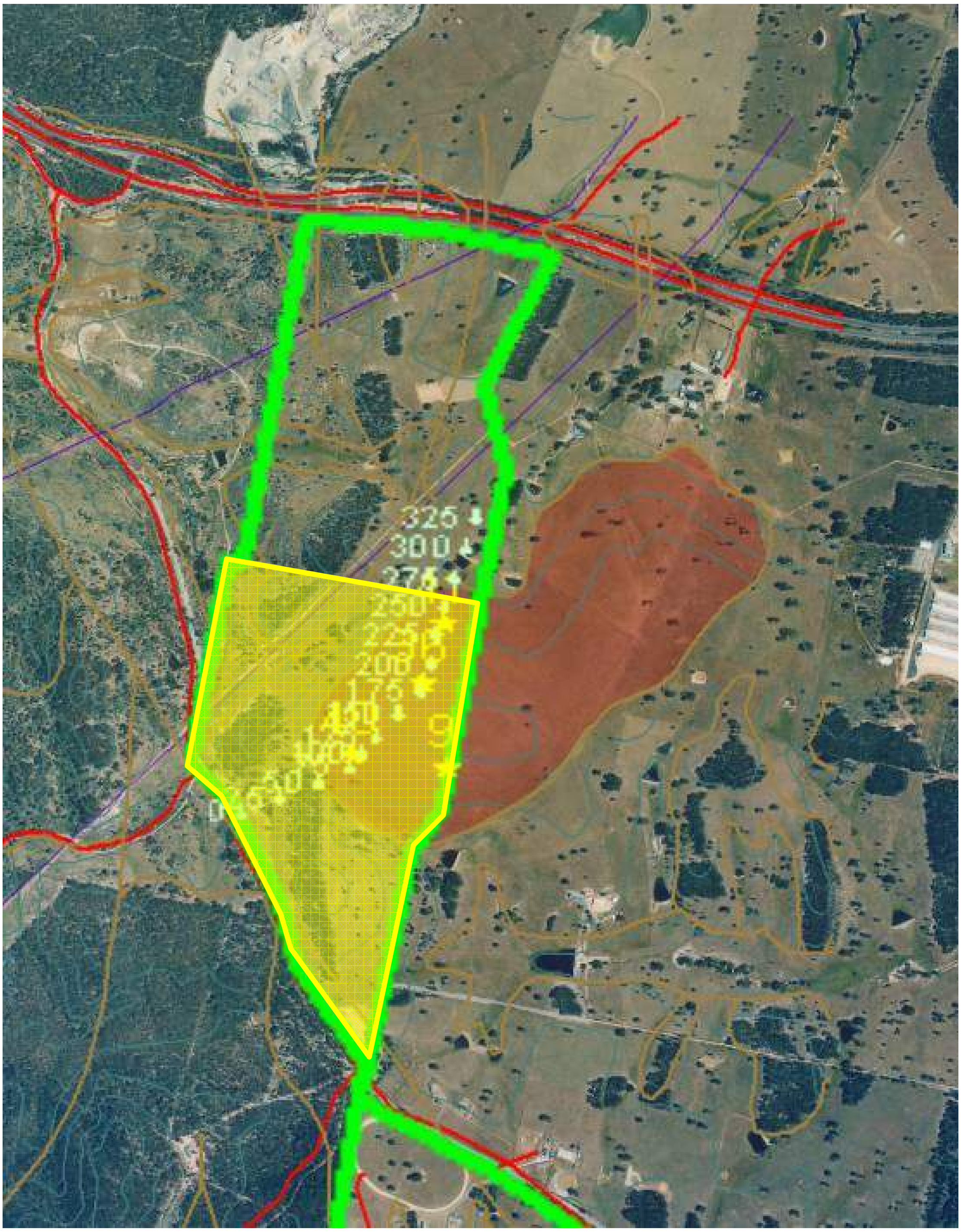


Figure 15 The northern extent of the proposed Marian Vale property showing rock sample locations, a magnetic traverse, the NSW Geological Survey mapped extent of the alkali Tertiary basalt (marked in semitransparent brown) and an airphoto background.

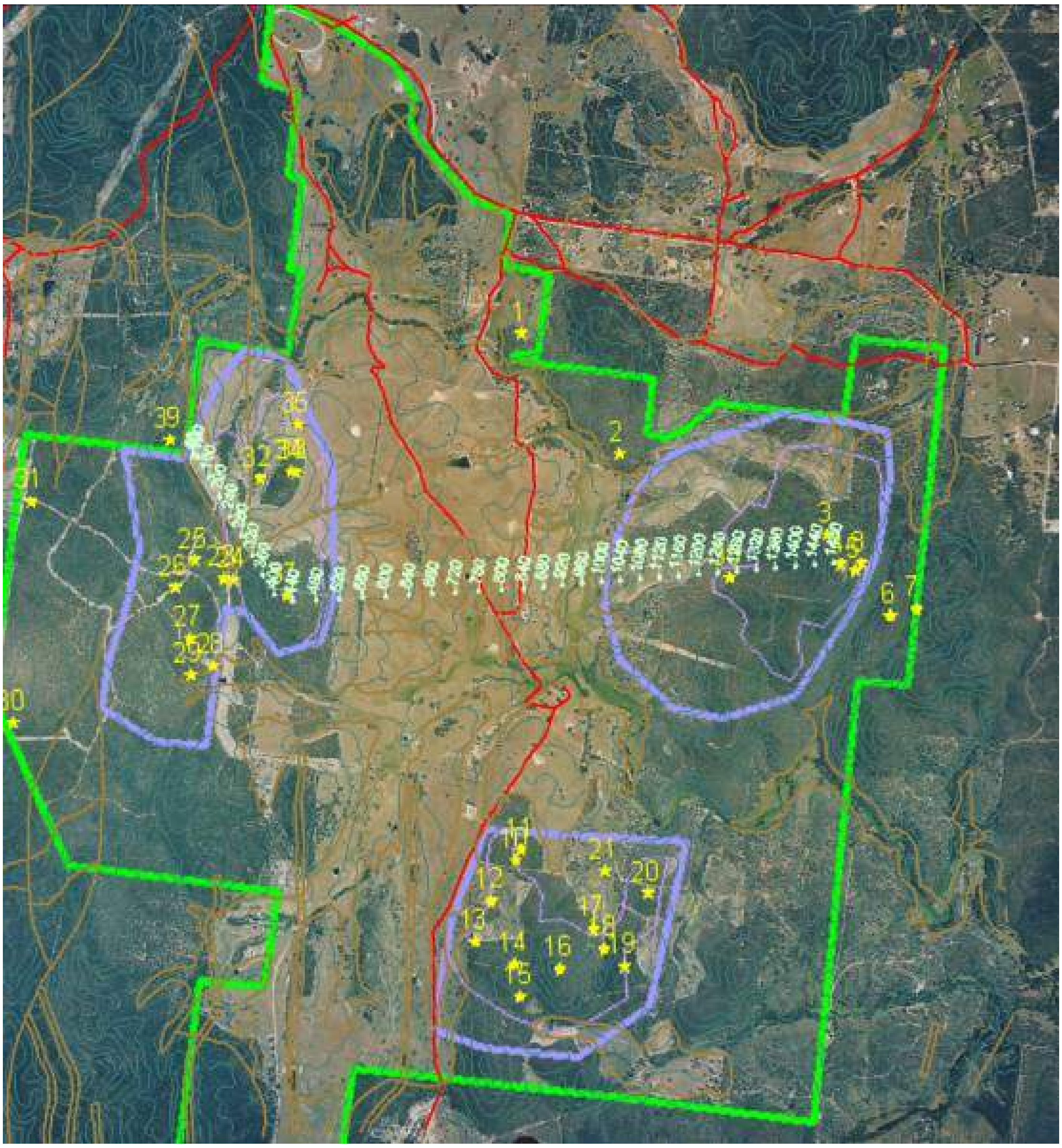


Figure 16 The Central extent of the proposed Marian Vale property showing a magnetic traverse and sample locations.

Figure 17 An airphoto of the southern extent of the proposed Marian Vale property - placed here just for completeness.

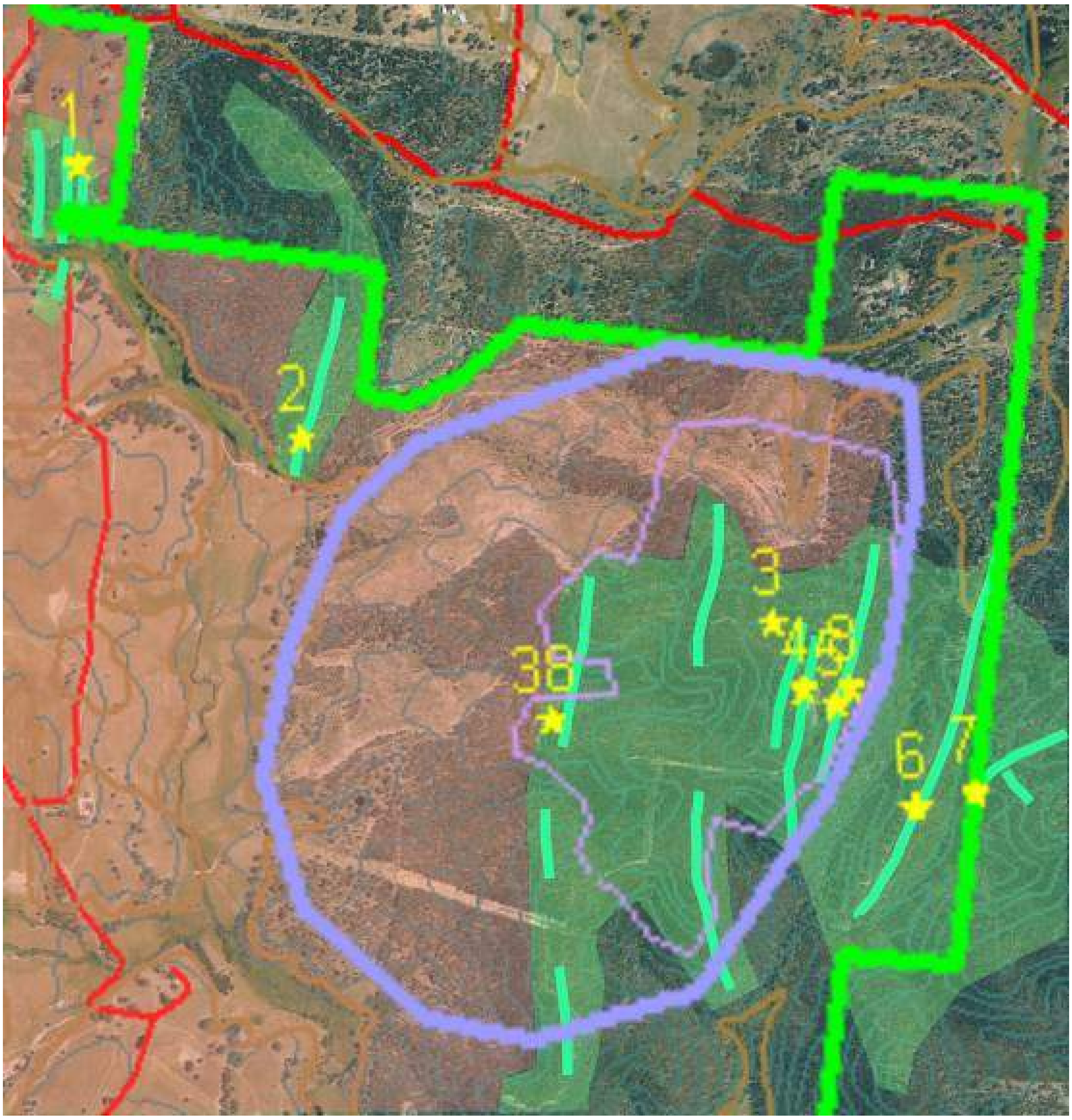


Figure 18 Geological Mapping conducted in the east of Marian Vale showing identified areas of hard and soft metasandstone as per the map key.

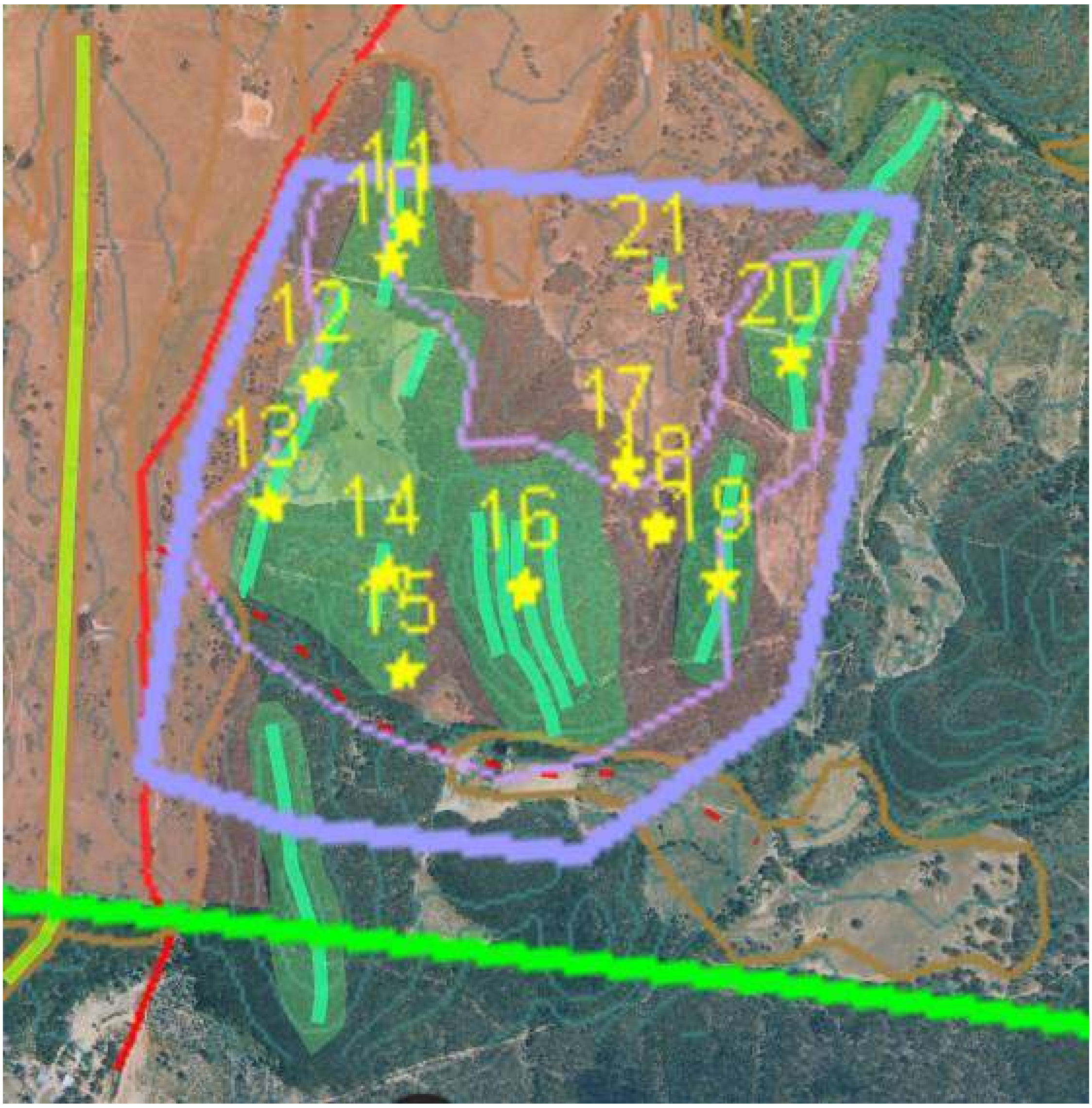


Figure 19 Geological Mapping conducted in the south-east of Marian Vale showing identified areas of hard and soft metasandstone as per the map key.

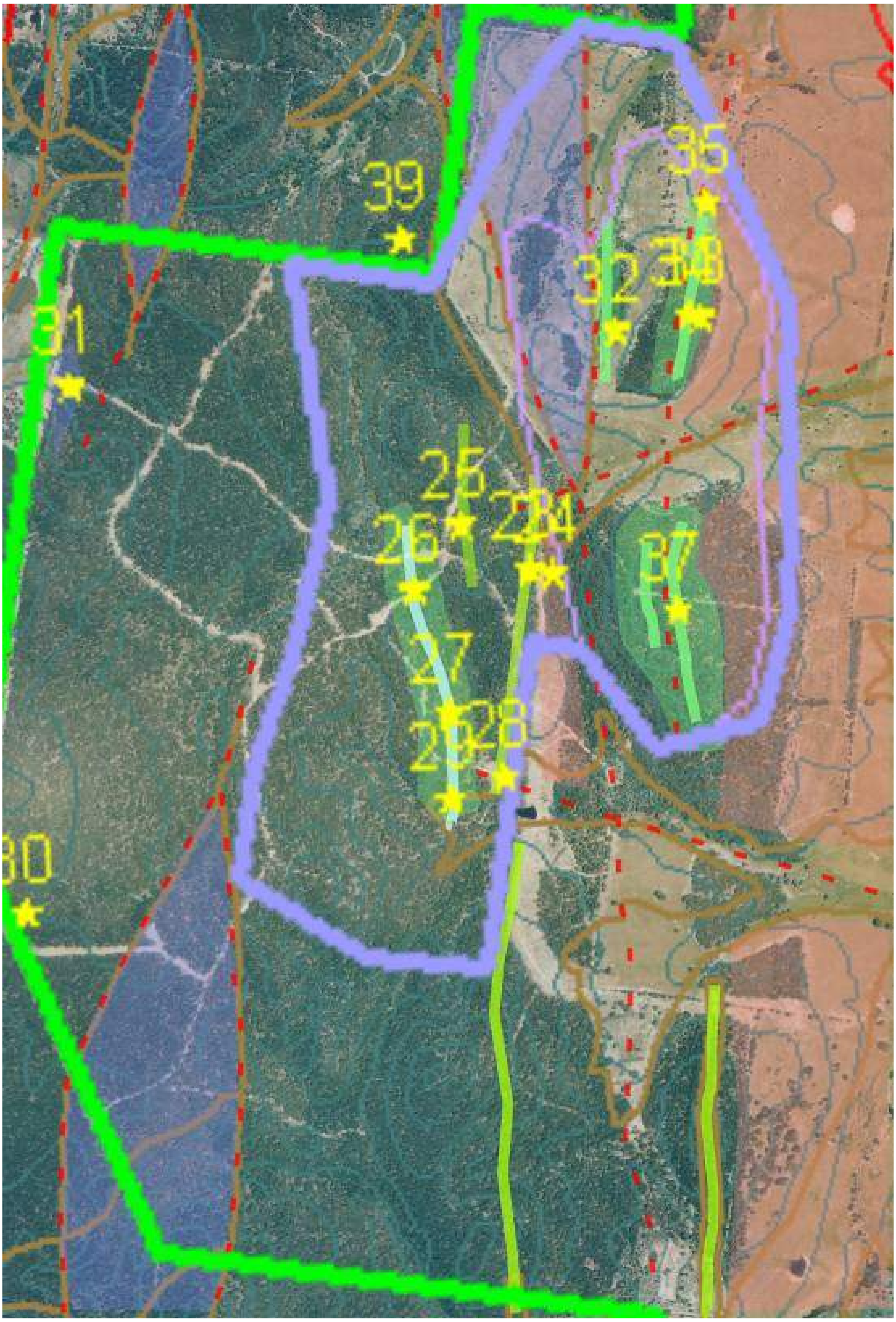


Figure 20 Geological Mapping conducted in the west of Marian Vale showing identified areas of hard and soft metasandstone and Warbisco shale as per the map key. Un-mapped areas simply lack surface evidence of lithology and are affected by extensive faulting which makes extrapolation unwieldy.

Magnetic traverses

A GEM GSM19T magnetometer was supplied by Hydroilex to conduct trial magnetic field surveying in the hope that it may show up lithology variation due to variation in ferrous mineral content between the hard more siliceous metasandstone and the softer sediments. Any such variation proved to be too subtle to observe over the central and east parts of Marian Vale. Fault and fracture zones seemed to be primary causes of small magnetic anomalies observed. Larger faults and anomalies occurred across western Marian Vale where there is a fault zone associated with the Towrang fault. The anomalies are numerous suggesting that fault and fracture zones that cross the area are so numerous that they are not possible to map thoroughly.

A traverse was also conducted across the basalt while the opportunity was available. Clearly the basalt has an anomaly as is evident on NSW Geological Survey aeromagnetic data. Extent of the basalt is probably easier to map using magnetics than by drilling. Strong magnetic field anomalies exist on the basalt edges and medium intensity anomalies also exist right across the basalt indicating lack of uniformity. This suggests that concentration of gabbro dykes across the basalt is not constant.

The magnetometer was suffering from frequent spiking and quality of data was therefore compromised. No base station was set up so diurnal variation could not be removed. Larger spikes have been removed from the data but smaller spikes remain. Better quality interpretation could be conducted if better quality data could be obtained.

Navigation was conducted by recording GPS co-ordinates of points along the traverses. The track was interpolated between these points.

The total magnetic field data is presented in the following graphs and locations of the traverses are plotted on relevant maps.

Magnetic anomalies in the NSW Geological Survey dataset also exist 3 km NE of the basalt and 2.5 km WSW of the basalt suggesting the presence of two other similar bodies. No exposure of the body to the WSW has been identified (possibly no one has looked for it). The body to the NE was assessed previously (known to Laterals Planning staff) and was considered to be unsuitable for uses as coarse aggregate. Although details have been lost it is suspected that this was because it is almost solely gabbro rather than basalt as marked on the geological map.

If exploitation of the Basalt is to be attempted then further magnetic surveying could be conducted to try to better identify gabbro distribution and the edges of the deposit.

A clear way of determining the distribution of any wide zones of weathering in the Basalt would be to conduct an electromagnetic survey over it. This would map areas where rock has deeply decomposed to soil and is therefore unsuitable for conversion to coarse aggregate. An electromagnetic survey would give information that is much less ambiguous than magnetic data. EM instruments can be configured to focus on various depths of interest. A DualEM 4 would focus on a 1.5 to 4.5 metre depth that could be verified at point locations using a backhoe.

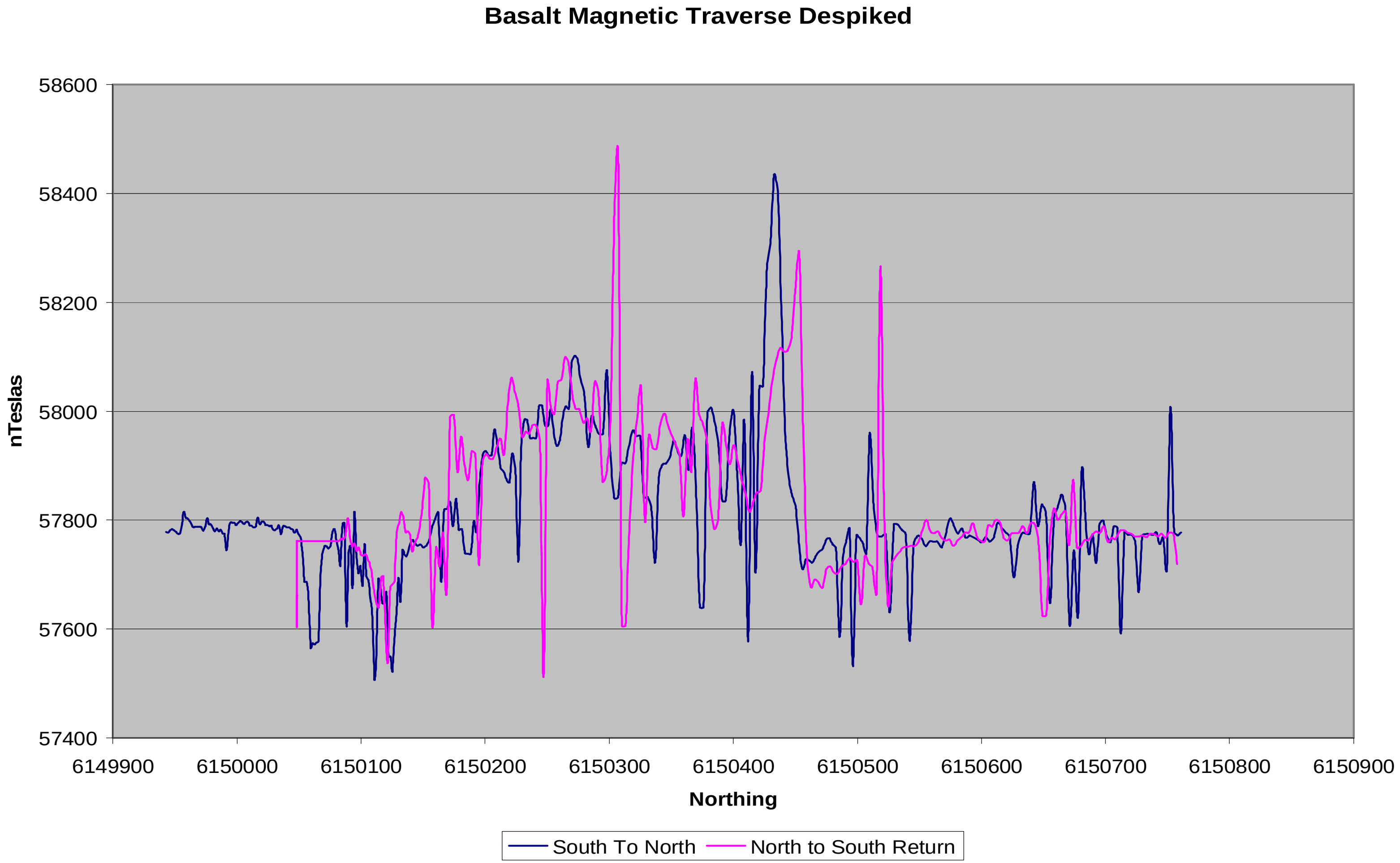


Figure 21 Results of two total magnetic field intensity traverses over the basalt at the north of Marian Vale. Only the track of the south to north traverse has been plotted on maps (following).

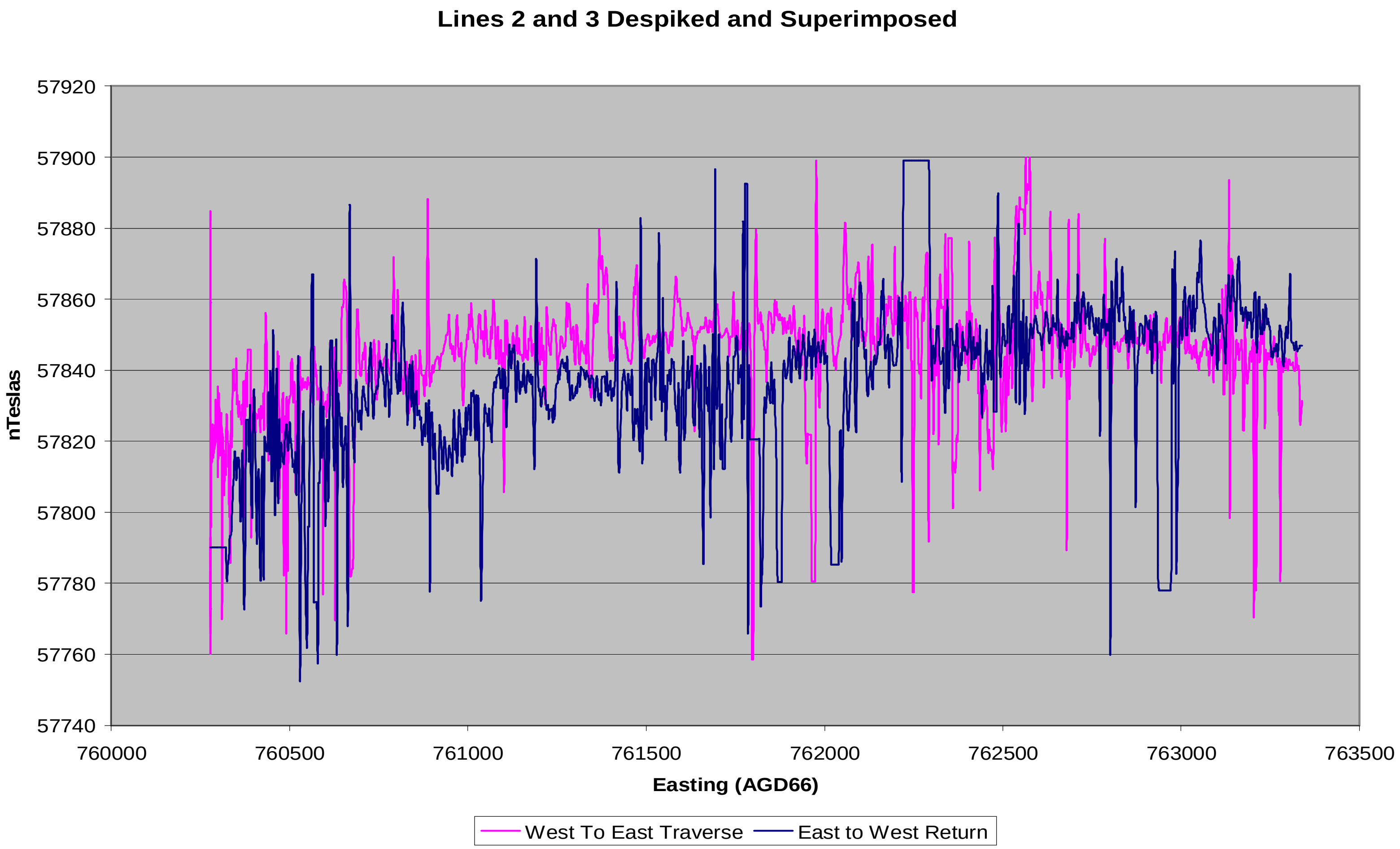


Figure 22 Results of two total magnetic field intensity traverses across Marian Vale. Look for anomalies that have some width. It is believed that they almost all relate to fault and fracture zones. Only the track of the west to east traverse has been plotted on maps (following).

A backhoe pit on the Tertiary Basalt

A backhoe pit was dug in the Tertiary Basalt at sample site 36. Geological Survey of NSW mapping has suggested that the rock is an alkali basalt flow, however, some weathered gabbro was found in the backhoe pit. The Gabbro may be of dykes that intruded the basalt after it was deposited suggesting that the basalt is at its source and overlies a basalt plug that could be quarried deeply. The top 500mm of the pit encountered topsoil and basalt floaters. The next 1.9 metres encountered basalt pillars, subsoil and weathered gabbro. It is suspected that the subsoil is primarily the remnants of gabbro dykes. The basalt pillars are made up of horizontally layered basalt boulders and are about 700mm in diameter. They showed little sign of weathering below 500mm from the surface. Photos of the pit are included.

Figure 23 Basalt pit - site 35. Notice the pile of rock on the left.

Figure 24 From 0 to 1metre deep in the basalt backhoe pit – site 36

Figure 25 From 1 to 2 metres deep in the backhoe pit showing the edge of one basalt pillar flanked by two basalt pillars that have been broken in half.

Figure 26. Basalt of a pillar half removed by the backhoe.

Conclusion

The Basalt partly on the northern part of the Marian Vale property extension under contract is potentially of great value as a source of coarse aggregate. Other sources of coarse aggregate on the property could only be mined with large stripping ratios as they exist only in near vertical bands typically less than 3m thick. The best concentrations of such bands are on the east side of Marian Vale. On the west side, fractured bands containing numerous quartz vienlets, chert bands and rock hardening caused by faulting all exist. Aggregate sources on the west side are likely to be complicated to mine and utilize.

Rock of the Adaminaby Group is potentially of good consistent quality for manufacturing sand and clay. The potential success of sand and clay manufacture on Marian Vale is likely to depend mostly on the amount of energy required to crush and sort soft metasandstone, siltstone and shale to the desired products. Most consistent rock is available in the central and eastern parts of Marian Vale. Drilling inclinded to the east could be used to verify the location of bands of different composition. Care should be taken if west Marian Vale sites are used as sources as numerous complicating geological features, already mentioned, exist there. A decision must be made on whether it is best to place quarries over hard metasandstone bands, so as to get a percentage of coarse aggregate, or over soft metasandstone and shale, so as to reduce crushing and separation costs. The possibility of separation of coarse aggregate from other components needs to be tested.

The consistent simple mineralogy of the Adaminaby Group sediments is likely to be advantageous for manufacture of sand and brickmaking clay. As the rock is made principally of quartz and sericite it absorbs little water and clay derived from it will not contract significantly when backed to form bricks or other ceramic products.

Testing of the Basalt sample obtained is recommended and, should the sample prove to be good for coarse aggregate production, further investigation and quarrying of the basalt. Further investigation could involve drilling, EM surveying and more backhoe pits located using the EM surveying. Presence of gabbro among the basalt is both good and bad news – good because it suggests that the Basalt is at its source and is likely to extend to great depth, and bad because the gabbro will need to be crushed and sieved out of the basalt before it is suitable for use as coarse aggregate.

References

Geochempet Services, 2005, Petrographic reports on three rock spalls samples (57429, 57430 and 57431).

Lee, J., 2005, Summary of Preliminary Results of 2005 Drilling Results and Aquifer Testing Programme 'Marian Vale' Tiyces Lane, Goulburn for Millerview Constructions Pty. Ltd.

Macrae, G., 2005, Goulburn Industrial Minerals and Rocks – draft version only. Mineral Resources of NSW – Orange office. (Note Greg is now working elsewhere and is contactable using gmacrae@aapt.net.au).

Mineral Resources of NSW, 2003, Goulburn Comprehensive 1:100000 Geological Map – Geoscience Database CD. Version 1, July 2003

Mineral Resources of NSW, 2003, Industrial Minerals Database, Version 2, May 2003.

Pienmunne, J.T., 2001. Supply and demand for coarse aggregate in the Sydney Planning Region. Geological Survey of New South Wales, Report GS2002/525 (unpublished).

Ward, C. and Zhongsheng, L., 2005, Mineralogy of Rock Samples for Hydroilex.

Appendix – Macrae's draft notes on the Goulburn Industrial Minerals and Rocks. NSW Geological Survey.

L. Pavement condition report regarding Tiyces Lane and pavement life reports incorporating:

a. Pavement Condition Report – R2009142.

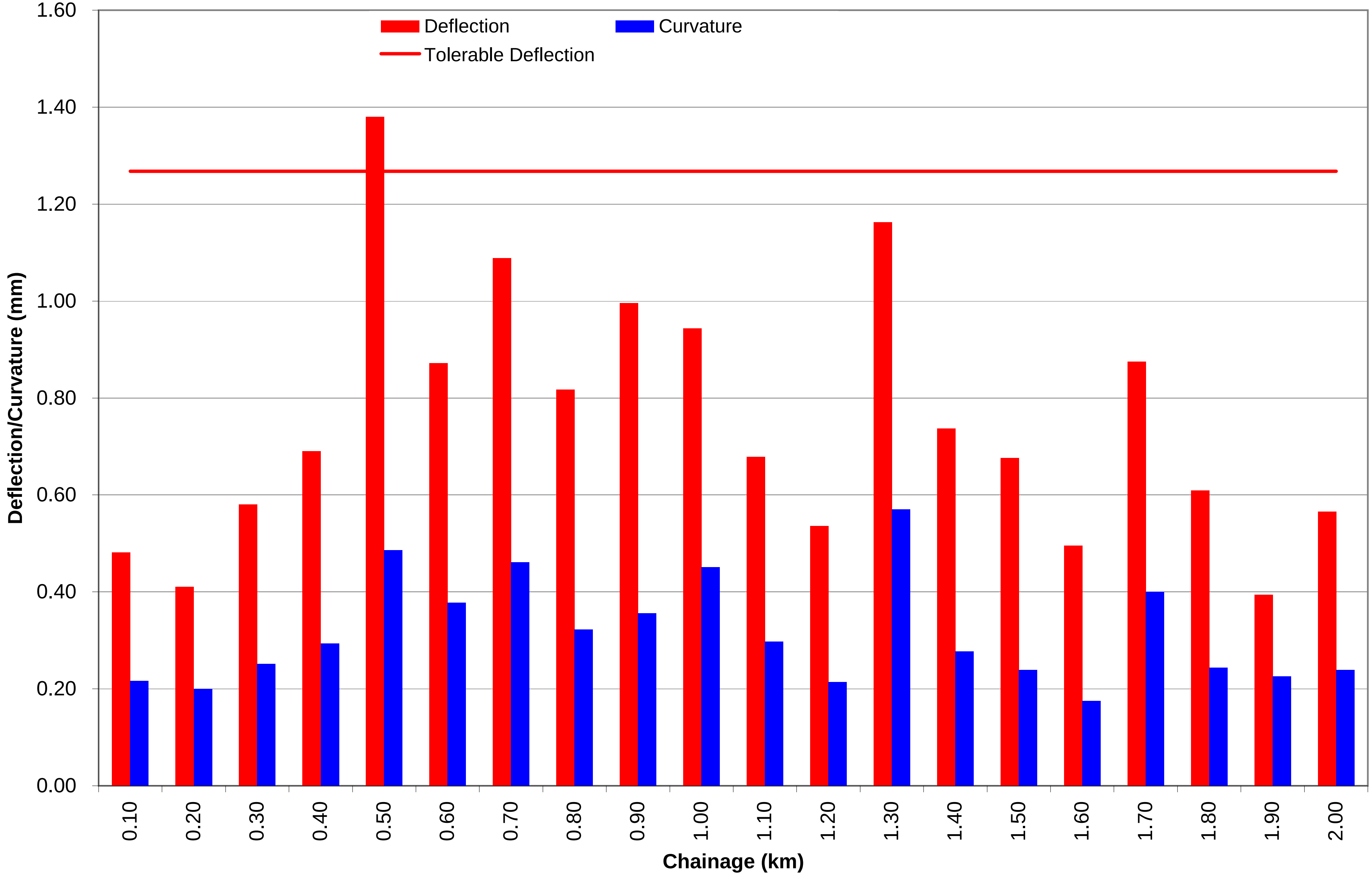
b. Pavement ODS2009142-1 Remaining Life 1.

c. Pavement ODS2009142-1 Remaining Life 2.

d. Pavement ODS2009142-1 Remaining Life 3.

e. Pavement ODS2009142-1 Remaining Life 4.

Tiyces Lane from the proposed quarry entrance to Hume Highway, Goulburn.



Pavement Management Services

ABN 64 002 245 329
Unit 7B/26 Powers Rd, Seven Hills, NSW 2147
Phone +61 2 9674 9488

Report No: ODS2009142-1
Test Method: PMS-TP4
Analysis Method: PMS-QP4-002
Job No: 2009142
Client: Marian Vale Pastoral Co.
Tested By: Jason Hawken
Testing Date: 30-Mar-09
Test Equipment: HWD 100

ESA's/Lane/Day: 31
Annual Growth Rate: 3%
Design Traffic Intensity (20 years): 3.08E+05 ESA
Tolerable Beam: 1.27 mm
Tolerable Curvature: 0.24 mm
WMAPT (Singleton): 22.3 °C
Overlay Design Material: Granular (Granular/Asphalt)
Report Date: 29-Apr-09

Empirical Overlay Design Report - Spray Seal Surfaced Unbound Pavement

Tiyces Lane from the proposed quarry entrance to Hume Highway, Goulburn.

Chainage (km)	Temp (℃)	Lane	Thickness (mm) Base	Thickness (mm) Subbase	Modulus (MPa) Base	Modulus (MPa) Subbase	Modulus (MPa) Subgrade	Temp Adjusted Beam Deflection	Temp Adjusted Curvature	Design Overlay (mm) Granular Overlay	Remaining Life Calc's. (Current Pavement) ESA's	Remaining Life Calc's. (Current Pavement) Years
0.10	30.7	2	220	200	771	166	196	0.48	0.22	0	6.5E+09	20
0.20	30.7	2	220	200	1131	98	262	0.41	0.20	0	3.1E+10	20
0.30	30.7	2	220	200	1046	22	442	0.58	0.25	0	1.0E+09	20
0.40	30.7	2	220	200	636	60	129	0.69	0.29	0	1.9E+08	20
0.50	30.7	2	220	200	256	130	43	1.38	0.49	28	2.1E+05	15
0.60	30.7	2	220	200	458	84	118	0.87	0.38	0	1.9E+07	20
0.70	30.9	2	220	200	329	92	87	1.09	0.46	0	2.2E+06	20
0.80	30.9	2	220	200	480	86	116	0.82	0.32	0	3.6E+07	20
0.90	31.1	2	220	200	509	40	159	1.00	0.36	0	5.2E+06	20
1.00	31.1	2	220	200	483	46	107	0.94	0.45	0	8.9E+06	20
1.10	31.1	2	200	200	638	154	62	0.68	0.30	0	2.2E+08	20
1.20	31.2	2	200	200	668	357	136	0.54	0.21	0	2.3E+09	20
1.30	31.2	2	200	200	290	84	68	1.16	0.57	0	1.2E+06	20
1.40	31.2	2	200	200	470	234	73	0.74	0.28	0	1.0E+08	20
1.50	31.3	2	200	200	688	204	81	0.68	0.24	0	2.3E+08	20
1.60	31.3	2	200	200	881	402	127	0.50	0.18	0	4.9E+09	20
1.70	31.3	2	200	200	377	117	110	0.88	0.40	0	1.9E+07	20
1.80	31.3	2	200	200	542	433	77	0.61	0.24	0	6.4E+08	20
1.90	31.4	2	200	200	1058	189	580	0.39	0.23	0	4.6E+10	20
2.00	31.4	2	200	200	681	140	156	0.57	0.24	0	1.3E+09	20
MEAN					**620**	**157**	**156**	**0.75**	**0.32**			
STANDARD DEVIATION					**248**	**115**	**130**	**0.26**	**0.11**			
CHARACTERISTIC NUMBERS					**325**	**45**	**67**	**1.10**	**0.46**	**0**	**2.1E+06**	**20**

NOTE:

1. Characteristic Numbers are based on a 90th percentile confidence level
2. Lane 2 is in the counter direction with all chainage values increasing in the prescribed direction and assumes trucks in loaded state
3. Base comprises of spray seal and 200 mm gravel layer and subbase assumes 200 mm of existing gravel layer
4. Calculations are based on empirical methods and should only be used to provide an indication of structural capacity or as seed values in a mechanistic design procedure
5. The overlay requirements indicate the thickness of additional material required to overcome any structural deficiencies of the pavement based on the pavement consisting of a spray seal wearing course and being subject to only permanent deformation as the primary modes of pavement failure.
6. The remaining life calculations are based on the above assumptions and considering only the beam deflection

Prepared By ....
Diana (Senior Project Engineer)

Pavement Management Services

ABN 64 002 245 329
Unit 7B/26 Powers Rd, Seven Hills, NSW 2147
Phone +61 2 9674 9488

Report No:	ODS2009142-1	**ESA's/Lane/Day:**	2	
Test Method:	PMS-TP4	**Annual Growth Rate:**	3%	
Analysis Method:	PMS-QP4-002	**Design Traffic Intensity (20 years):**	2.33E+04	ESA
Job No:	2009142	**Tolerable Beam:**	1.65	mm
Client:	Marian Vale Pastoral Co.	**Tolerable Curvature:**	0.41	mm
Tested By:	Jason Hawken	**WMAPT (Singleton):**	22.3	°C
Testing Date:	30-Mar-09	**Overlay Design Material:**	Granular	(Granular/Asphalt)
Test Equipment:	HWD 100	**Report Date:**	29-Apr-09	

Empirical Overlay Design Report - Spray Seal Surfaced Unbound Pavement

Tiyces Lane from Hume Highway to the proposed quarry entrance, Goulburn.

			Thickness (mm)		Modulus (MPa)			Temp Adjusted		Design Overlay (mm)	Remaining Life Calc's.	
Chainage (km)	**Temp (°C)**	**Lane**	**Base**	**Subbase**	**Base**	**Subbase**	**Subgrade**	**Beam Deflection**	**Curvature**	**Granular Overlay**	**(Current Pavement) ESA's**	**Years**
0.05	28.3	1	220	200	692	83	170	0.63	0.27	0	4.9E+08	20
0.15	28.6	1	220	200	2193	24	878	0.36	0.17	0	1.0E+11	20
0.25	28.9	1	220	200	911	72	214	0.49	0.22	0	5.2E+09	20
0.35	29.1	1	220	200	780	120	72	0.66	0.19	0	3.2E+08	20
0.45	29.3	1	220	200	139	62	37	2.10	1.10	99	3.5E+03	4
0.55	29.4	1	220	200	454	322	73	0.62	0.32	0	5.1E+08	20
0.65	29.3	1	220	200	538	44	166	0.93	0.36	0	1.1E+07	20
0.75	29.5	1	220	200	525	194	82	0.76	0.28	0	7.9E+07	20
0.85	29.5	1	220	200	383	518	57	0.75	0.29	0	8.7E+07	20
0.95	29.5	1	220	200	633	175	143	0.63	0.26	0	4.5E+08	20
1.05	29.6	1	200	200	317	202	67	0.97	0.48	0	7.0E+06	20
1.15	29.6	1	200	200	445	211	101	0.78	0.34	0	6.1E+07	20
1.25	29.6	1	200	200	454	94	77	0.96	0.36	0	7.8E+06	20
1.35	29.6	1	200	200	597	281	96	0.67	0.25	0	2.5E+08	20
1.45	29.6	1	200	200	734	98	133	0.70	0.20	0	1.7E+08	20
1.55	29.5	1	200	200	992	227	244	0.43	0.20	0	2.1E+10	20
1.65	29.6	1	200	200	615	360	90	0.59	0.20	0	8.4E+08	20
1.75	29.8	1	200	200	919	225	244	0.42	0.20	0	2.6E+10	20
1.85	30.7	1	200	200	7522	2	4602	0.35	0.19	0	1.7E+11	20
1.95	30.8	1	200	200	281	362	35	0.96	0.44	0	7.7E+06	20
2.05	31.0	1	200	200	753	78	306	0.62	0.26	0	5.3E+08	20
MEAN					**994**	**179**	**376**	**0.73**	**0.31**			
STANDARD DEVIATION					**1514**	**130**	**961**	**0.36**	**0.19**			
CHARACTERISTIC NUMBERS					**317**	**44**	**57**	**0.96**	**0.44**	**0**	**7.7E+06**	**20**

NOTE:
1. Characteristic Numbers are based on a 90th percentile confidence level
2. Lane 1 is in the prescribed direction and the unloaded lane
3. Base comprises of spray seal and 200 mm gravel layer and subbase assumes 200 mm of existing gravel layer
4. Calculations are based on empirical methods and should only be used to provide an indication of structural capacity or as seed values in a mechanistic design procedure
5. The overlay requirements indicate the thickness of additional material required to overcome any structural deficiencies of the pavement based on the pavement consisting of a spray seal wearing course and being subject to only permanent deformation as the primary modes of pavement failure.
6. The remaining life calculations are based on the above assumptions and considering only the beam deflection

Prepared By ....
Diana (Senior Project Engineer)

MARIAN VALE PASTORAL COMPANY PTY LTD

PAVEMENT CONDITION REPORT: TIYCES LANE, HUME HIGHWAY TO PROPOSED QUARRY ENTRANCE – 2009

REPORT NO. R2009142-1

VER	REV	REVISION DESCRIPTION	VER. DATE	PREPARED BY	REVIEWED BY
1	0	First draft for client review	28 April 09	D.Scruby	J. Erskine

Winner	Winner	Winner	Finalist	Winner	Winner	Featured in
Gold Award Specialist Services	New or Improved Technique	NSW Eng Excellence Awards	National Eng. Excellence Awards	Most Innovative Product	Export award	Australian Technology Show Case

EXECUTIVE SUMMARY

Fugro PMS was commissioned by Marian Vale Pastoral Pty Ltd to conduct a pavement condition survey of Tiyces Lane, Goulburn between Hume Highway to the proposed quarry entrance. Length of pavement to be surveyed was approximately 2 km in length. Structural testing using a Falling Weight Deflectometer was conducted on 30th March 2009 in the outer wheel path at 100 m intervals in order to determine the current structural capacity of the pavement.

Based on the traffic data provided a total 20 yr design traffic volume of $2.33x10^4$ ESA's was derived for the unloaded lane 1 and $3.08x10^5$ ESA's for the loaded lane 2 and has been considered to remain constant for the entire project section. The results of the remaining life assessment indicate that Tiyces Lane overall has sufficient structural capacity to carry the design traffic volumes based on pure empirical methods. From the analysis one area of concern was observed in Lane 1 at 0.450 km from the Hume Highway and a slight deficiency in Lane 2 at 0.500 km from the Hume Highway.

The results of the structural testing indicate that the base material is of a variable quality ranging from fair to good quality with an overall characteristic modulus of 317 MPa in the prescribed direction and 325 MPa in the counter direction. The subbase material was found to be of an average to very poor quality and again highly variable throughout the project section but typically very poor quality. The characteristic modulus was found to be 44 MPa and 45 MPa respectively for the unloaded and loaded lanes. The high variability observed in the subbase modulus values may be attributed to possible differences between the assumed subbase thickness of 200 mm and the actual thicknesses, which are unknown. The subgrade material is of variable quality ranging from poor to fair quality but typically fair with an overall characteristic modulus in the prescribed and counter lanes of 57 MPa and 67 MPa respectively.

At present the stiffness of the base material supports the remaining life results, which suggest that there is sufficient capacity in the pavement to carry the design traffic volumes. Whilst the stiffness of the pavement is variable this variability does not impact the empirical remaining life results presented as the analysis uses the deflection (beam) values only, which are independent of the pavement thickness.

Table of Contents

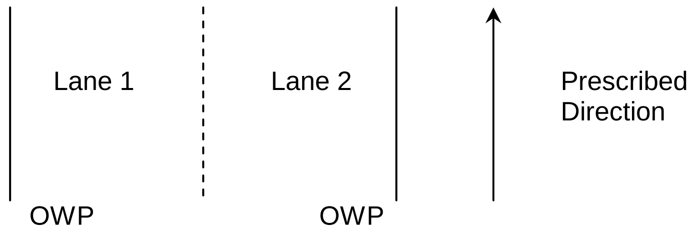
PAGE

1 INTRODUCTION

1.1 Introduction and Background

Fugro PMS was commissioned by Marian Vale Pastoral Pty Ltd to conduct a pavement condition survey of Tiyces Lane, Goulburn between Hume Highway to the proposed quarry entrance. Length of pavement to be surveyed was approximately 2 km in length (4 lane km). Lane 1 was considered to be from Hume Highway to the quarry entrance. Lane 2 was considered to be in the counter direction to Lane 1 as illustrated in Figure 1-1 following.

Figure 1-1: Lane Naming Convention



1.2 Objective

The objective of this condition report is to determine the structural adequacy of the pavement from a Falling Weight Deflectometer (FWD) survey with regards to the proposed quarry and the increase in trafficking.

1.3 Scope of Work

The scope of work covered:

- Structural condition survey for the assessment of structural capacity of the pavement.
- Determine pavement condition

1.4 Referenced Documents

1. ASTM D4604 “Standard Test Method for Deflection with a Falling – Weight – Type Impulse Load Devices” American Society fro Testing Materials, Conshohocken, PA, 2002.
2. PMS-TP4-FWD “Falling Weight Deflectometer (FWD) Test Procedure” Fugro PMS, Sydney, 2000.
3. PMS-QP4-002 “Flexible Pavement Design Procedure” Fugro PMS, Sydney
4. Austroads Pavement Design “A guide to the Structural Design of Road Pavements” Kelvin Press, Manly Vale NSW, 1992.

2 METHOD AND ASSUMPTIONS

2.1 Location Details

Testing was performed along Tiyces Lane between the Hume Highway and the proposed quarry entrance. Table 2-1 following, summarises the details used for this project and Figure 2-1 following, is a map of the sites.

Table 2-1: Section Locations

Section	Identifier	Lane	Start Location	End Location	Length (m)
Tiyces Lane	000001A1	Prescribed (Lane 1)	Hume Highway	Proposed Quarry Entrance	2000
	000001A2	Counter (Lane 2)	Proposed Quarry Entrance	Hume Highway	2000

Figure 2-1: Site Location

2.2 Test Methods

2.2.1 FWD Testing

The FWD testing was conducted on 30th March 2009 in accordance with ASTM D4606 [1] and PMS-TP4-FWD [2]. The FWD testing measured the pavement condition in the outer wheel path at 100 m intervals with an offset of 50 m between both trafficable lanes. At each test point a target load of 700 MPa was applied and peak defections were recorded from 9 geophones, with spacing ranging from 0 m (under the centre of the load) to a distance of 1.5 m from the load.

2.3 Remaining life Assessment

2.3.1 Back-Calculations and Forward Calculations

Based on the results of the FWD testing and pavement thickness, the existing pavement layer modulus values were back-calculated using the ELMOD computer program and the radius of curvature method. The back-calculation was completed in accordance with the procedure stated in PMS-QP4-002 [3], with the following assumption used:

- Base layers comprise a 2 coat spray seal wearing course and unbound granular material with a total depth of 220 mm from zero chainage to approx. 1.00 km
- Base layers comprise an unbound granular material with a total depth of 200 mm from 1.00 km to 2.05 km
- Sub-base layer comprises of the existing gravel layer thickness with a total depth of 200 mm
- There was an infinite depth to bed rock

Once the existing pavement layer modulus values were determined from back calculations, the equivalent beam and curvature readings were determined from the FWD testing, based on the regression equation § 4.3 of PMS-QP4-002 [3].

2.3.2 Deflection Based Approach

The structural life of the pavement was assessed by means of the deflection based approach, still commonly used in Australia. The approach used for the determination of the structural life was based on the deflection measurements in terms of beam only, with the beam results being related to structural life in accordance with § 10 of the Austroads Design Guide [4].

Deflection measurements in terms of curvature were not included due to the pavement being an unbound granular pavement with and unsealed or thin spray sealed surface and subject to permanent deformation only as the primary mode of failure.

3 PAVEMENT CONDITION RESULTS

3.1 Structural Assessment

3.1.1 Design Traffic

Traffic count data were provided by the Laterals, estimating 14 truck movements per day, each with a capacity of 37 tonnes once the quarry has opened. Current traffic counts have not been supplied, though it is believed that there are currently zero truck movements per day.

This report has assumed a five axle articulated vehicle with axle loads as presented in Figure 3-1, to be representative of the proposed quarry trucks.

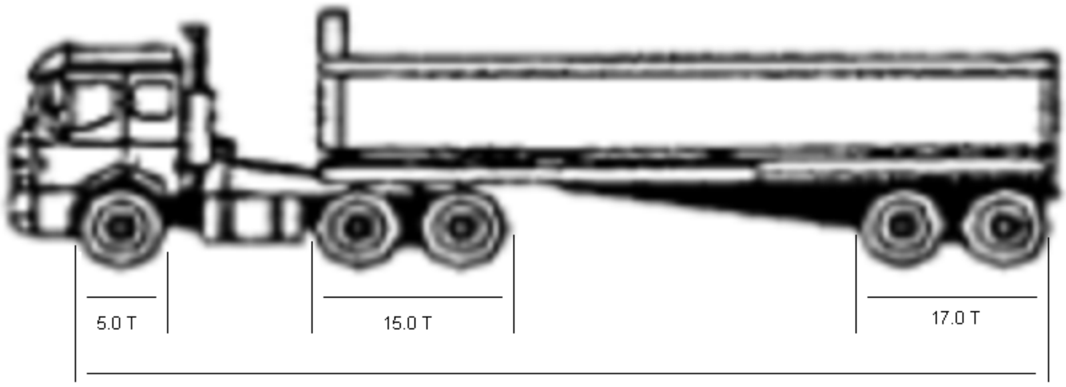


Figure 3-1 Axle Configuration and Loading

As the loading on each axle group is in excess of the equivalent standard axle group load presented in Table following the equivalent ESA's / axle group based on the fourth power law has been used in the traffic calculation.

Table 3-1 Axle Group Loads

Axle Group	Equivalent Standard Axle Group Load (kN)	Axle Group Load (kN)		ESA's / Axle Group	
		Loaded	Unloaded	Loaded	Unloaded
Single axle with single tyres (SAST)	53	49	40	0.73	0.32
Tandem Axle with dual tyres (TADT)	135	147	40	1.41	0.01
Tandem Axle with dual tyres (TADT)	135	167	40	2.34	0.01
Total				4.48	0.34

From this data a total 20 yr design traffic volume of 2.33×10^4 ESA's was derived for the unloaded lane 1 and 3.08×10^5 ESA's for the loaded lane 2 and has been considered to remain constant for the entire project section.

3.1.2 FWD Test Results

The results of the structural testing indicate that the base material in both directions is of a fair to good quality with an overall characteristic modulus of 317 MPa in the prescribed direction and 325 MPa in the counter direction. It should also be noted that the base modulus varies substantially in both the prescribed and counter direction.

The subbase material is of an average to very poor quality and highly variable throughout the project section but typically very poor quality. The characteristic modulus based on a 90^{th} percentile level of confidence is 44 MPa and 45 MPa respectively in the unloaded (Lane 1) and loaded (Lane 2) directions. The high variability observed in the subbase modulus values may be attributed to difference between assumption of the subbase layer comprising 200 mm of existing gravel and actual thicknesses which are unknown. As this analysis is based on empirical methods and the modulus results aren't used in the analysis but rather are provided for additional supporting / reference purposes such discrepancies will not affect the interpretation of the final results. The sub grade material is of poor to fair quality and highly variable but typically fair with an overall characteristic modulus in the prescribed and counter lanes of 57 MPa and 67 MPa respectively.

At present the stiffness of the base material suggests that there is sufficient capacity in the pavement to carry the design traffic volumes, though there is one area of concern between 0.450 km and 0.500 km in both lanes with Lane 1 exhibiting the greatest deficiency.

The FWD testing results can be found in Appendix A. Results have been presented with the chainage values increasing from Hume Highway to the proposed quarry entrance.

3.2 Remaining Life Assessment

The results of the remaining life assessment indicate that Tiyces Lane overall has sufficient structural capacity to carry the design traffic volumes based on pure empirical methods. Though (as previously stated) there is one area of concern in Lane 1 at 0.450 km from the Hume Highway and a slight deficiency in Lane 2 at 0.500 km from the Hume Highway. Whilst there is a high degree of variability in the modulus results of the base, subbase and subgrade, this variability does not impact the remaining life results as these use the deflection (beam) values only which are independent of thickness.

The empirical remaining life calculations sheets can be found in Appendix A.

4 CONCLUSIONS

Based on the traffic data provided a total 20 yr design traffic volume of 2.33×10^4 ESA's was derived for the unloaded lane 1 and 3.08×10^5 ESA's for the loaded lane 2 and has been considered to remain constant for the entire project section. The results of the remaining life assessment indicate that Tiyces Lane overall has sufficient structural capacity to carry the design traffic volumes based on pure empirical methods. From the analysis one area of concern was observed in Lane 1 at 0.450 km from the Hume Highway and a slight deficiency in Lane 2 at 0.500 km from the Hume Highway.

The results of the structural testing indicate that the base material is of a variable quality ranging from fair to good quality with an overall characteristic modulus of 317 MPa in the prescribed direction and 325 MPa in the counter direction. The subbase material was found to be of an average to very poor quality and again highly variable throughout the project section but typically very poor quality. The characteristic modulus was found to be 44 MPa and 45 MPa respectively for the unloaded and loaded lanes. The high variability observed in the subbase modulus values may be attributed to possible differences between the assumed subbase thickness of 200 mm and the actual thicknesses, which are unknown. The subgrade material is of variable quality ranging from poor to fair quality but typically fair with an overall characteristic modulus in the prescribed and counter lanes of 57 MPa and 67 MPa respectively.

At present the stiffness of the base material supports the remaining life results, which suggest that there is sufficient capacity in the pavement to carry the design traffic volumes. Whilst the stiffness of the pavement is variable this variability does not impact the empirical remaining life results presented as the analysis uses the deflection (beam) values only, which are independent of the pavement thickness.

5 APPENDIX A – STRUCTURAL TEST RESULTS

N. Air Assessments by Benbow Environmental incorporating:
a. Quantitative Air Assessment October 2009.
b. Revised Air Assessment May 2016.
c. Air Quality Monitoring Report May 2016.

AIR ASSESSMENT REPORT –
AMENDED QUANTITATIVE AIR ASSESSMENT
FOR MARIAN VALE PASTORAL CO PTY LTD
63 TIYCES LANE, TOWRANG, NSW

Prepared for: Peter Miller, Director of Marian Vale Pastoral Co Pty Ltd
Goulburn Council

Prepared by: R T Benbow, Principal Consultant
BENBOW ENVIRONMENTAL

Report No: 161048_Air_Rev1
May 2016
(Released: 9 May 2016)

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SUMMARY

The quantitative air assessment prepared in October 2009 has been updated to show the changes in the predicted levels of particulates and dust from a proposed change in the access roadway.

The remainder of the original report has not been altered and the findings are based on the original air dispersion modelling.

The 2009 site plan showed the access road according to Figure 1 Site Plan – Aerial Photograph, shown over page (for reference this is Figure 2-2 from the 2009 report).

The nearest receptor to the original access road was Residence R1 as shown on Figure 2 Site Location (for reference this is Figure 2-5 Site Location from the 2009 Report). Residence R1 is immediately adjacent to the original as proposed access road.

The other residences, R11 and R12, are also adjacent to the original access road.

The contribution of the use of the roadway to the predicted particulate and dust levels was considered as an unpaved road surface.

The contribution from the roadway was included in the modelling and at the receptors nearest the roadway, compliance with the particulates PM_{10} and TSP were well below the criteria.

A similar finding exists for dust deposition. The proposed change in the location of the access road is shown on Figure 3.

Figure 1: Site Plan – Aerial Photograph

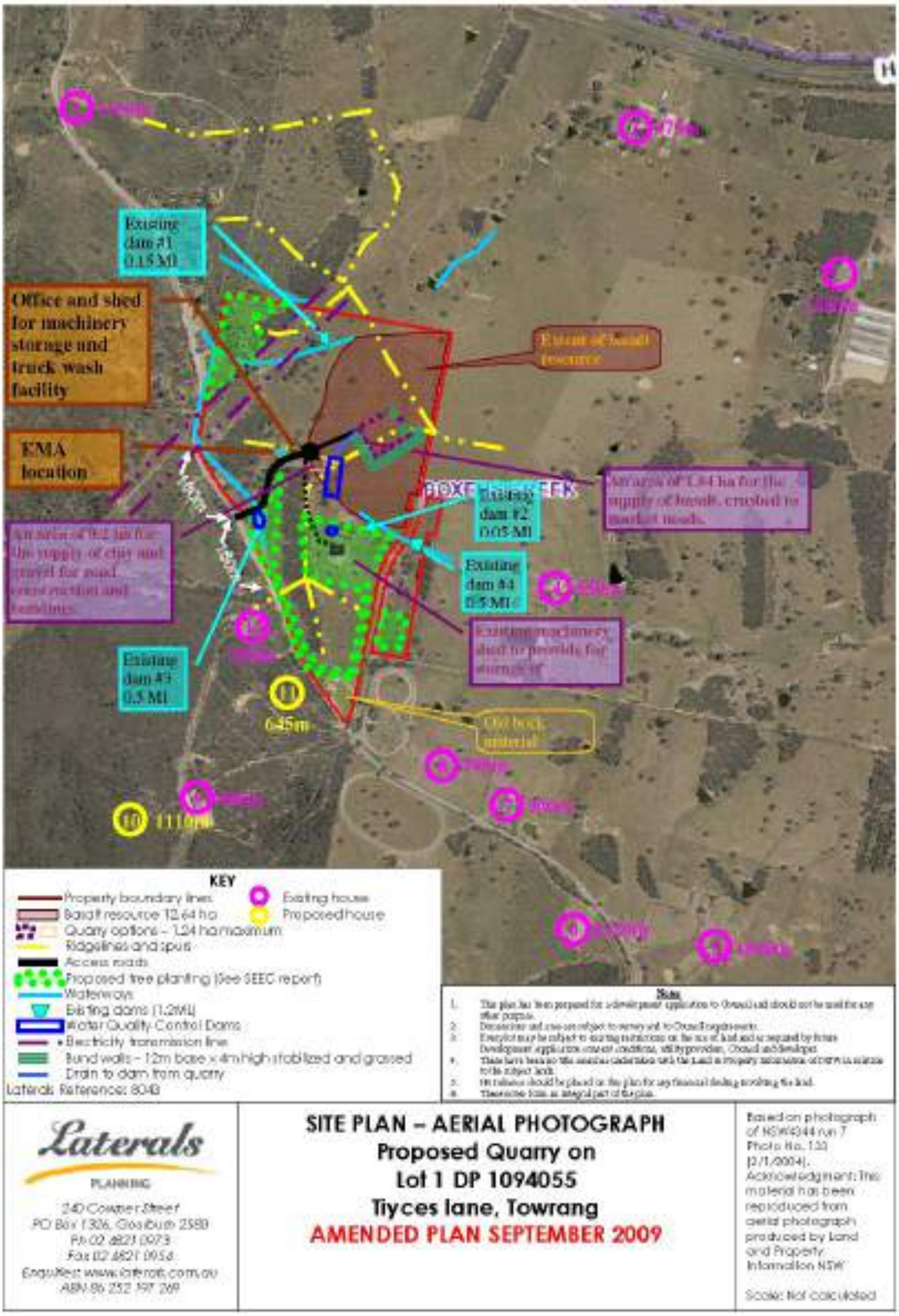
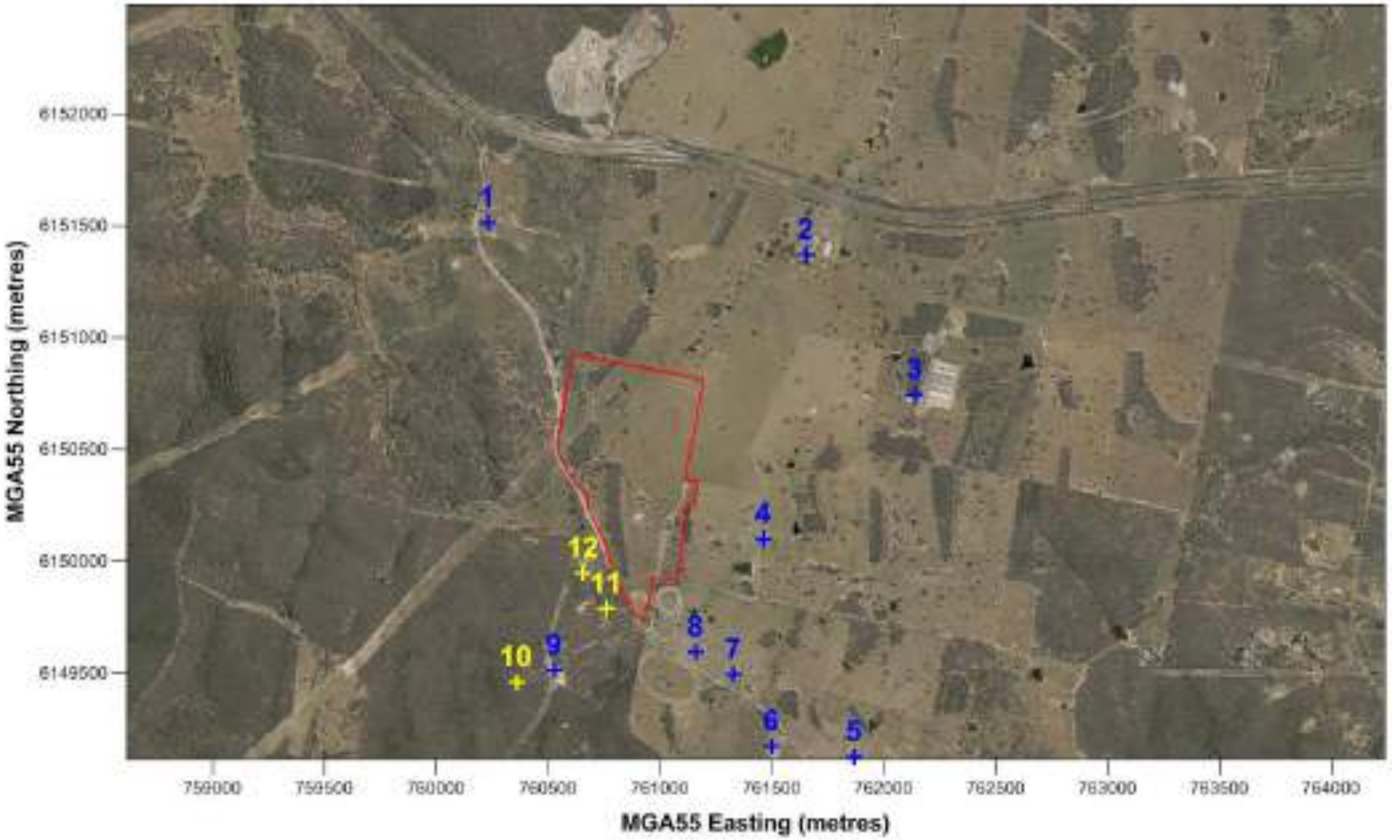
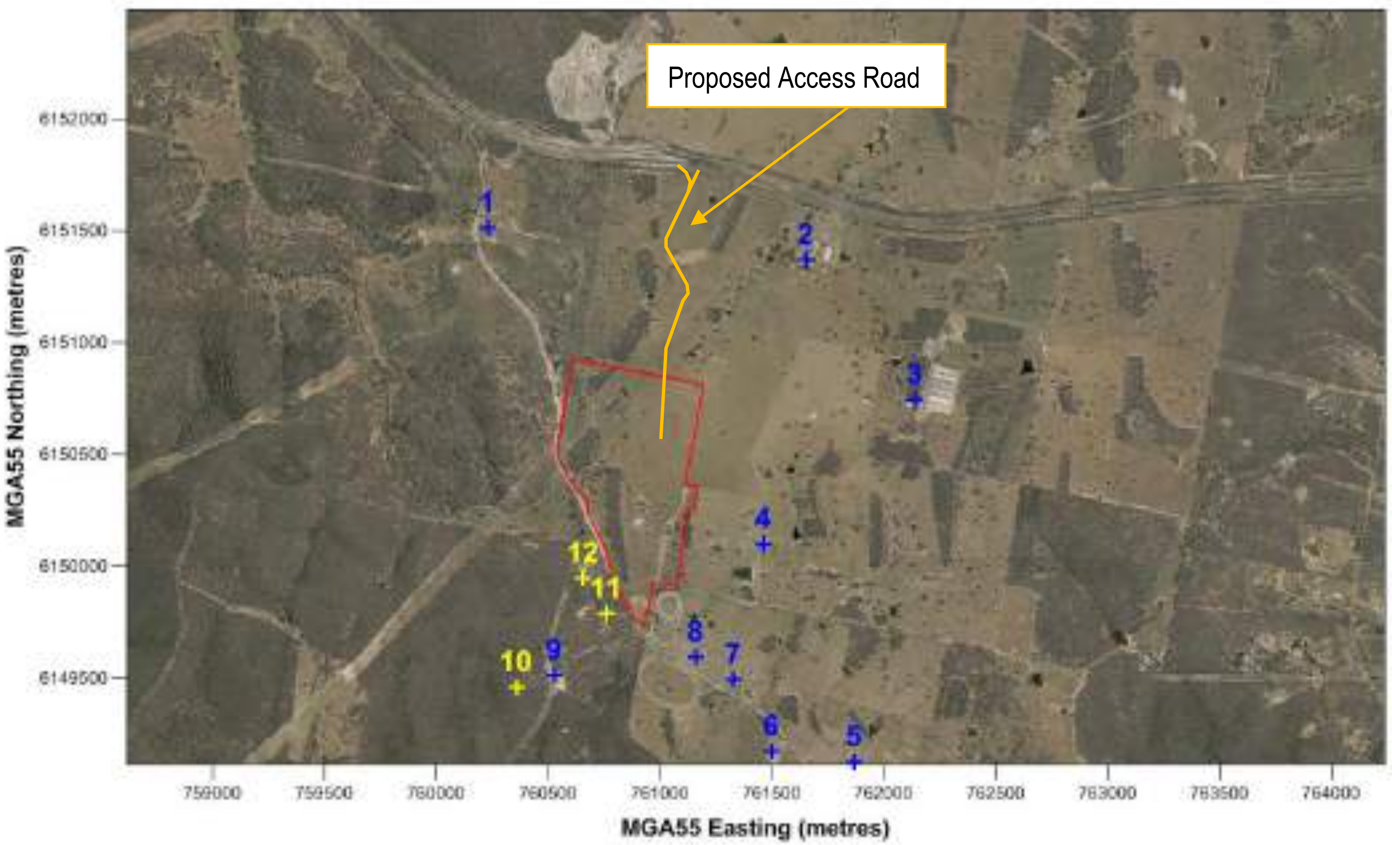


Figure 2: Site Location



Legend:	**Source:** © Department of Lands
Subject Site Boundary Receptors – Existing Residences Receptors – Proposed Residences	

Figure 3: Proposed Location of Access Road



Legend: Subject Site Boundary Receptors – Existing Residences Receptors – Proposed Residences	**Source:** © Department of Lands

The new access road is well distant from Receivers 1 and 2. Although the predicted level of particulate and dust complied with the criteria, the relocation of the road is an improvement that is strongly supported.

The relocation of the access road would not remove the need for reasonable control of roadway generated dust.

The usual controls adopted by quarries are the following:

- Speed restriction to 40 km/hr;
- Maintain road surface in good condition; and
- Use suitable roadbase and routinely maintain the aggregate content of the roadbase.

The predicted levels of particulates and dust would not increase at any of the receivers from the relocation of the access road and this change to the proposed quarry is strongly supported.

R T Benbow
Principal Consultant

QUANTITATIVE AIR ASSESSMENT
FOR MARIAN VALE PASTORAL CO PTY LTD
63 TIYCES LANE, TOWRANG, NSW

Prepared for: Peter Miller, Director of Marian Vale Pastoral Co Pty Ltd
Goulburn Council

Prepared by: Duke Ismael, Environmental Engineer
Filbert Hidayat, Environmental Engineer
R T Benbow, Principal Consultant
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Report No: 109099_Air_Final_Rep
October 2009
(Released: 2 October 2009)

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TABLES PAGE

FIGURES PAGE

ATTACHMENTS

1. INTRODUCTION

Benbow Environmental (BE) was commissioned by Laterals Planning on behalf of Figtree Reserve Pty Ltd to prepare a quantitative air assessment for the proposed quarry in 63 Tiyces Lane, Towrang NSW.

The proposed development includes the construction of an office, machinery storage shed, operation of an extractive area, access road, and on-going rehabilitative and site screening involving tree planting. The subject site will be used to perform an open pit excavation of material, where it would be transported off-site as per demand. The extracted material would be crushed and screened to provide a range of materials for use in construction.

This report presents a brief description of the existing site and its operations, the surrounding environment, the proposed development, and a quantitative assessment of potential dust impacts of the proposed development. The assessment has been carried out in accordance with the requirements listed in the document, "Approved Methods for the Modelling and Assessment of Air Pollutants in NSW" published by the Department of Environment and Climate Change NSW (DECC NSW 2005).

1.1 SCOPE OF ASSESSMENT

The scope of this assessment includes the following:

- Review of the proposed development's operations and activities;
- Identification of potential dust impacts associated with the construction and operational phases of the proposed development;
- Predict ground level concentration dust impacts from the proposed development at the nearest potentially affected receptors using air dispersion modelling;
- Assessment of potential dust impacts against relevant legislation and guidelines; and
- Provide a statement of potential air quality impacts, as well as recommendations if necessary.

2. SITE DESCRIPTION

2.1 SITE DESCRIPTION AND LOCALITY

The subject site is located in a rural setting about 1 km south of the Hume Highway at Tiyces Lane, Towrang NSW, in the Southern Highlands. The resource covers an area of approximately 12.64 ha on a 44 ha site. The population of Towrang has just exceeded 400 people, where 90% of the population lived in the northern direction from the site, divided by Hume Highway. The site is predominantly surrounded by undeveloped land. A few rural residences exist within the vicinity of the site.

The road that veers from the Hume Highway leading to the start of Tiyces Lane is partly gravelled. Access from the site is from Tiyces Lane which is being sealed up to the entry point of the site.

Figure 2-1 and Figure 2-2 provides the topographical and aerial site plan (respectively) outlining the details of the proposed quarry. The proposal is to develop a basalt quarry (area coverage of 1.13 ha) and a gravel quarry (area coverage of 0.21 ha).

Figure 2-1: Topographical Site Plan

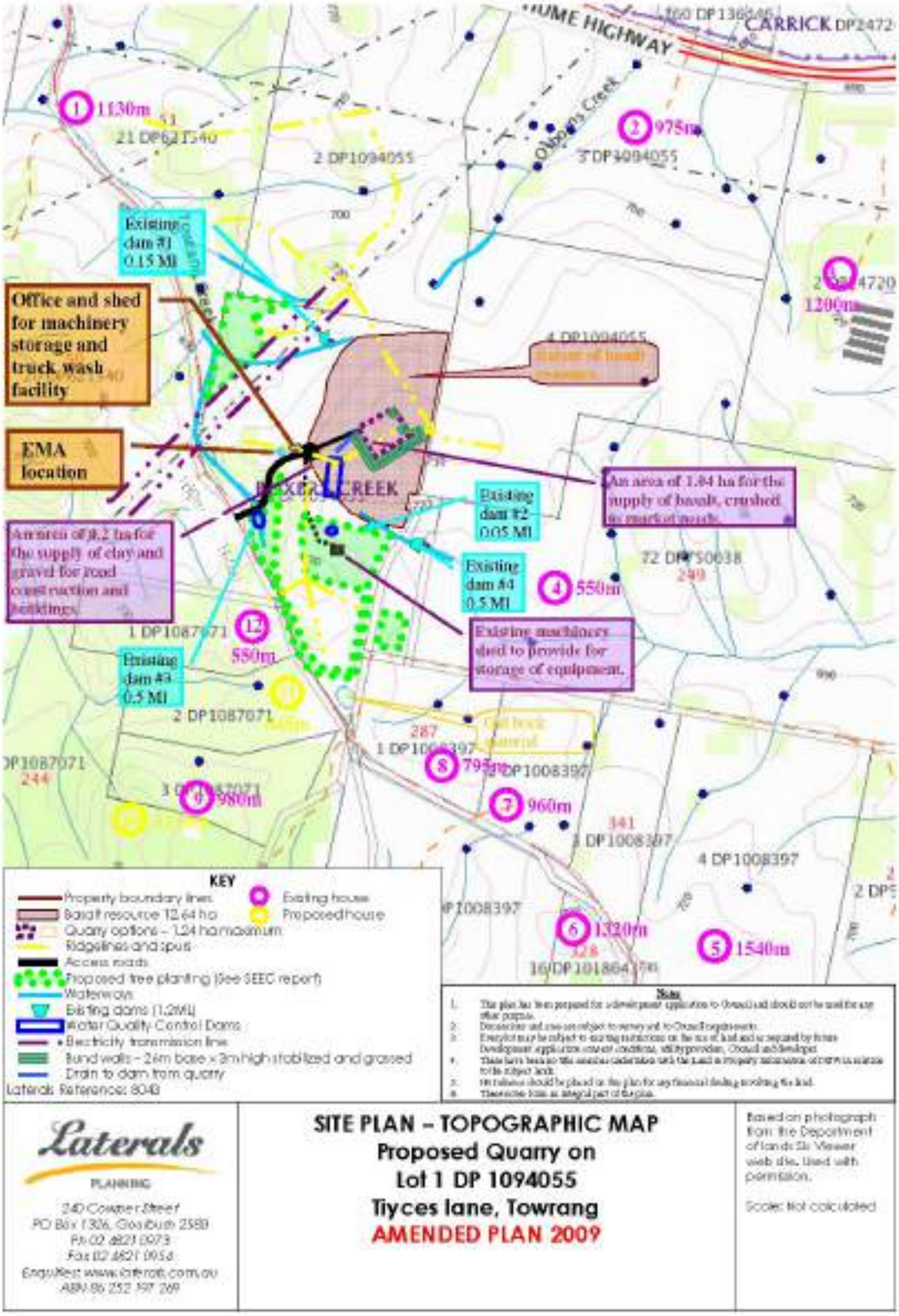


Figure 2-2: Site Plan - Aerial Photograph

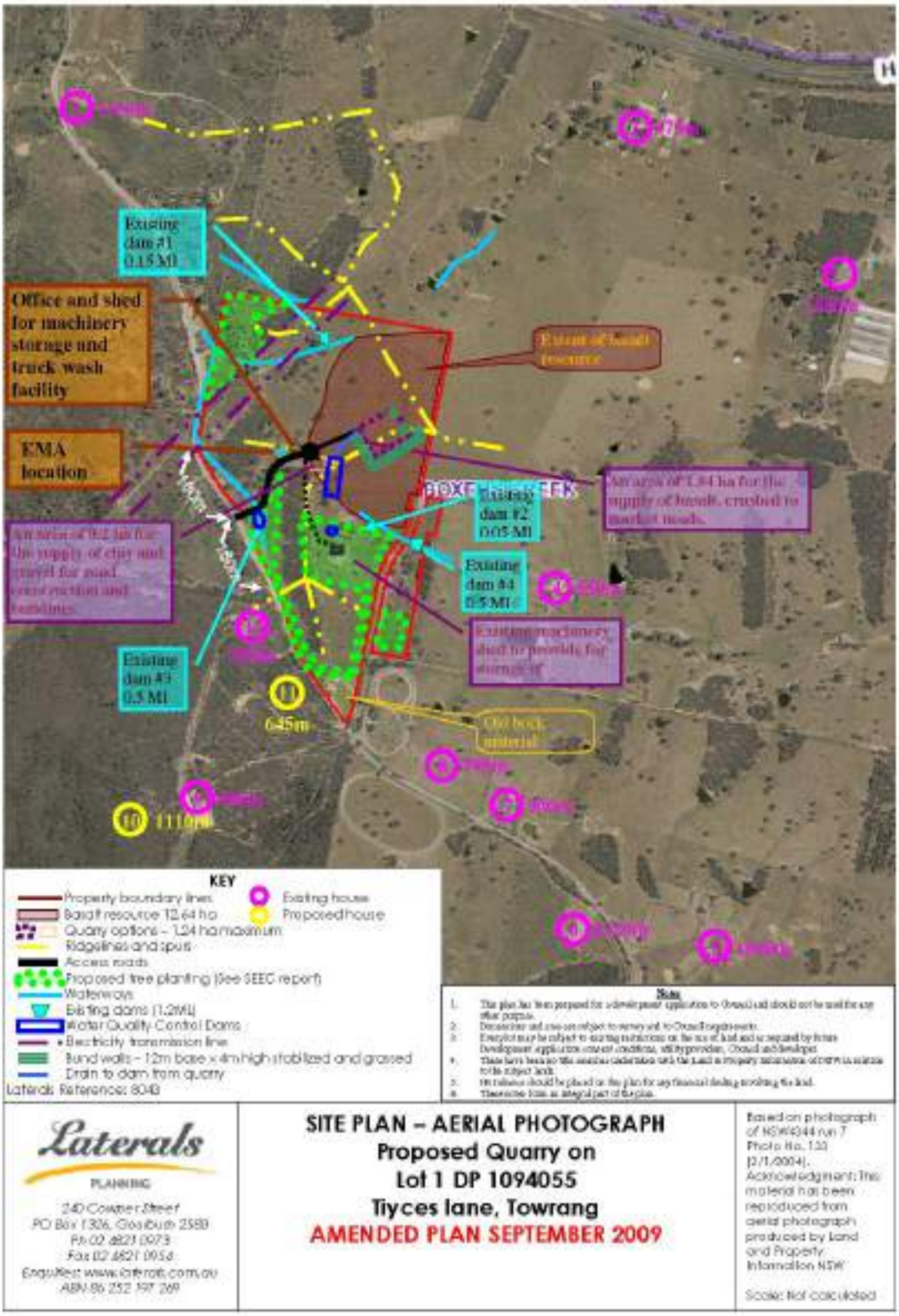


Figure 2-3: Site Plan

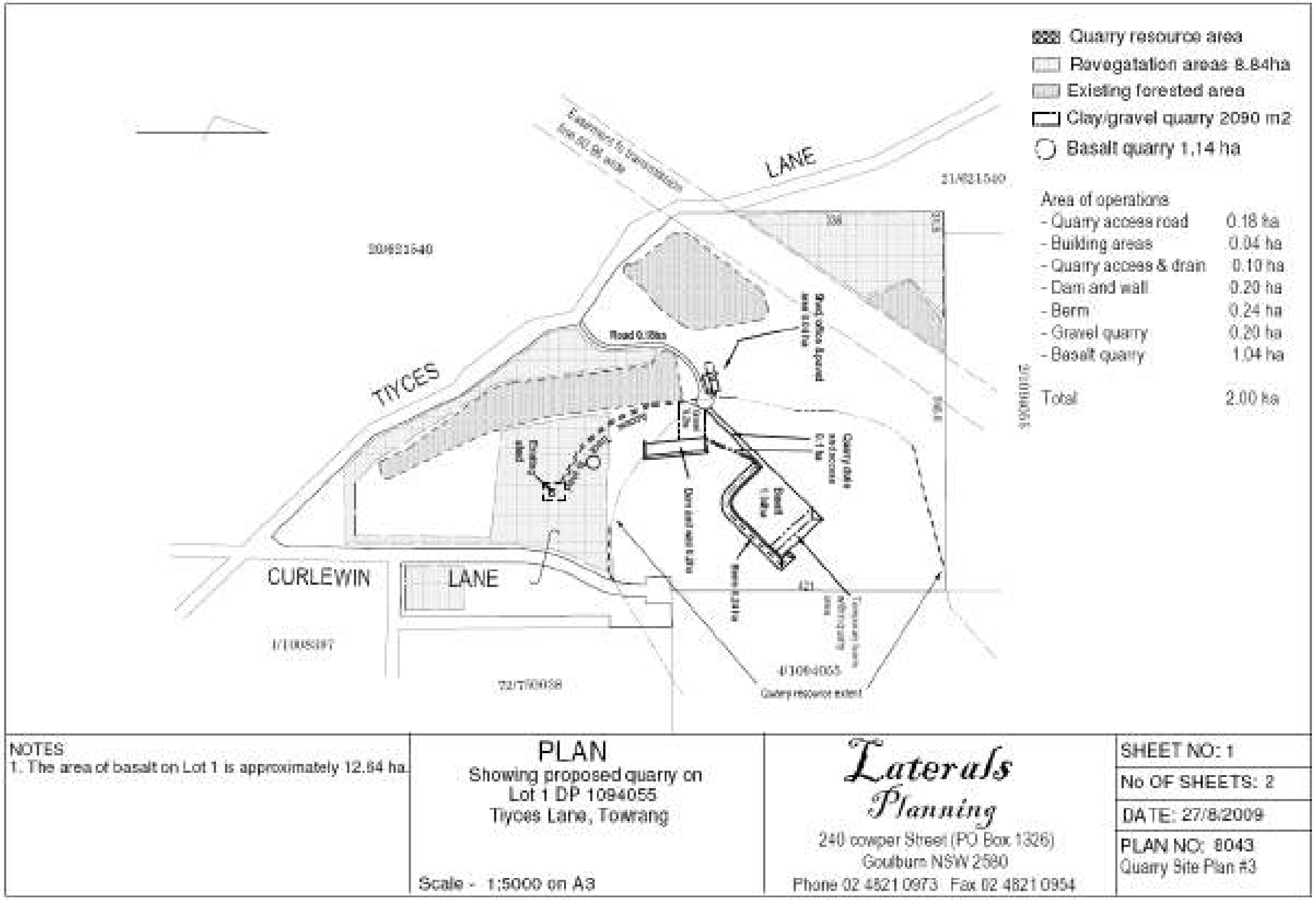
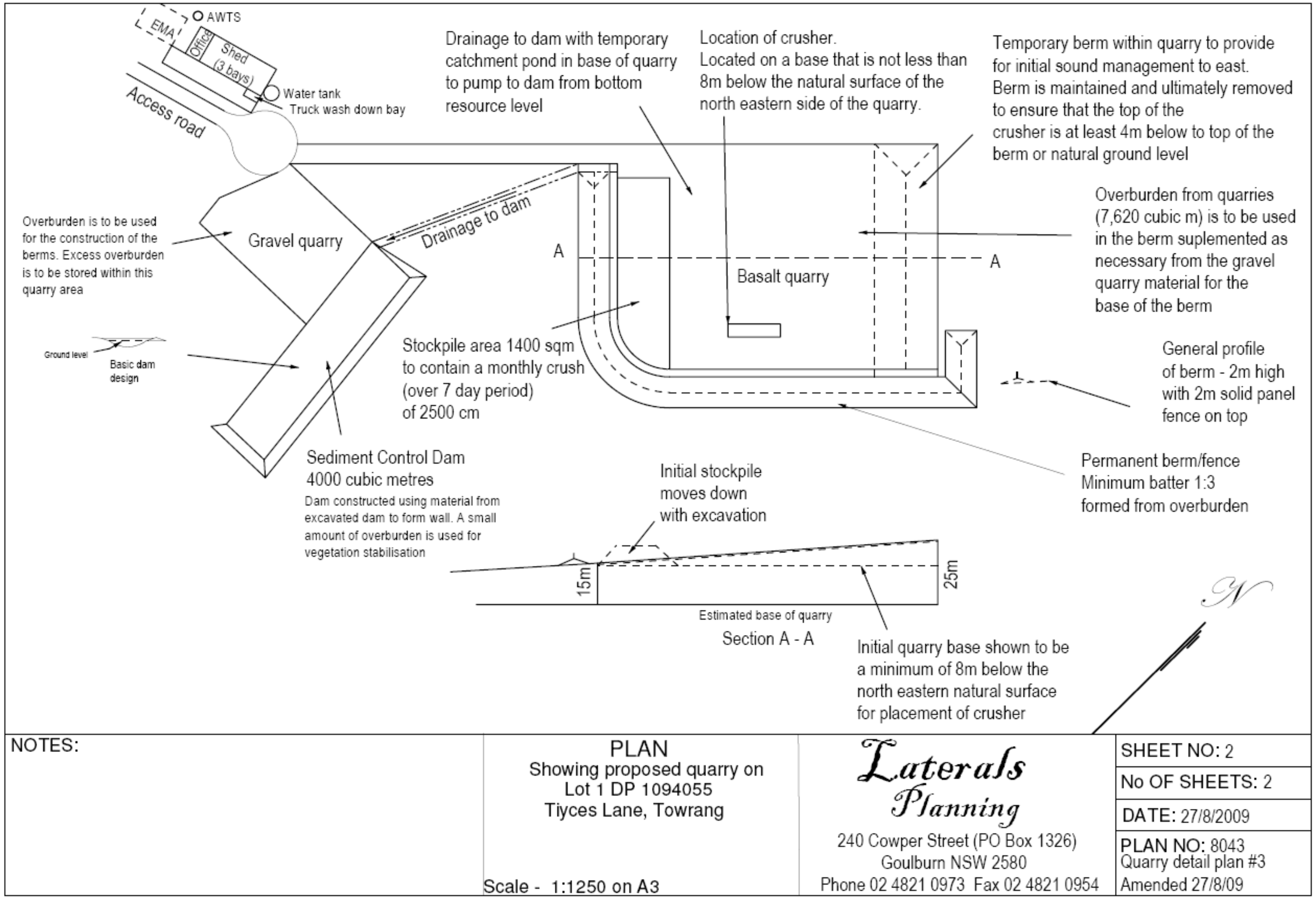


Figure 2-4: Detailed Site Plan



2.2 DESCRIPTION OF SITE AND SURROUNDS

The site is currently defined as Rural Zone 1(a) under the current Goulburn Local Environmental Plan. The site is surrounded in all directions by undeveloped land. The proposed zoning for the site is Rural Landscape Zone RU2 under the Draft Goulburn Mulwaree LEP2008. The proposed site would require construction of access road, connecting to Tiyces Lane, for approximately 250 m. The site is located south of ridge line, thus minimising dust emission impact on residences in a Northern direction from the site.

On the western direction of the proposed site, lies the forest region of Mount Towrang and Mount Towrang itself, while to the immediate east, the lands are cleared for approximately 2 km, followed by the forest region.

To the west, there is Towrang Creek, parallel with the western site border together with an un-named drainage depression commencing at and perpendicular with the eastern boundary.

To the north, lies Osborne Creek, running at a perpendicular axis to the northern site border. Further to the south is an un-named drainage depression.

Electrical easement is located to the north-west of the proposed site.

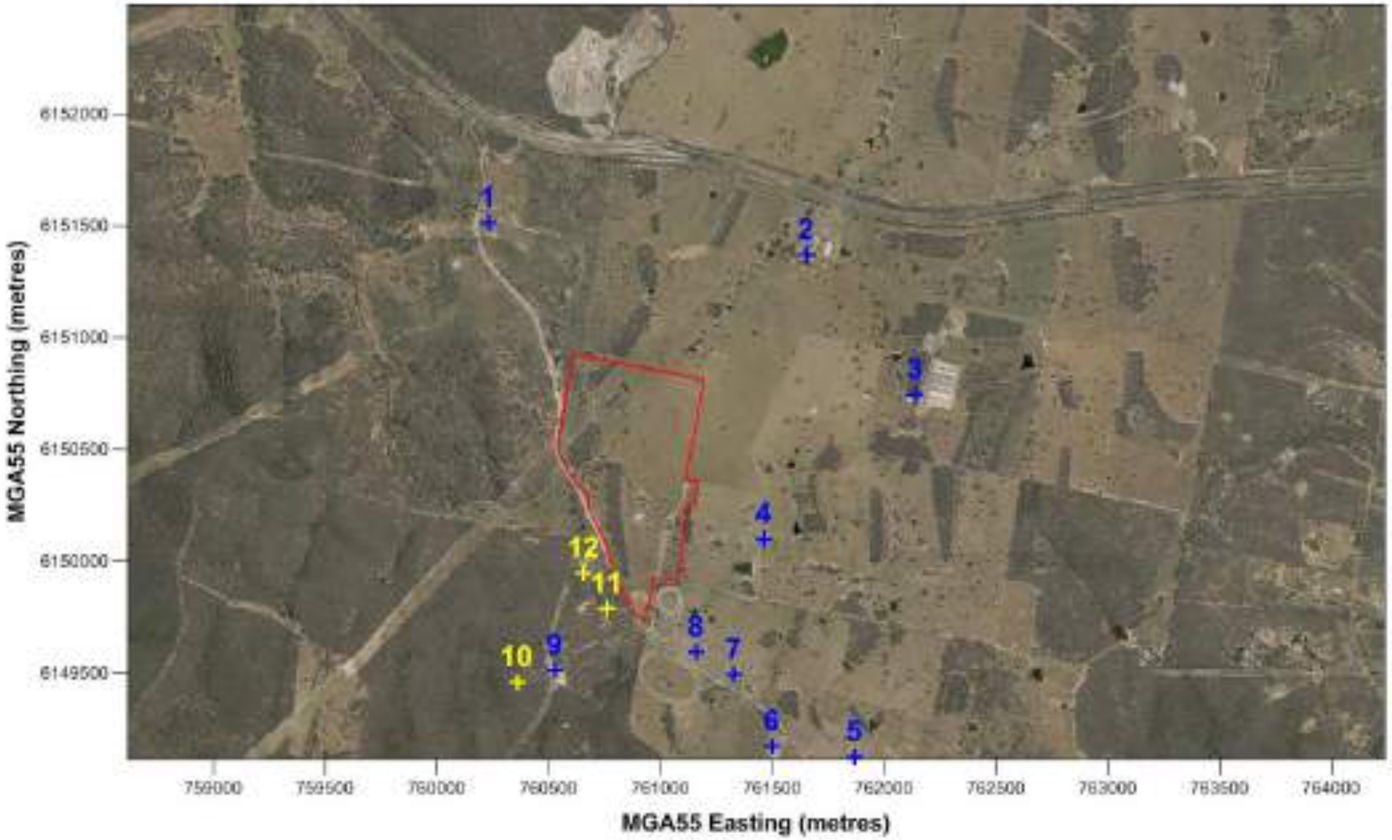
2.3 SENSITIVE RECEPTORS

Table 2-1 lists the nearby receptors that might be affected with the proposed development. The locations of the residences are shown as aerial photo in Figure 2-5.

Table 2-1: Potentially Sensitive Receptors

Receptors	Address	Direction	Distance from Site Boundary (m)
1	51 Tiyces Lane, Boxers Creek 2580 Lot 21 DP 621540	NW	700
2	Hume Highway, Boxers Creek 2580 Lot 3 DP 10904055	NE	723
3	Boxers Creek 2580 Lot 2 DP 247200	E	968
4	249 Tiyces Lane, Boxers Creek 2580 Lot 72 DP 750038	E	358
5	Tiyces Lane, Boxers Creek 2580 Lot 16 DP 1018643	SE	1,143
6	328 Tiyces Lane, Boxers Creek 2580 Lot 16 DP 1018643	SE	807
7	Boxers Creek 2580 Lot 2 DP 1008397	SE	486
8	287 Tiyces Lane, Boxers Creek 2580 Lot 1 DP 1008397	SE	268
9	244 Tiyces Lane, Towrang 2580 Lot 3 DP 1087071	SW	448
10	244 Tiyces Lane, Towrang 2580 Lot 4 DP 1087071	SW	622
11	Tiyces Lane, Towrang 2580 Lot 2 DP 1087071	SW	97
12	Tiyces Lane, Towrang 2580 Lot 1 DP 1087071	W	132

Figure 2-5: Site Location



Legend:
Subject Site Boundary
Receptors – Existing Residences
Receptors – Proposed Residences

Source: © Department of Lands

2.4 SURROUNDING LAND USE

The area surrounding the proposed site is undeveloped land with several rural settlements to the east, and south-east direction. The only available access road is Tiyces Lane, which connected to the Hume Highway from a Southern direction.

Due to the nature of the area, the existing sources of air pollution would come from motor vehicle emissions, dust from non-grassed areas, residential activity and the horse training facility. These sources would mainly consist of combustion gasses, such as oxides of nitrogen, carbon and sulphur, and dust from unsealed roads or areas and would be considered to be minimal due to the size and frequency of each of these activities.

3. THE PROPOSAL

3.1 PROPOSED DEVELOPMENT

The proposed development has two quarry pits. The final location of the quarry will depends on the exposed nature of the resources. The proposed development would involve construction of offices, machinery shed, the use of the premises to quarry construction materials and provide a stockpile area for loading onto trucks to transport the materials. The proposal would require construction of access roadways, parking areas, landscaping, storage areas and security fencing.

3.2 BUILDING CONSTRUCTION AND SITE DEVELOPMENT

Within the boundary of the proposed site, currently one machinery shed for equipment storage, and four water dams exists. The proposed site would be required to build the offices and another shed for machinery storage.

3.3 REVIEW OF OPERATIONS

The preliminary equipment list for the site is presented below.

Machinery List for Extractive Activity

- Crusher (mobile) (1);
- Material sizing screen (1);
- Bulldozer (1);
- Front end loader (1);
- Backhoe (1);
- Trucks (estimate average of 3); and
- Water truck (1).

Site Infrastructure

- Office (including staff amenities) (1);
- Machinery shed (1);
- Equipment shed (Dangerous goods storage (fuel/oil) existing);
- On site waste water management facility;
- Access roads to office site (@ 6m width) and central quarry (@4m width);
- Security compound fencing around infrastructure (including lockable access gate to Tiyces lane);
- Electricity extension to security compound;
- Telephone extension to security compound;
- Water supply – existing dams on site; and
- Bore (proposed).

4. CURRENT LEGISLATION AND GUIDELINES

4.1 DIRECTOR GENERAL'S REQUIREMENTS

Director General's Requirements for the proposed development in relation to air quality are presented as follows:

> ***Key Issues:*** *The EIS must assess the following potential impacts of the proposal during construction and operation, and describe what measures would be implemented to avoid, minimise, mitigate, offset, manage and /or monitor these potential impacts:*
> *• Air quality (dust) in accordance with relevant Department of Environment and Climate Change guidelines. This assessment must consider any potential impacts on nearby sensitive environments and private receptors.*

A qualitative study has been undertaken to identify the receptors and the controls that one needed.

4.2 LEGISLATION

4.2.1 Protection of the Environment Operations Act, 1997

The Protection of the Environment Operations Act, 1997 (POEO Act) applies the following definitions relating to air pollution:

> ***"Air pollution"*** *means the emission into the air of any air impurity.*
>
> *While "air impurity" includes smoke, dust (including fly ash), cinders, solid particles of any kind, gases, fumes, mists, odours and radioactive substances*

The following clauses of this Act have most relevance to the site:

> *• Clause 124 (Operation of Plant)*
>
> *The occupier of any premises who operates any plant in or on those premises in such a manner as to cause air pollution from those premises is guilty of an offence if the air pollution so caused, or any part of the air pollution so caused, is caused by the occupier's failure:*
>
> *(a) to maintain the plant in an efficient condition, or*
>
> *(b) to operate the plant in a proper and efficient manner,*

• Clause 126 (Dealing with Materials)

(1) The occupier of any premises who deals with materials in or on those premises in such a manner as to cause air pollution from those premises is guilty of an offence if the air pollution so caused, or any part of the air pollution so caused, is caused by the occupiers failure to deal with those materials in a proper and efficient manner.

(2) In this section:

***Deal** with materials means process, handle, move, store or dispose of the materials.*

***Materials** include raw materials, materials in the process of manufacture, manufactured materials, by-products or waste materials.*

• Clause 127 Proof of causing pollution

To prove that air pollution was caused from premises within the meaning of Sections 124 – 126,it is sufficient to prove that air pollution was caused on the premises, unless the defendant satisfies the court that the air pollution did not cause air pollution outside the premises.

• Clause 128 Standards of air impurities not to be exceeded

(1) The occupier of any premises must not carry on any activity, or operate any plant, in or on the premises in such a manner as to cause or permit the emission at any point specified in or determined in accordance with the regulations of air impurities in excess of:

(a) The standard of concentration and the rate, or

(b) The standard of concentration or the rate.

Prescribed by the regulations in respect of any such activity or any such plant.

(2) Where neither such a standard nor rate has been so prescribed, the occupier of any premises must carry on any activity, or operate any plant, in or on the premises by such practicable means as may be necessary to prevent or minimise air pollution

The proposed development would be required to meet the above stated requirements.

4.2.2 The Protection of the Environment Operations (Clean Air) Regulation 2002

The proposed activity is considered to be "scheduled" as it would require an Environmental Protection Licence with the NSW DECC, due to the proposed production capacity approximately being close to the criteria of 60,000 tonnes per annum (which approximately equivalent to 30,000 m^3 per annum). Schedule 6 of the Protection of the Environment Operations (Clean Air) Regulation 2002 (Clean Air Regulation) provides standards of concentration for non-scheduled premises for general activities and plant. Group 6 would be the appropriate classification for the new development. Group 6 relates to an activity that has *commenced to be carried on, or to operate, on or after 1 September 2005, as a result of an environment protection licence granted under the Protection of the Environment Operations Act 1997 pursuant to an application made on or after 1 September 2005* under the regulation.

Table 4-1: Excerpt from Protection of the Environment Operations (Clean Air) Regulation 2002, Schedule 6 – *Standards of concentration for scheduled premises: General activities and plant*

Air Impurity	Activity or Plant	Group 6 Standard of Concentration
Solid Particles (Total)	Any activity or plant (except as listed below)	50 mg/m^3

Sources of dust associated with the proposed development would be required to meet the above listed requirements.

4.3 AMBIENT AIR QUALITY GOALS

The National Environment Protection Council sets uniform standards for ambient air quality. The standards relevant to this study are shaded in the following table.

Table 4-2: NEPM Standards and Goals for Ambient Air Quality

Pollutant	Averaging Period	Maximum Concentration	Goal within 10 years Maximum Allowable Exceedances
Particle as PM_{10}	1 day	50 µg/m^3	1 day a year

The National Environmental Protection Measure for Ambient Air Quality: Air Monitoring Plan for NSW established a goal for six air pollutants: carbon monoxide, photochemical oxidants (as ozone), nitrogen dioxide, sulphur dioxide, lead and particles as PM_{10}.

4.4 ESTABLISHMENT OF ASSESSMENT CRITERIA

Relevant air quality assessment criteria have been primarily adopted from the DECC NSW document "Approved Methods for the Modelling and Assessment of Air Pollutants in NSW" (DECC NSW 2005). These criteria are presented in Table 4-3.

Table 4-3: DECC NSW Air Quality Standards/Goal (Dust)

Pollutant	Descriptor	Standard	Averaging Time
Particulate Matter < 10µm (PM_{10})	Concentration	30 µg/m³ 50 µg/m³	Annual 24-hour
Total Suspended Particulates (TSP)	Concentration	90 µg/m³	Annual
Deposited Dust	Deposition	2 g/m²/month $^{y\ a}$ 4 g/m²/month $^{y\ b}$	Annual

Notes:
µg/m³ - micrograms/cubic meter
<10µg - less than 10 microns in aerodynamic diameter
a - maximum increase in deposited dust level
b - maximum total deposited dust level
1 - background levels are to be considered when reporting potential impacts
2 - total impact (incremental impact plus background) may require reporting and comparison with the impact assessment criteria

4.5 PROJECT SPECIFIC AIR QUALITY CRITERIA

The air quality criteria considered most relevant for this project would be PM_{10}, TSP and deposited dust as outlined in Table 4-3. These criteria are the most stringent of that detailed in this section and therefore would be applied in a quantitative dust study.

Modelling results of a quantitative study would be subjected to criteria in Table 4-2 and Table 4-3. Therefore, the use of the air quality criteria is considered to be the most reasonable means of ensuring that the activities of the proposed development do not adversely impact on the air quality amenity of residents.

5. QUANTITATIVE AIR ASSESSMENT

The quantitative air impact assessment comprises of the analysis of the following aspects:

- Meteorology and suitable site-representative meteorological data;
- Terrain elevation within proximity to the subject site;
- Local background air quality;
- Site representative emission sources and emission factors; and
- Air dispersion modelling methodology utilised for the assessment.

These aspects are discussed in further detail in the following sub-sections.

5.1 METEOROLOGY AND SITE-SPECIFIC METEOROLOGICAL DATA

A site-specific meteorological data specifically made for the region of Towrang was generated for the subject site using the computer simulation program "The Air Pollution Model" (TAPM). TAPM is a three-dimensional meteorological and air pollution model developed by the CSIRO Division of Atmospheric Research. TAPM uses databases of terrain, vegetation, soil, type, sea surface temperature and synoptic-scale meteorological analyses for Australia. The TAPM-generated Towrang meteorological file contained values for temperature, wind speed, wind direction, mixing height, stability class and standard wind deviation parameters.

To validate the use of the developed TAPM-generated meteorological file, its wind patterns were compared to a 5-year (long term) meteorological data from the nearest Bureau of Meteorology (BoM) monitoring station. This is discussed in further detail in Section 5.1.2.

5.1.1 Wind Speed and Stability Class

The "stability" of the atmosphere is a classification used to describe the structure of the atmosphere in terms of temperature, specifically, how temperature changes in the atmosphere with altitude. Classification is often in accordance with the Pasquill-Gifford classification system that consists of six stability class groups, shown in Table 5-1. The class "A" describes an atmosphere where the air is well mixed and there is little hindrance of dispersion into the atmosphere. At the other end of the scale is class "F", which describes conditions under which temperature inversions would occur, where winds are calm or absent and air close to the earth's surface cannot rise into the atmosphere due to the presence of warmer air layers above. The classes in between A and F indicate changing degrees of stability due to variations in temperature in the atmosphere.

Table 5-1: Pasquill-Gifford Stability Class System

Stability Class	Description
A	Extremely Unstable
B	Unstable
C	Slightly Unstable
D	Neutral
E	Slightly Stable
F	Very Stable

Table 5-2 and Table 5-3 present the statistical information of the TAPM-generated Camden meteorological file. An annual average wind speed of 3.48 $m.s^{-1}$ was determined for the 2007 TAPM-generated meteorological file. The tables show that the primary wind directions were from the south-west followed closely by winds from the south direction. Winds were least likely to originate from the north-west.

Worst case dispersion conditions for emissions would occur during F-class stability conditions – generally associated with still / light winds and clear skies during the night time or early morning period (stable conditions). Analysis of the referenced site-specific meteorological data indicates the F-class dispersion conditions were present for approximately 15.8% of the time in the TAPM-Generated Towrang meteorological file, suggesting a reasonable low-risk of enhanced impacts due to this weather condition.

Looking at Table 5-3, it can be seen that stability class frequencies in the meteorological file are not biased towards giving enhanced dispersive conditions. Stability class D is the most frequent, with an occurrence of 51.4%. Stability classes A, B, C, which offer the best dispersion conditions, occur with frequencies of 0.4%, 3.8% and 15.5% respectively.

Table 5-2: Wind Direction / Stability Class Frequency Distribution (Count) for Referenced Meteorological Data Input File – TAPM-Generated Meteorological File 2007

Frequency Distribution (Count)							
Direction (Blowing From)	**Stability Class**						
	A	**B**	**C**	**D**	**E**	**F**	**Total**
N	4	47	114	231	89	258	743
NE	1	96	256	472	275	228	1328
E	8	59	249	686	195	97	1294
SE	4	38	130	829	91	53	1145
S	6	15	27	120	62	20	250
SW	4	16	68	130	30	43	291
W	6	36	364	1521	314	415	2656
NW	2	28	150	513	93	267	1053
Total	35	335	1358	4502	1149	1381	8760

Table 5-3: Wind Direction / Stability Class Frequency Distribution (Percentage) for Referenced Meteorological Data Input File – TAPM-Generated Towrang Meteorological File 2007

Frequency Distribution (Percentage %)							
Direction (Blowing From)	**Stability Class**						
	A	**B**	**C**	**D**	**E**	**F**	**Total**
N	0.05	0.54	1.30	2.64	1.02	2.95	8.48
NE	0.01	1.10	2.92	5.39	3.14	2.60	15.16
E	0.09	0.67	2.84	7.83	2.23	1.11	14.77
SE	0.05	0.43	1.48	9.46	1.04	0.61	13.07
S	0.07	0.17	0.31	1.37	0.71	0.23	2.85
SW	0.05	0.18	0.78	1.48	0.34	0.49	3.32
W	0.07	0.41	4.16	17.36	3.58	4.74	30.32
NW	0.02	0.32	1.71	5.86	1.06	3.05	12.02
Total	0.40	3.82	15.50	51.39	13.12	15.76	100.00

5.1.2 Wind Rose Plots

Wind rose plots show the direction from which the wind is coming from with triangles known as "petals". The petals of the plots in the figure summarise wind direction data into 8 compass directions i.e. north, north-east, east, south-east, etc. The length of the triangles, or "petals", indicates the frequency that the wind blows from the direction presented. Longer petals for a given direction indicate a higher frequency of wind from that direction. Each petal is divided into segments, with each segment representing one of the six wind speed classes. Thus, the segments of a petal show what proportion of wind for a given direction falls into each class. The proportion of time, for which wind speed is less than speeds in the first class (i.e. 0.5 $m.s^{-1}$), when speed is negligible, is referred to as calm hours or "calms". Calms are not shown on a wind rose as they have no direction, but the proportion of time that form part of the period under consideration is noted under each wind rose.

The concentric circles in each wind rose are the axis, which denote frequencies. In comparing the plots it should be noted that the axis varies between wind roses, although all wind roses are the similar in size. The frequencies denoted on the axes of the wind rose are indicated beneath each wind rose.

The nearest BoM monitoring station found within proximity to the subject site is the Goulburn Automatic Weather Station (AWS) (Station No. 070330). This was used as a basis of comparison with the TAPM-generated meteorological file.

Wind Rose Plots for Goulburn AWS Dataset and the 2007 TAPM-Generated Towrang Meteorological File are shown in Figure 5-1 and Figure 5-2.

5.1.3 Local Wind Trends

Figure 5-1 and Figure 5-2 indicate that wind characteristics for both the Goulburn AWS and TAPM-generated meteorological file show a high degree of similarity. Whilst the wind speeds vary – the TAPM-generated Towrang meteorological file wind speeds are consistently lower than Goulburn AWS.

Over the course of a year, westerly winds dominate for both the Goulburn AWS and the Towrang data at approximately 21% and 22% respectively. All other directions contribute wind with frequencies less than or equal to 15%. The Towrang data shows the next dominant winds from the north-east, east and south-east at approximately 14% whilst the Goulburn AWS data shows the second most-dominant winds from the east and north-west at approximately 15%.

In summer at Towrang, winds frequently blow from the north-east (30%), followed closely by easterly (25%), and northerly (14%). Goulburn AWS data indicates that the easterly (27%), westerly (15%), north-easterly (15%) and south-easterly (16%) are dominant. Calms for Towrang and Goulburn in this season are 0.32% and 5.97% respectively.

During autumn, the Towrang file shows dominance from the west direction (30%), followed by winds from the north-west (16%), east (14%) and south-east (14%). The Goulburn AWS data file shows that winds from this region dominantly blow from the west (20%), followed by winds from the east (14%), north-west (13%) and south-east (12%). Calms for Towrang and Goulburn in this season are 1.54% and 17.32% respectively.

For the region of Towrang, winter winds dominantly come from the west only (49%) with little contribution from the south-east (16%) and north-west (11%). Westerly winds (30%) also dominate in the Goulburn AWS data, followed by winds from north-west (20%). Calms for Towrang and Goulburn in this season are 0.59% and 15.72% respectively.

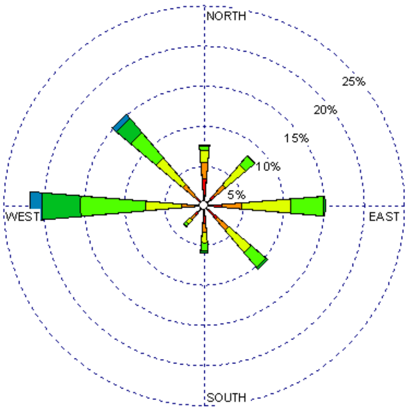
In spring at Towrang, westerly winds remain dominant (30%) followed by winds from the east (17%), north-east (13%) and south-east (13%). The Goulburn AWS data also shows dominance of winds from the west (23%) with significant contributions from the north-west (16%), east (14%) and south-east (10%).

Average wind speed values range from 2.88 m/s (autumn) up to 4.06 m/s (winter) at Towrang whilst the Goulburn AWS data shows a range of values from 3.71 m/s (autumn) up to 4.78 (spring).

As outlined above, there are some differences between the wind patterns of the TAPM-generated meteorological data and the long term Goulburn AWS data, which is to be expected. However, the similarities between the two data sets suggest that the TAPM-generated Towrang meteorological file is suitable for use in the dispersion modelling of this assessment.

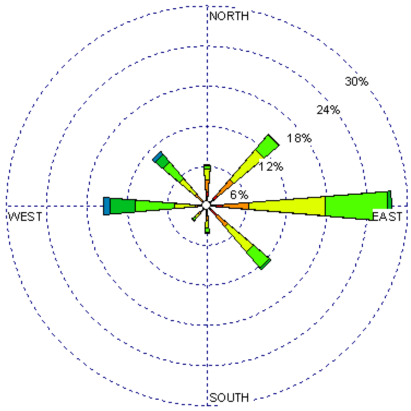
Figure 5-1: Annual Wind Rose Plots from the 2004-2008 Goulburn BoM Station Dataset

All Seasons



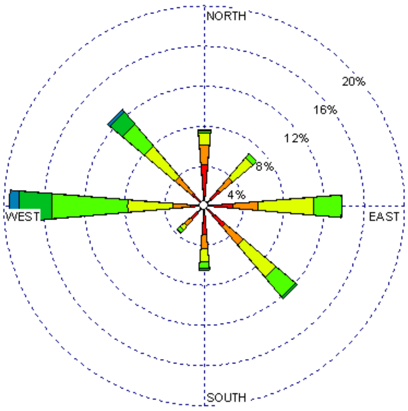
Average Wind Speed: 4.43 m/s
Calms Frequency: 12.07 %
Axis Frequencies: 5%, 10%, 15%, 20%, 25%

Summer (December – February)



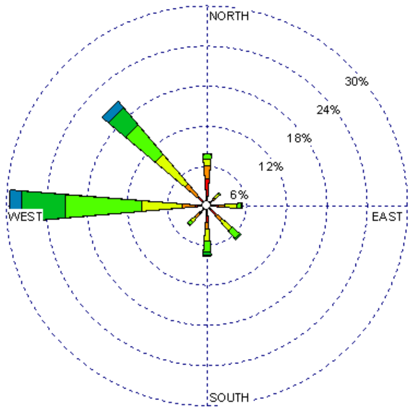
Average Wind Speed: 4.69 m/s
Calms Frequency: 5.97 %
Axis Frequencies: 6%, 12%, 18%, 24%, 30%

Autumn (March – May)



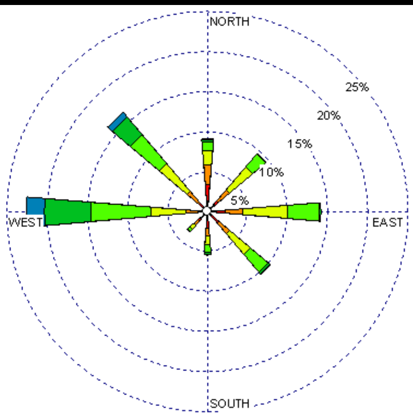
Average Wind Speed: 3.71 m/s
Calms Frequency: 17.32 %
Axis Frequencies: 4%, 8%, 12%, 16%, 20%

Winter (June – August)



Average Wind Speed: 4.52 m/s
Calms Frequency: 15.72 %
Axis Frequencies: 6%, 12%, 18%, 24%, 30%

Spring (September – November)



Average Wind Speed: 4.78 m/s
Calms Frequency: 9.12 %
Axis Frequencies: 5%, 10%, 15%, 20%, 25%

Legend

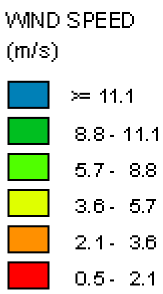
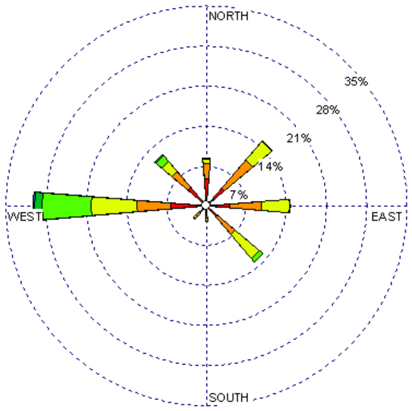


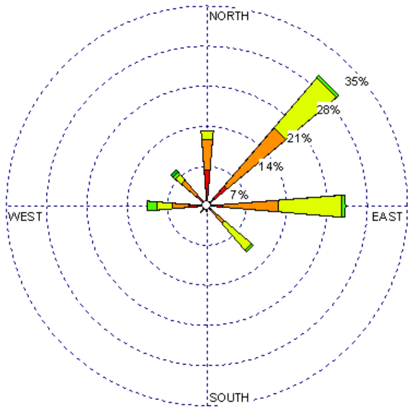
Figure 5-2: Annual Wind Rose Plots from the 2007 TAPM-Generated Meteorological File

All Seasons



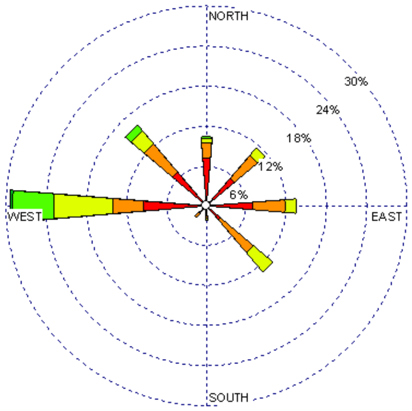
Average Wind Speed: 3.48 m/s
Calms Frequency: 0.87%
Axis Frequencies: 7%, 14%, 21%, 28%, 35%

Summer (December – February)



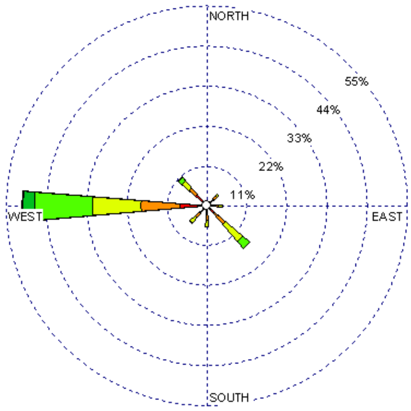
Average Wind Speed: 3.34 m/s
Calms Frequency: 0.32 %
Axis Frequencies: 7%, 14%, 21%, 28%, 35%

Autumn (March – May)



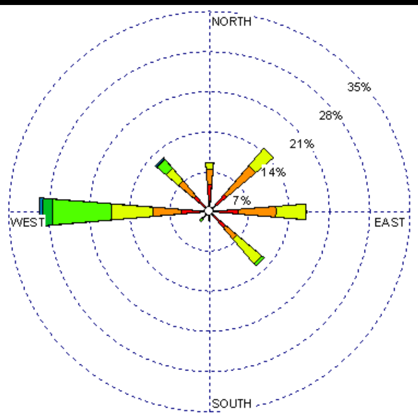
Average Wind Speed: 2.88 m/s
Calms Frequency: 1.54 %
Axis Frequencies: 6%, 12%, 18%, 24%, 30%

Winter (June – August)



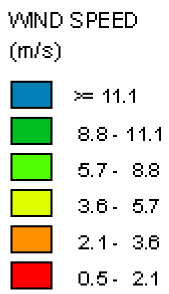
Average Wind Speed: 4.06 m/s
Calms Frequency: 0.59 %
Axis Frequencies: 11%, 22%, 33%, 44%, 55%

Spring (September – November)



Average Wind Speed: 3.62 m/s
Calms Frequency: 1.01 %
Axis Frequencies: 7%, 14%, 21%, 28%, 35%

Legend



5.2 TERRAIN OF THE REGION

An assessment of the 1:25,000 topographic map for the region indicates the subject site and surrounding landscapes are subject to minor changes in elevation. The elevation of the area ranges between 670 metres to approximately 830 metres within the regional area of the site location. The terrain of the subject site location is approximately 720 to 730 metres in Australian Height Datum (AHD) Elevation and is seen to decrease towards the north-west and south-east section of the subject boundary indicated in Figure 2-5. The terrain further decreases towards this direction, outside the indicated site boundary. A further decrease in elevation is seen towards the north-east whilst the south-east region shows an increase in elevation of approximately 100 metres compared to the subject site elevation.

A terrain information file was consequently constructed by digitising the 1:25,000 topographic contour map with 10 m contour intervals for the region of interest. This was incorporated into the air dispersion modelling to take into account the terrain effects on the emissions from the subject site.

Two 3-dimensional views of the site have been provided as Figure 5-3 and Figure 5-4. The first figure shows the terrain with the z-axis (i.e. vertical axis) exaggerated by a factor of 5 (i.e. a given distance on the x-axis or y-axis appears 5 times as great on the z-axis). This figure helps to present the terrain features and how they are shaped. It should be noted that these figures are an approximation of the actual terrain, based on terrain information taken from maps of the area.

5.3 LOCAL BACKGROUND AIR QUALITY

No monitoring station has been found to provide representative background air quality measurements for the subject site. However, the local background air quality can be defined based on the surrounding land use.

The region of subject site location is predominantly occupied by heavy vegetation (i.e. forests) with residential homes scattered across the regional area. These homes are expected to increase in the near future. No major sources of emissions such as industrial facilities are found to be within the region of interest. Emissions from road vehicle travel and activities from the nearby horse training facility are expected to provide minor contribution to the background air quality. With these, it is expected that the levels of PM_{10}, TSP and Dust Deposition are low to negligible.

For this assessment, it has then been considered and assumed that background levels of PM_{10}, TSP and Dust Deposition are negligible.

Figure 5-3: 3-Dimensional Terrain Surface View for the Site Location (Z Axis Exaggerated by a Factor of 5)

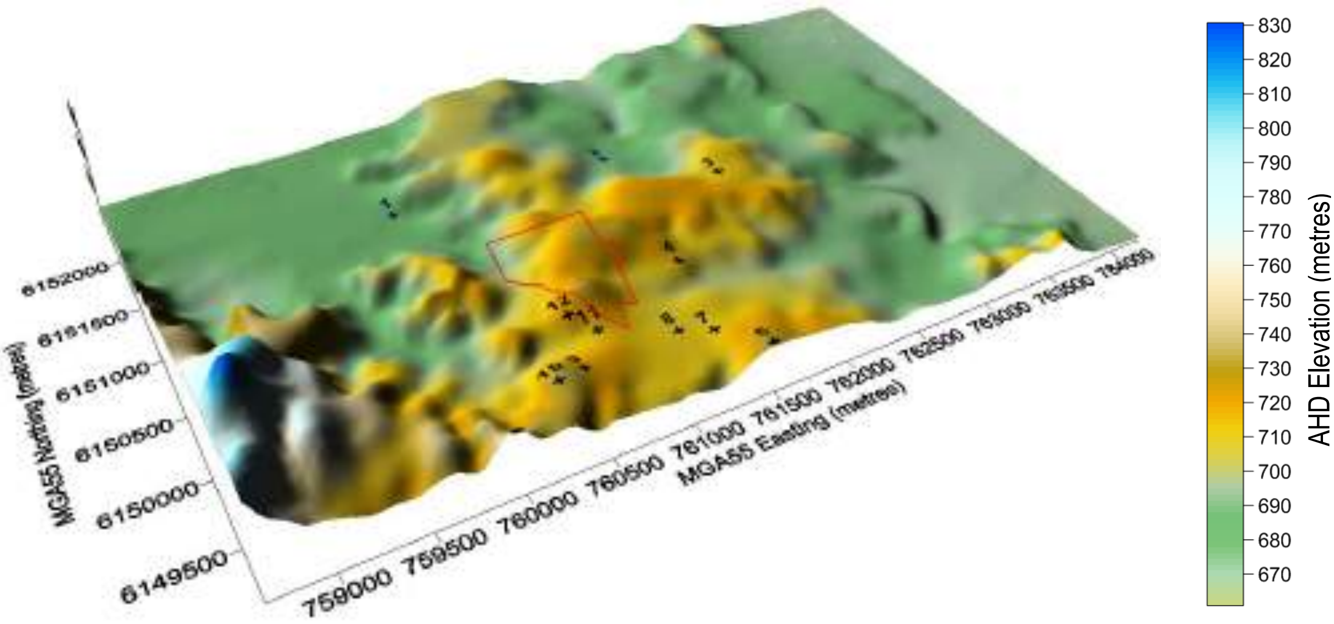
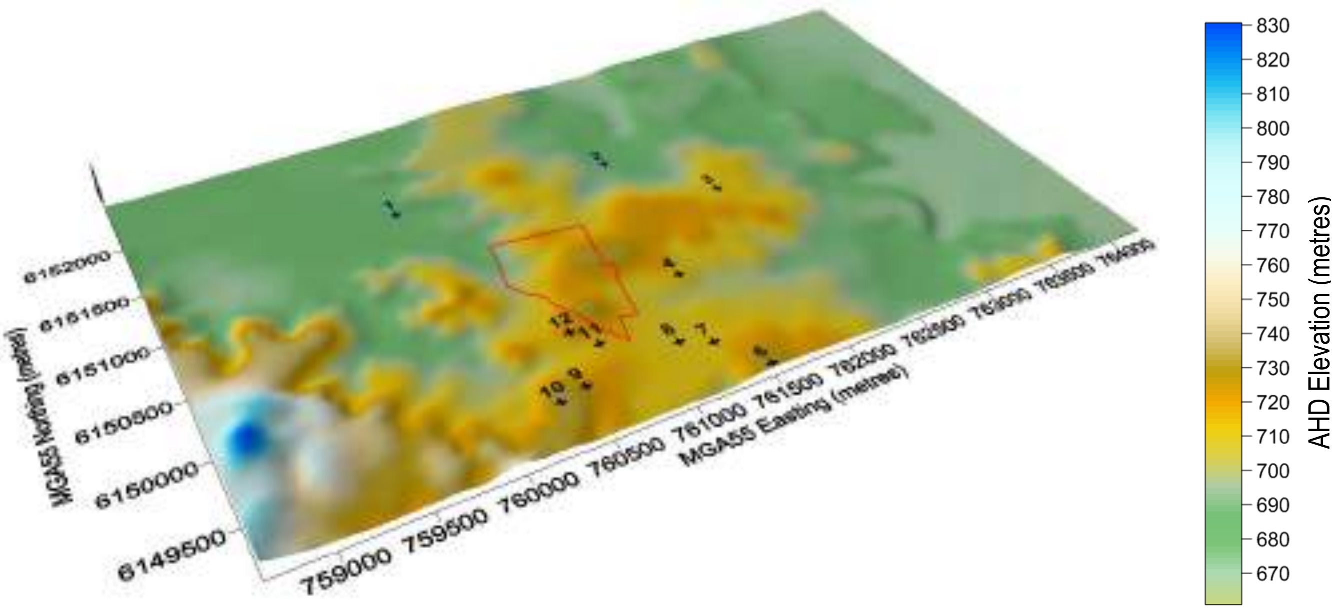


Figure 5-4: 3-Dimensional Terrain Surface View for the Site Location (Unexaggerated Z-Axis)



5.4 EMISSION SOURCES AND EMISSION RATES

The following emission sources were considered in the assessment:

- Vehicle Travel Emissions;
- Loading, Unloading and Material Handling Emissions;
- Wind Erosion from Stockpiles;
- Crushing and Screening Emissions; and
- Excavation Emissions.

5.4.1 Vehicle Travel Emissions

"*Dust Emissions* " written by F.W. Parrett (Parrett 1992) contains a methodology of calculating dust emission rates from vehicle travel on paved roads based on the dust suspension, exhaust emissions and tyre usage. Compared to generic emission factors, the referenced equation focuses on developing a site-specific emission factor based on site-specific conditions and properties, shown as Equation 5-1. Calculated emission factors are shown in Table 5-4.

Equation 5-1

$$E = 0.81PS\left(\frac{V}{30}\right)\left(\frac{365-R}{365}\right)\left(\frac{T}{4}\right)$$

Where

E = emission factor in lb/vehicle mile
P = fraction of particles from surface which will remain suspended
E_x = particle emissions from vehicle exhausts
Y = wear from tyres
T = number of tyres per vehicle

Table 5-4: Adopted Emission Factors for Vehicle Travel on Paved Roads

Activity	PM_{10} Emission Factor	TSP Emission Factor	Units
Dust loss from staff vehicle movements on unpaved roads	8.38×10^{-2}	1.64×10^{-1}	lb/vehicle mile
Dust loss from truck travel movements on unpaved roads	1.26×10^{-1}	2.46×10^{-1}	lb/vehicle mile

Note: TSP emission factors were conservatively estimated using the PM_{10}-to-TSP ratio of 0.5 referenced from the NPI EETM emission factors.
These emission factors are converted into the SI units of g/s for use in the modelling.

5.4.2 Loading, Unloading and Material Handling Emissions

Particulate emission rates for loading, unloading and material handling activities were estimated based on correlations listed in the National Pollutant Inventory (NPI) guidelines "*Emission Estimation Technique Manual (EETM) for Mining*" (NPI DEH 2001). The referenced equations focus on developing a site-specific emission factors based on the site-specific conditions and properties, shown as Equation 5-2 and Equation 5-3.

Equation 5-2: $$E = k0.0016\left(\frac{U}{2.2}\right)^{1.3}\left(\frac{M}{2}\right)^{-1.4}$$

Where

E = emission factor for loading and unloading emissions in kg/ton
k = 0.74 for TSP
0.35 for PM_{10}
U = mean wind speed in m/s
M = material moisture content in %

Equation 5-3: $$E = h(s^r)(M^{-X})$$

Where

E = emission factor for material handling emissions in kg/hr
h = 2.60 for TSP
0.34 for PM_{10}
s = silt content in %
r = 1.2 for TSP
1.5 for PM_{10}
M = material moisture content in %
x = 1.3 for TSP
1.4 for PM_{10}

The calculated emission factors are for uncontrolled emissions and are listed in Table 5-5.

Table 5-5: Adopted Emission Factors from NPI EETM Guidelines

Activity	PM_{10} Emission Factor	TSP Emission Factor	Units
Loading and Unloading Emissions	0.40	2.21	kg/tonne
Material Handling Emissions	2.82×10^{-4}	5.96×10^{-4}	kg/hr

Source: NPI DEH (2001)

5.4.3 Wind Erosion Emissions from Stockpiles

"*Dust Emissions*" written by F.W. Parrett (Parrett 1992) contains a methodology of calculating dust emission rates from wind eroded stockpiles based on the parameters of silt content, wind speed and moisture. Compared to generic emission factors, the referenced equation focuses on developing a site-specific emission factor based on site-specific conditions and properties, shown as Equation 5-4.

Equation 5-4: $E_w = 0.05(S / 5)(D / 90)(d / 235)(f / 15)$

Where

E_w = emission factor for wind erosion in lb/ton of material stored
S = silt content (weight percent of material stored)
D = number of days material is stored
d = number of dry days per year
f = percentage of time wind speed exceeds 12 mph (equivalent to 5.36 m/s)

Table 5-6: Adopted Emission Factors for Wind Erosion

Activity	PM_{10} Emission Factor	TSP Emission Factor	Units
Wind Erosion	3.89×10^{-3}	7.62×10^{-3}	kg/tonne

5.4.4 Crushing and Screening Emissions

Fine particulate emission factors for the main activities of the site were estimated based on factors listed in the U.S. EPA AP 42 Emission Factors "*Chapter 11.19 - Introduction to Construction and Aggregate Processing, Section 2 - Crushed Stone Processing and Pulverised Mineral Processing*" (USEPA 2004). The referenced AP 42 emission factors were used as representative emission factors for the crushing and screening activities of the subject site, which are listed in Table 5-7. It is to be noted that these emission factors are for uncontrolled emissions.

Table 5-7: Adopted Emission Factors from AP 42 Emission Factors

Activity	PM_{10} Emission Factor	TSP Emission Factor	Units
Crushing (Fines)	0.0075	0.0195	kg/tonne
Screening	0.0043	0.0125	kg/tonne

Source: USEPA (2004)

5.4.5 Excavation Emissions

Emissions from loading, unloading and material handling were estimated based on methodology listed in the National Pollutant Inventory (NPI) guidelines "*Emission Estimation Technique Manual (EETM) for Mining*" (NPI DEH December 2001). The referenced equations focus on developing a site-specific emission factors based on the site-specific conditions and properties, shown as Equation 5-5. It is to be noted that Equation 5-5 is similar to the "Loading, Unloading and Material Handling" emission equation.

Equation 5-5: $$E_w = k(0.0016)\frac{(U/2.2)^{1.3}}{(M/2)^{1.4}}$$

Where

E_w = Emission factor using a front end loader or an Excavator in kg/tonne
k = 0.74 for particles less than 30 micrometres aerodynamic diameter
0.35 for particles less than 10 micrometres aerodynamic diameter
U = Mean wind speed in m/s
M = Moisture content in %

Table 5-8: Adopted Emission Factors from NPI EETM Guidelines

Activity	PM_{10} Emission Factor	TSP Emission Factor	Units
Excavator	2.82×10^{-4}	5.94×10^{-4}	kg/tonne
Front End Loader	2.82×10^{-4}	5.94×10^{-4}	kg/tonne

Source: NPI DEH (2001)

5.4.6 Air Emissions Inventory Summary

Table 5-9 summarises the air emission sources and emission rates to be utilised for the air dispersion modelling.

Table 5-9: Summary of Air Emission Sources and Emission Rates

Emission Sources	Emission Rates (g/s)		Reference Source for the Emission Factor Used in Air Dispersion Modelling
	PM_{10}	TSP	
Vehicle Travel Emissions • Truck Travel • Staff Vehicle Travel	 6.56×10^{-2} 9.84×10^{-2}	 1.29×10^{-2} 1.93×10^{-2}	Parrett 1992
Loading, Unloading and Material Handling	1.12×10^{-1}	6.17×10^{-1}	NPI Database
Wind Erosion Emissions From Stockpiles	3.08×10^{-6}	6.04×10^{-6}	Parrett 1992
Crushing Process Screening Process	2.08×10^{-2} 1.19×10^{-2}	5.42×10^{-2} 3.47×10^{-2}	USEPA AP42
Excavation Process	1.57×10^{-3}	3.31×10^{-3}	NPI Database

5.5 MODELLING METHODOLOGY

5.5.1 Air Dispersion Model Utilised

The CALPUFF PRO (Version 6.0.306) Gaussian plume dispersion model was used to predict potential off-site impacts. The meteorological data discussed in Section 5.1 is considered to be representative of the wind climate at the subject site and study region in general. A total of 8,760 individual temperature, wind speed and wind direction events were obtained for the meteorological input file. This was to ensure that sufficient meteorological data was available so as to guarantee that worst-case conditions were adequately represented in the air dispersion model predictions.

5.5.2 Modelling Scenarios and Assumptions

The scenarios considered in the air dispersion modelling are shown in Table 5-10.

Table 5-10: Modelling Scenarios Considered

Scenario No.	Description
1	No dust suppression controls used for any activities on site.
2	Dust suppression controls used for the following activities: • Excavation process • Crushing and Screening works • Loading, Unloading and Material Handling activities

The following reduction controls, which are referenced from the NPI guidelines "*Emission Estimation Technique Manual (EETM) for Mining*" (NPI DEH December 2001), were applied to the air dispersion model for Scenario 2:

Table 5-11: Dust Suppression Control Factors

Control Method	Reduction
Water sprays in Excavations	70%
Water sprays in Crushing and Screening	70%
Water sprays in Loading, Unloading and Material Handling Activities	70%

The following assumptions were used in CALPUFF:

- Constant emission rates were used in the model for all emission sources. Emissions outside operational hours were also assessed and hence and hence impact results would be conservative. Wind erosion emissions from stockpiles storage emissions would not be conservative, since stockpiles are stored on site 24 hours per day, 7 days per week.

- All vehicle travel paths were assumed to release emissions, which is a more conservative approach in assessing wheel-generated emissions. Excavation, loading, unloading, material handling and stockpile storage emissions are released from the entire allocated area for each corresponding activity and can be considered to be a more conservative method in assessing emissions compared to how emissions would be released in reality (which would be from a much smaller area).

5.6 MODELLING RESULTS

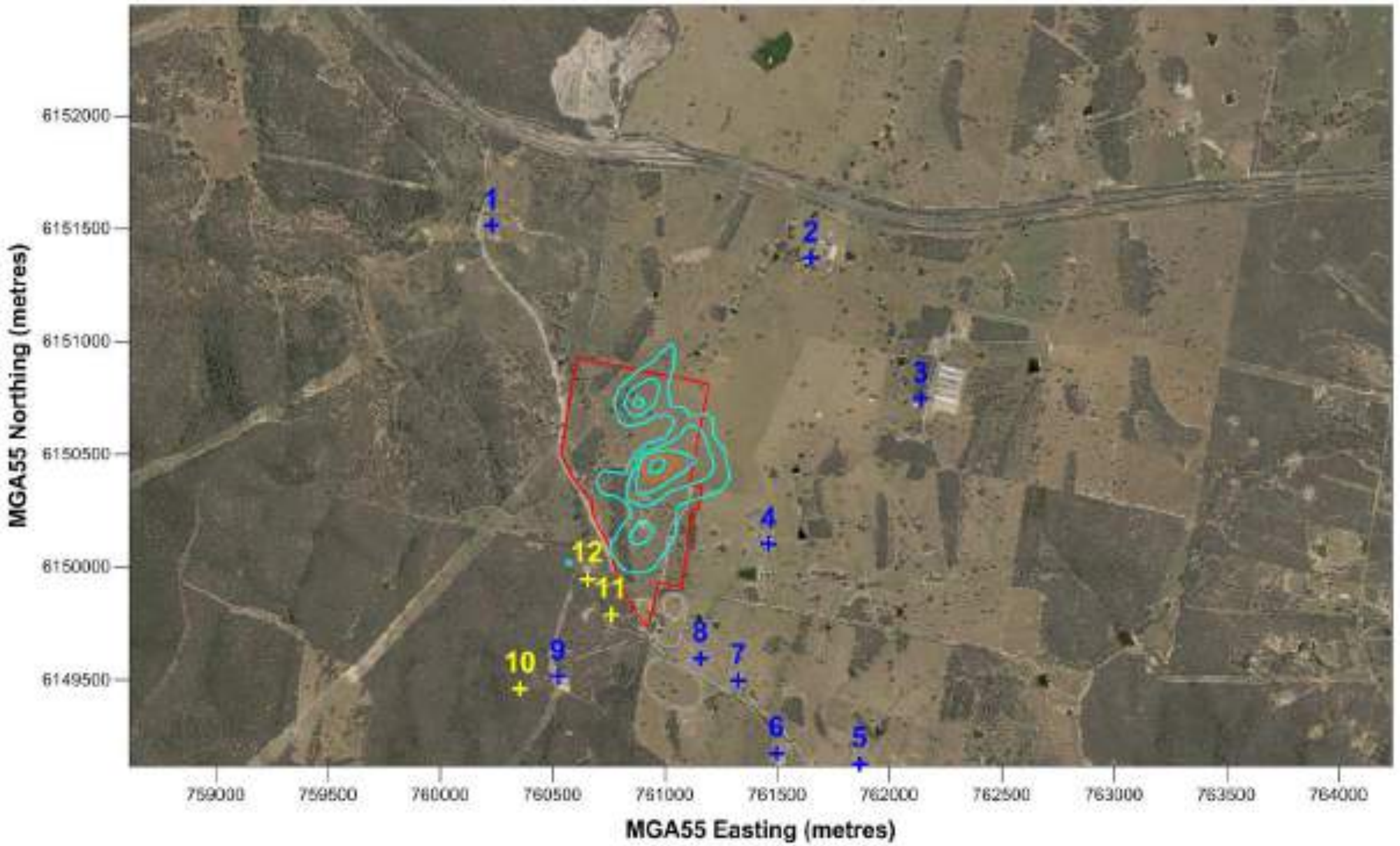
The Ground Level Concentration (GLC) results from CALPUFF are summarised in Table 5-12. A sample control file has been attached as Attachment 1. Concentration isopleths for Scenario 2 have been provided as Figure 5-5, Figure 5-6, Figure 5-7, and Figure 5-8.

Table 5-12: Summary of Ground Level Concentration Impact Results from CALPUFF

Scenario ID	Impact Type	Pollutant	Averaging Time	Ground Level Concentration Impacts at Receptors (mg/m³)												Criteria	Units
				1	2	3	4	5	6	7	8	9	10	11	12		
1	Incremental	PM10	24-hour	0.002	0.003	0.011	0.017	0.004	0.006	0.010	0.008	0.011	0.015	0.015	0.023	0.050	mg/m³
			1-year	0.000	0.000	0.000	0.002	0.000	0.000	0.000	0.000	0.001	0.001	0.001	0.002	0.030	mg/m³
		TSP	1-year	0.000	0.000	0.001	0.004	0.001	0.001	0.001	0.001	0.003	0.002	0.004	0.006	0.090	mg/m³
		Dust Dep.	1-year	0.001	0.000	0.003	0.009	0.001	0.002	0.003	0.003	0.006	0.005	0.008	0.013	2	g/m²/month
	Cumulative	PM10	24-hour	0.002	0.003	0.011	0.017	0.004	0.006	0.010	0.008	0.011	0.015	0.015	0.023	0.050	mg/m³
			1-year	0.000	0.000	0.000	0.002	0.000	0.000	0.000	0.000	0.001	0.001	0.001	0.002	0.030	mg/m³
		TSP	1-year	0.000	0.000	0.001	0.004	0.001	0.001	0.001	0.001	0.003	0.002	0.004	0.006	0.090	mg/m³
		Dust Dep.	1-year	0.001	0.000	0.003	0.009	0.001	0.002	0.003	0.003	0.006	0.005	0.008	0.013	2	g/m²/month
2	Incremental	PM10	24-hour	0.002	0.003	0.007	0.012	0.003	0.005	0.007	0.007	0.007	0.011	0.015	0.018	0.050	mg/m³
			1-year	0.000	0.000	0.000	0.001	0.000	0.000	0.000	0.000	0.001	0.001	0.001	0.002	0.030	mg/m³
		TSP	1-year	0.000	0.000	0.001	0.003	0.000	0.000	0.001	0.001	0.002	0.001	0.002	0.004	0.090	mg/m³
		Dust Dep.	1-year	0.000	0.000	0.002	0.006	0.001	0.001	0.001	0.002	0.003	0.003	0.005	0.009	2	g/m²/month
	Cumulative	PM10	24-hour	0.002	0.003	0.007	0.012	0.003	0.005	0.007	0.007	0.007	0.011	0.015	0.018	0.050	mg/m³
			1-year	0.000	0.000	0.000	0.001	0.000	0.000	0.000	0.000	0.001	0.001	0.001	0.002	0.030	mg/m³
		TSP	1-year	0.000	0.000	0.001	0.003	0.000	0.000	0.001	0.001	0.002	0.001	0.002	0.004	0.090	mg/m³
		Dust Dep.	1-year	0.000	0.000	0.002	0.006	0.001	0.001	0.001	0.002	0.003	0.003	0.005	0.009	2	g/m²/month

Note: Cells marked in black highlights are exceedances to the corresponding criteria.

Figure 5-5: Isopleth for PM_{10} Impacts Under 24-Hour Averaging Time (Scenario 2)



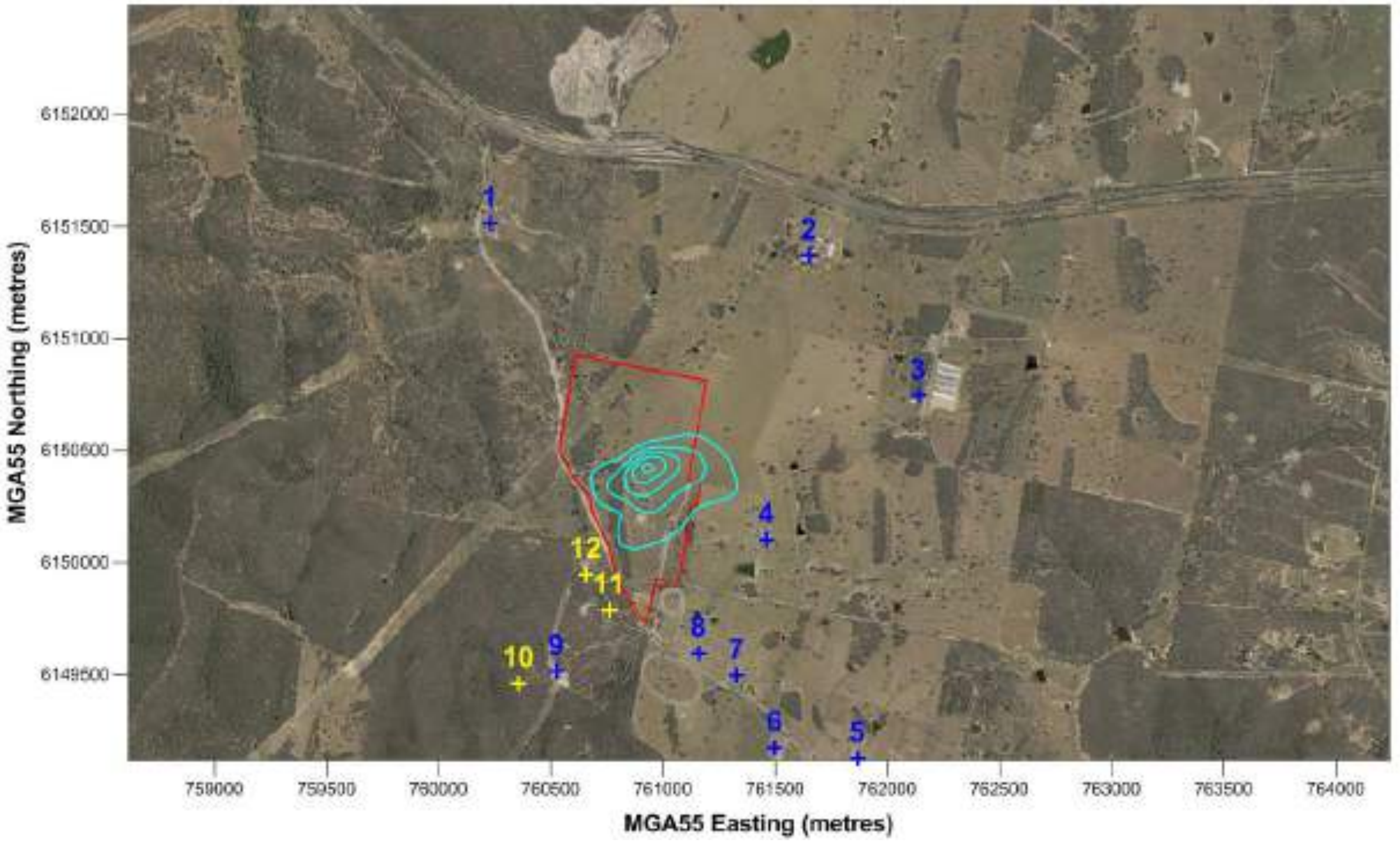
Legend:
Site Boundary
Existing Receptors
Proposed Receptors
GLC Contours
GLC at Criteria

GLC range:
0.0001 – 0.0629 mg/m^3

Contours Shown (Outer to Inner):
0.02, 0.03, 0.04, 0.05 and 0.06 mg/m^3

Criteria:
0.050 mg/m^3

Figure 5-6: Isopleth for PM_{10} Impacts Under 1-Year Averaging Time (Scenario 2)



Legend:
- Site Boundary
- Existing Receptors
- Proposed Receptors
- GLC Contours

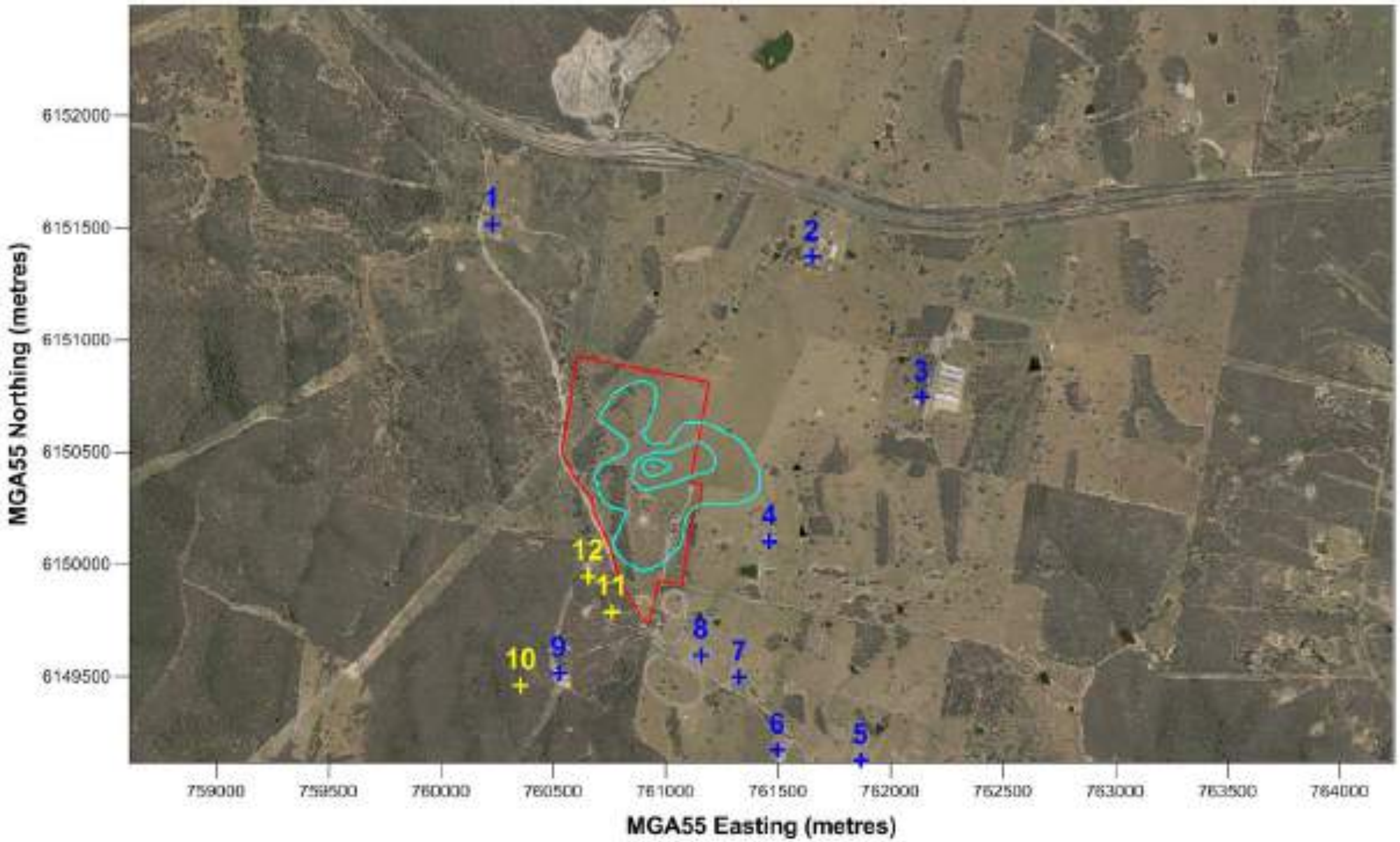
GLC range:
4.34×10^{-6} – 0.0110 mg/m^3

Contours Shown (Outer to Inner):
0.002, 0.004, 0.006, 0.008 and 0.01 mg/m^3

Criteria:
0.030 mg/m^3

Note:
The detected GLC range is lower than the criteria

Figure 5-7: Isopleth for TSP Impacts Under 1-Year Averaging Time (Scenario 2)



Legend:
Site Boundary
Existing Receptors
Proposed Receptors
GLC Contours

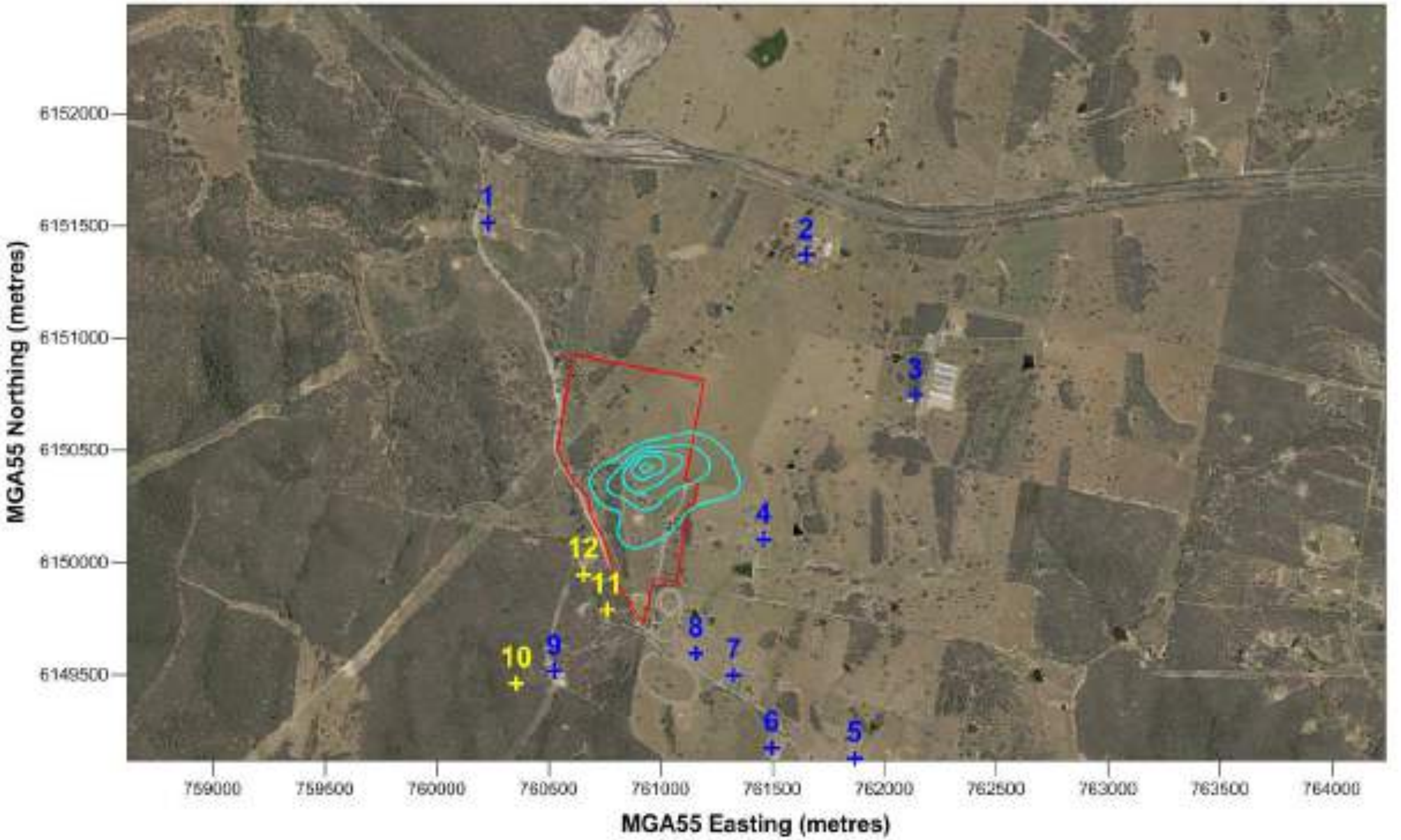
GLC range:
3.11 x 10^{-5} – 0.072 mg/m^3

Contours Shown (Outer to Inner):
0.01, 0.03, 0.05 and 0.07 mg/m^3

Criteria:
0.090 mg/m^3

Note:
The detected GLC range is lower than the criteria

Figure 5-8: Isopleth for Dust Deposition Impacts Under 1-Year Averaging Time (Scenario 2)



Legend:
- Site Boundary
- Existing Receptors
- Proposed Receptors
- GLC Contours

GLC range:
1.74×10^{-5} – 0.055 g/m^2/month

Contours Shown (Outer to Inner):
0.01, 0.02, 0.03, 0.04 and 0.05 g/m^2/month

Criteria:
2 g/m^2/month - incremental
4 g/m^2/month - cumulative

Note:
The detected GLC range is lower than the criteria

5.7 DISCUSSIONS

No exceedances were found for both scenarios except for the PM_{10} 24-hour averaging time impacts under Scenario 1. However, it has been found that the implementation of controls for the excavation, crushing, screening, loading, unloading and material handling eliminates the exceedances measured from Scenario 1.

The outcomes suggest that controls are compulsory in order to satisfy the assessment criteria. Other than this, it is expected that the proposed development would comply with the requirements listed in the DECC NSW approved guidelines.

6. CONCLUSION

The document "Approved Methods for the Modelling and Assessment of Air Pollutants in New South Wales" has been closely followed in preparing and conducting this quantitative air assessment. The assessment also involved the review and analysis of the site-specific operational parameters and activities relevant in assessing the environmental dust impacts that the subject site can potentially establish, especially upon the nearest receptors – may it be existing or proposed.

Air dispersion modelling outcomes suggest that controls are required in order to minimise the dust particulate impacts. It is suggested that controls, which are water sprays for dust suppression, be applied during excavation, crushing, screening, loading, unloading and material handling activities on site.

Provided that these controls are established, it is the opinion of Benbow Environmental that the proposed development satisfies the requirements of air quality compliance.

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7. REFERENCES

1. DEC NSW 2005
Department of Environment and Conservation, New South Wales, "Approved Methods for the Modelling and Assessment of Air Pollutants in New South Wales", August 2005

2. NPI DEH 2001
National Pollutant Inventory (NPI) Guidelines, "Emission Estimation Technique Manual (EETM) for Mining", Version 2.3, 5 December 2001

3. Parrett 1992
Parrett F.W. 1992, "Dust Emissions"- a review, Applied Environmetrics, 1992

4. USEPA 2004
U.S. Environment Protection Agency, "Chapter 11.19 – Introduction to Construction and Aggregate Processing, Section 2 – Crushed Stone Processing and Pulverized Mineral Processing", August 2004

8. BIBLIOGRAPHY

1. "Good Practice Guide for Atmospheric Dispersion Modelling", Prepared by the National Institute of Water and Atmospheric Research, Aurora Pacific Limited and Earth Tech Incorporated for the Ministry for the Environment (New Zealand), June 2004

9. LIMITATIONS

Our services for this project are carried out in accordance with our current professional standards for site assessment investigations. No guarantees are either expressed or implied.

This report has been prepared solely for the use by Marian Vale Pastoral Co Pty Ltd and Figtree Reserve Pty Ltd, as per our agreement for providing environmental assessment services. Although all due care has been taken in the preparation of this study, no warranty is given, nor liability accepted (except that required by law) in relation to the information contained within this document.

Marian Vale Pastoral Co Pty Ltd and Figtree Reserve Pty Ltd are entitled to rely upon the findings in the report within the scope of work described in this report. No responsibility is accepted for the use of any part of the report in any other context or for any other purpose.

Opinions and judgements expressed herein, which are based on our understanding and interpretation of current regulatory standards, should not be construed as legal opinions.

ATTACHMENTS

Attachment 1: Extract of a Sample CALPUFF Control File

```
109099
CALPUFF
Loading, Unloading and Material Handling - TOTAL
---------------- Run title (3 lines) ------------------------------------------

                    CALPUFF MODEL CONTROL FILE
                    --------------------------

-------------------------------------------------------------------------------

INPUT GROUP: 0 -- Input and Output File Names

--------------
Default Name  Type          File Name
------------  ----          ---------
CALMET.DAT    input    ! METDAT =C:\ACTIVE~1\109099\CALMET\CALMET.DAT   !
    or
ISCMET.DAT    input    * ISCDAT =             *
    or
PLMMET.DAT    input    * PLMDAT =             *
    or
PROFILE.DAT   input    * PRFDAT =             *
SURFACE.DAT   input    * SFCDAT =             *
RESTARTB.DAT  input    * RSTARTB=             *
--------------------------------------------------------------------------------
CALPUFF.LST   output   ! PUFLST =C:\ACTIVE~1\109099\CALPUFF\CPFLU.LST  !
CONC.DAT      output   ! CONDAT =C:\ACTIVE~1\109099\CALPUFF\CPFLUC.DAT     !
DFLX.DAT      output   ! DFDAT  =C:\ACTIVE~1\109099\CALPUFF\CPFLUF.DAT     !
WFLX.DAT      output   * WFDAT  =             *

VISB.DAT      output   * VISDAT =             *
TK2D.DAT      output   * T2DDAT =             *
RHO2D.DAT     output   * RHODAT =             *
RESTARTE.DAT  output   * RSTARTE=             *
--------------------------------------------------------------------------------
Emission Files
--------------
PTEMARB.DAT   input    * PTDAT  =             *
VOLEMARB.DAT  input    * VOLDAT =             *
BAEMARB.DAT   input    * ARDAT  =             *
LNEMARB.DAT   input    * LNDAT  =             *
--------------------------------------------------------------------------------
Other Files
-----------
OZONE.DAT     input    * OZDAT  =             *
VD.DAT        input    * VDDAT  =             *
CHEM.DAT      input    * CHEMDAT=             *
H2O2.DAT      input    * H2O2DAT=             *
HILL.DAT      input    * HILDAT=             *
HILLRCT.DAT   input    * RCTDAT=             *
COASTLN.DAT   input    * CSTDAT=             *
FLUXBDY.DAT   input    * BDYDAT=             *
BCON.DAT      input    * BCNDAT=             *
DEBUG.DAT     output   * DEBUG =             *
MASSFLX.DAT   output   * FLXDAT=             *
MASSBAL.DAT   output   * BALDAT=             *
FOG.DAT       output   * FOGDAT=             *
--------------------------------------------------------------------------------
All file names will be converted to lower case if LCFILES = T
Otherwise, if LCFILES = F, file names will be converted to UPPER CASE
         T = lower case      ! LCFILES = F !
         F = UPPER CASE
NOTE: (1) file/path names can be up to 70 characters in length


Provision for multiple input files
----------------------------------

     Number of CALMET.DAT files for run (NMETDAT)
                                Default: 1       ! NMETDAT =   1   !
```

```
     Number of PTEMARB.DAT files for run (NPTDAT)
                                Default: 0       ! NPTDAT =  0  !

     Number of BAEMARB.DAT files for run (NARDAT)
                                Default: 0       ! NARDAT =  0  !

     Number of VOLEMARB.DAT files for run (NVOLDAT)
                                Default: 0       ! NVOLDAT =  0  !

!END!

-------------
Subgroup (0a)
-------------

  The following CALMET.DAT filenames are processed in sequence if NMETDAT>1

Default Name  Type          File Name
------------  ----          ---------
 none         input    * METDAT=     *   *END*


--------------------------------------------------------------------------------

INPUT GROUP: 1 -- General run control parameters
--------------

    Option to run all periods found
    in the met. file     (METRUN)   Default: 0       ! METRUN =   0  !

         METRUN = 0 - Run period explicitly defined below
         METRUN = 1 - Run all periods in met. file

     Starting date:    Year   (IBYR)  --    No default   ! IBYR  =  2007  !
                       Month  (IBMO)  --    No default   ! IBMO  =  1  !
                       Day    (IBDY)  --    No default   ! IBDY  =  1  !
     Starting time:    Hour   (IBHR)  --    No default   ! IBHR  =  1  !
                       Minute (IBMIN) --    No default   ! IBMIN =  0  !
                       Second (IBSEC) --    No default   ! IBSEC =  0  !

     Ending date:      Year   (IEYR)  --    No default   ! IEYR  =  2008  !
                       Month  (IEMO)  --    No default   ! IEMO  =  1  !
                       Day    (IEDY)  --    No default   ! IEDY  =  1  !
     Ending time:      Hour   (IEHR)  --    No default   ! IEHR  =  1  !
                       Minute (IEMIN) --    No default   ! IEMIN =  0  !
                       Second (IESEC) --    No default   ! IESEC =  0  !

     (These are only used if METRUN = 0)

     Base time zone        (XBTZ) -- No default       ! XBTZ= -10.0  !
     The zone is the number of hours that must be
     ADDED to the time to obtain UTC (or GMT)
     Examples: PST = 8., MST = 7.
               CST = 6., EST = 5.

     Length of modeling time-step (seconds)
     Equal to update period in the primary
     meteorological data files, or an
     integer fraction of it (1/2, 1/3 ...)
     Must be no larger than 1 hour
     (NSECDT)                   Default:3600     ! NSECDT =  3600  !
                                Units: seconds

     Number of chemical species (NSPEC)
                                Default: 5       ! NSPEC =  2   !

     Number of chemical species
     to be emitted  (NSE)       Default: 3       ! NSE =  2   !

     Flag to stop run after
     SETUP phase (ITEST)        Default: 2       ! ITEST =  2   !
     (Used to allow checking
```

```
     of the model inputs, files, etc.)
           ITEST = 1 - STOPS program after SETUP phase
           ITEST = 2 - Continues with execution of program
                       after SETUP

     Restart Configuration:

        Control flag (MRESTART)      Default: 0       ! MRESTART =  0   !

           0 = Do not read or write a restart file
           1 = Read a restart file at the beginning of
               the run
           2 = Write a restart file during run
           3 = Read a restart file at beginning of run
               and write a restart file during run

        Number of periods in Restart
        output cycle (NRESPD)        Default: 0       ! NRESPD =  0   !

           0 = File written only at last period
          >0 = File updated every NRESPD periods

     Meteorological Data Format (METFM)
                                     Default: 1       ! METFM =  1   !

           METFM = 1 - CALMET binary file (CALMET.MET)
           METFM = 2 - ISC ASCII file (ISCMET.MET)
           METFM = 3 - AUSPLUME ASCII file (PLMMET.MET)
           METFM = 4 - CTDM plus tower file (PROFILE.DAT) and
                       surface parameters file (SURFACE.DAT)
           METFM = 5 - AERMET tower file (PROFILE.DAT) and
                       surface parameters file (SURFACE.DAT)

     Meteorological Profile Data Format (MPRFFM)
            (used only for METFM = 1, 2, 3)
                                     Default: 1       ! MPRFFM =  1   !

           MPRFFM = 1 - CTDM plus tower file (PROFILE.DAT)
           MPRFFM = 2 - AERMET tower file (PROFILE.DAT)

     PG sigma-y is adjusted by the factor (AVET/PGTIME)**0.2
     Averaging Time (minutes) (AVET)
                                     Default: 60.0    ! AVET = 60. !
     PG Averaging Time (minutes) (PGTIME)
                                     Default: 60.0    ! PGTIME = 60. !


!END!


--------------------------------------------------------------------------------

INPUT GROUP: 2 -- Technical options
--------------


     Vertical distribution used in the
     near field (MGAUSS)                   Default: 1     ! MGAUSS =  1   !
        0 = uniform
        1 = Gaussian

     Terrain adjustment method
     (MCTADJ)                              Default: 3     ! MCTADJ =  3   !
        0 = no adjustment
        1 = ISC-type of terrain adjustment
        2 = simple, CALPUFF-type of terrain
            adjustment
        3 = partial plume path adjustment

     Subgrid-scale complex terrain
     flag (MCTSG)                          Default: 0     ! MCTSG =  0   !
        0 = not modeled
```

```
   1 = modeled

Near-field puffs modeled as
elongated slugs? (MSLUG)              Default: 0     ! MSLUG =  0   !
   0 = no
   1 = yes (slug model used)

Transitional plume rise modeled?
(MTRANS)                              Default: 1     ! MTRANS =  1   !
   0 = no  (i.e., final rise only)
   1 = yes (i.e., transitional rise computed)

Stack tip downwash? (MTIP)            Default: 1     ! MTIP =  1  !
   0 = no  (i.e., no stack tip downwash)
   1 = yes (i.e., use stack tip downwash)

Method used to simulate building
downwash? (MBDW)                      Default: 1     ! MBDW =   1  !
   1 = ISC method
   2 = PRIME method

Vertical wind shear modeled above
stack top? (MSHEAR)                   Default: 0     ! MSHEAR =  0  !
   0 = no  (i.e., vertical wind shear not modeled)
   1 = yes (i.e., vertical wind shear modeled)

Puff splitting allowed? (MSPLIT)      Default: 0     ! MSPLIT =  0  !
   0 = no (i.e., puffs not split)
   1 = yes (i.e., puffs are split)

Chemical mechanism flag (MCHEM)       Default: 1     ! MCHEM =  0   !
   0 = chemical transformation not
       modeled
   1 = transformation rates computed
       internally (MESOPUFF II scheme)
   2 = user-specified transformation
       rates used
   3 = transformation rates computed
       internally (RIVAD/ARM3 scheme)
   4 = secondary organic aerosol formation
       computed (MESOPUFF II scheme for OH)

Aqueous phase transformation flag (MAQCHEM)
(Used only if MCHEM = 1, or 3)        Default: 0     ! MAQCHEM =  0   !
   0 = aqueous phase transformation
       not modeled
   1 = transformation rates adjusted
       for aqueous phase reactions

Wet removal modeled ? (MWET)          Default: 1     ! MWET =  0   !
   0 = no
   1 = yes

Dry deposition modeled ? (MDRY)       Default: 1     ! MDRY =  1   !
   0 = no
   1 = yes
   (dry deposition method specified
    for each species in Input Group 3)


Gravitational settling (plume tilt)
modeled ? (MTILT)                     Default: 0     ! MTILT =  0   !
   0 = no
   1 = yes
   (puff center falls at the gravitational
    settling velocity for 1 particle species)

Restrictions:
    - MDRY  = 1
    - NSPEC = 1  (must be particle species as well)
    - sg    = 0  GEOMETRIC STANDARD DEVIATION in Group 8 is
                 set to zero for a single particle diameter
```

```
Method used to compute dispersion
coefficients (MDISP)                 Default: 3     ! MDISP =  3   !

   1 = dispersion coefficients computed from measured values
       of turbulence, sigma v, sigma w
   2 = dispersion coefficients from internally calculated
       sigma v, sigma w using micrometeorological variables
       (u*, w*, L, etc.)
   3 = PG dispersion coefficients for RURAL areas (computed using
       the ISCST multi-segment approximation) and MP coefficients in
       urban areas
   4 = same as 3 except PG coefficients computed using
       the MESOPUFF II eqns.
   5 = CTDM sigmas used for stable and neutral conditions.
       For unstable conditions, sigmas are computed as in
       MDISP = 3, described above.  MDISP = 5 assumes that
       measured values are read

Sigma-v/sigma-theta, sigma-w measurements used? (MTURBVW)
(Used only if MDISP = 1 or 5)        Default: 3     ! MTURBVW =  3  !
   1 = use sigma-v or sigma-theta measurements
       from PROFILE.DAT to compute sigma-y
       (valid for METFM = 1, 2, 3, 4, 5)
   2 = use sigma-w measurements
       from PROFILE.DAT to compute sigma-z
       (valid for METFM = 1, 2, 3, 4, 5)
   3 = use both sigma-(v/theta) and sigma-w
       from PROFILE.DAT to compute sigma-y and sigma-z
       (valid for METFM = 1, 2, 3, 4, 5)
   4 = use sigma-theta measurements
       from PLMMET.DAT to compute sigma-y
       (valid only if METFM = 3)

Back-up method used to compute dispersion
when measured turbulence data are
missing (MDISP2)                     Default: 3     ! MDISP2 =  3  !
(used only if MDISP = 1 or 5)
   2 = dispersion coefficients from internally calculated
       sigma v, sigma w using micrometeorological variables
       (u*, w*, L, etc.)
   3 = PG dispersion coefficients for RURAL areas (computed using
       the ISCST multi-segment approximation) and MP coefficients in
       urban areas
   4 = same as 3 except PG coefficients computed using
       the MESOPUFF II eqns.

[DIAGNOSTIC FEATURE]
Method used for Lagrangian timescale for Sigma-y
(used only if MDISP=1,2 or MDISP2=1,2)
(MTAULY)                             Default: 0     ! MTAULY =  0  !
   0 = Draxler default 617.284 (s)
   1 = Computed as Lag. Length / (.75 q) -- after SCIPUFF
  10 < Direct user input (s)             -- e.g., 306.9


[DIAGNOSTIC FEATURE]
Method used for Advective-Decay timescale for Turbulence
(used only if MDISP=2 or MDISP2=2)
(MTAUADV)                            Default: 0     ! MTAUADV =  0  !
   0 = No turbulence advection
   1 = Computed (OPTION NOT IMPLEMENTED)
  10 < Direct user input (s)   -- e.g., 300


Method used to compute turbulence sigma-v &
sigma-w using micrometeorological variables
(Used only if MDISP = 2 or MDISP2 = 2)
(MCTURB)                             Default: 1     ! MCTURB =  1  !
   1 = Standard CALPUFF subroutines
   2 = AERMOD subroutines
```

```
PG sigma-y,z adj. for roughness?      Default: 0     ! MROUGH =  0  !
(MROUGH)
   0 = no
   1 = yes

Partial plume penetration of          Default: 1     ! MPARTL =  1  !
elevated inversion?
(MPARTL)
   0 = no
   1 = yes

Strength of temperature inversion     Default: 0     ! MTINV =  0  !
provided in PROFILE.DAT extended records?
(MTINV)
   0 = no (computed from measured/default gradients)
   1 = yes

PDF used for dispersion under convective conditions?
                                      Default: 0     ! MPDF =  0  !
(MPDF)
   0 = no
   1 = yes

Sub-Grid TIBL module used for shore line?
                                      Default: 0     ! MSGTIBL = 0  !
(MSGTIBL)
   0 = no
   1 = yes

Boundary conditions (concentration) modeled?
                                      Default: 0     ! MBCON = 0  !
(MBCON)
   0 = no
   1 = yes, using formatted BCON.DAT file
   2 = yes, using unformatted CONC.DAT file

Note:  MBCON > 0 requires that the last species modeled
       be 'BCON'.  Mass is placed in species BCON when
       generating boundary condition puffs so that clean
       air entering the modeling domain can be simulated
       in the same way as polluted air.  Specify zero
       emission of species BCON for all regular sources.

Individual source contributions saved?
                                      Default: 0     ! MSOURCE = 0  !
(MSOURCE)
   0 = no
   1 = yes


Analyses of fogging and icing impacts due to emissions from
arrays of mechanically-forced cooling towers can be performed
using CALPUFF in conjunction with a cooling tower emissions
processor (CTEMISS) and its associated postprocessors.  Hourly
emissions of water vapor and temperature from each cooling tower
cell are computed for the current cell configuration and ambient
conditions by CTEMISS. CALPUFF models the dispersion of these
emissions and provides cloud information in a specialized format
for further analysis. Output to FOG.DAT is provided in either
'plume mode' or 'receptor mode' format.

Configure for FOG Model output?
                                      Default: 0     ! MFOG =  0   !
(MFOG)
   0 = no
   1 = yes  - report results in PLUME Mode format
   2 = yes  - report results in RECEPTOR Mode format


Test options specified to see if
they conform to regulatory
values? (MREG)                        Default: 1     ! MREG =  0   !
```

```
        0 = NO checks are made
        1 = Technical options must conform to USEPA
            Long Range Transport (LRT) guidance
                       METFM    1 or 2
                       AVET     60. (min)
                       PGTIME   60. (min)
                       MGAUSS   1
                       MCTADJ   3
                       MTRANS   1
                       MTIP     1
                       MCHEM    1 or 3 (if modeling SOx, NOx)
                       MWET     1
                       MDRY     1
                       MDISP    2 or 3
                       MPDF     0 if MDISP=3
                                1 if MDISP=2
                       MROUGH   0
                       MPARTL   1
                       SYTDEP   550. (m)
                       MHFTSZ   0


!END!


-------------------------------------------------------------------------------

INPUT GROUP: 3a, 3b -- Species list
-------------------

------------
Subgroup (3a)
------------

  The following species are modeled:

! CSPEC =         PM10 !         !END!
! CSPEC =          PMC !         !END!

                                                       Dry                 OUTPUT
GROUP
    SPECIES                 MODELED                EMITTED            DEPOSITED
NUMBER
     NAME                  (0=NO,  1=YES)         (0=NO,  1=YES)         (0=NO,
(0=NONE,
   (Limit: 12                                      1=COMPUTED-GAS        1=1st
CGRUP,
    Characters                                     2=COMPUTED-PARTICLE   2=2nd
CGRUP,
    in length)                                       3=USER-SPECIFIED)     3=
etc.)

!         PM10  =         1,                1,           0,                 0   !
!          PMC  =         1,                1,           2,                 0   !

!END!

  Note:  The last species in (3a) must be 'BCON' when using the
         boundary condition option (MBCON > 0).  Species BCON should
         typically be modeled as inert (no chem transformation or
         removal).


-------------
Subgroup (3b)
-------------
  The following names are used for Species-Groups in which results
  for certain species are combined (added) prior to output.  The
  CGRUP name will be used as the species name in output files.
  Use this feature to model specific particle-size distributions
  by treating each size-range as a separate species.
```

```
  Order must be consistent with 3(a) above.


-------------------------------------------------------------------------------

INPUT GROUP: 4 -- Map Projection and Grid control parameters
--------------

     Projection for all (X,Y):
     -------------------------

     Map projection
     (PMAP)                     Default: UTM    ! PMAP = UTM  !

         UTM :  Universal Transverse Mercator
         TTM :  Tangential Transverse Mercator
         LCC :  Lambert Conformal Conic
          PS :  Polar Stereographic
          EM :  Equatorial Mercator
        LAZA :  Lambert Azimuthal Equal Area

     False Easting and Northing (km) at the projection origin
     (Used only if PMAP= TTM, LCC, or LAZA)
     (FEAST)                    Default=0.0     ! FEAST  = 0.000  !
     (FNORTH)                   Default=0.0     ! FNORTH = 0.000  !

     UTM zone (1 to 60)
     (Used only if PMAP=UTM)
     (IUTMZN)                   No Default      ! IUTMZN =  55   !

     Hemisphere for UTM projection?
     (Used only if PMAP=UTM)
     (UTMHEM)                   Default: N      ! UTMHEM = S  !
         N   :  Northern hemisphere projection
         S   :  Southern hemisphere projection

     Latitude and Longitude (decimal degrees) of projection origin
     (Used only if PMAP= TTM, LCC, PS, EM, or LAZA)
     (RLAT0)                    No Default      ! RLAT0 =  0N  !
     (RLON0)                    No Default      ! RLON0 =  0E  !

         TTM :  RLON0 identifies central (true N/S) meridian of projection
                RLAT0 selected for convenience
         LCC :  RLON0 identifies central (true N/S) meridian of projection
                RLAT0 selected for convenience
         PS  :  RLON0 identifies central (grid N/S) meridian of projection
                RLAT0 selected for convenience
         EM  :  RLON0 identifies central meridian of projection
                RLAT0 is REPLACED by 0.0N (Equator)
         LAZA:  RLON0 identifies longitude of tangent-point of mapping plane
                RLAT0 identifies latitude of tangent-point of mapping plane

     Matching parallel(s) of latitude (decimal degrees) for projection
     (Used only if PMAP= LCC or PS)
     (XLAT1)                    No Default      ! XLAT1 =  0N  !
     (XLAT2)                    No Default      ! XLAT2 =  0N  !

         LCC :   Projection cone slices through Earth's surface at XLAT1 and
XLAT2
         PS  :  Projection plane slices through Earth at XLAT1
                (XLAT2 is not used)

     ----------
     Note:  Latitudes and longitudes should be positive, and include a
            letter N,S,E, or W indicating north or south latitude, and
            east or west longitude.  For example,
            35.9  N Latitude  =  35.9N
            118.7 E Longitude = 118.7E
```

```
     Datum-region
     ------------

     The Datum-Region for the coordinates is identified by a character
     string.  Many mapping products currently available use the model of the
     Earth known as the World Geodetic System 1984 (WGS-84).  Other local
     models may be in use, and their selection in CALMET will make its output
     consistent with local mapping products.  The list of Datum-Regions with
     official transformation parameters is provided by the National Imagery and
     Mapping Agency (NIMA).

     NIMA Datum - Regions(Examples)
     --------------------------------------------------------------------------
---
     WGS-84    WGS-84 Reference Ellipsoid and Geoid, Global coverage (WGS84)
     NAS-C     NORTH AMERICAN 1927 Clarke 1866 Spheroid, MEAN FOR CONUS (NAD27)
     NAR-C     NORTH AMERICAN 1983 GRS 80 Spheroid, MEAN FOR CONUS (NAD83)
     NWS-84    NWS 6370KM Radius, Sphere
     ESR-S     ESRI REFERENCE 6371KM Radius, Sphere

     Datum-region for output coordinates
     (DATUM)                   Default: WGS-84    ! DATUM = AUG  !


METEOROLOGICAL Grid:

     Rectangular grid defined for projection PMAP,
     with X the Easting and Y the Northing coordinate

            No. X grid cells (NX)      No default     ! NX =  113   !
            No. Y grid cells (NY)      No default     ! NY =  68   !
         No. vertical layers (NZ)      No default     ! NZ =  10   !

           Grid spacing (DGRIDKM)      No default     ! DGRIDKM = .05 !
                                       Units: km

                Cell face heights
                    (ZFACE(nz+1))      No defaults
                                       Units: m
   ! ZFACE = .0, 20.0, 40.0, 80.0, 150.0, 250.0, 500.0, 750.0, 1000.0, 1500.0,
              2000.0 !

            Reference Coordinates
           of SOUTHWEST corner of
                 grid cell(1, 1):

            X coordinate (XORIGKM)     No default     ! XORIGKM = 758.616 !
            Y coordinate (YORIGKM)     No default     ! YORIGKM = 6149.116 !
                                      Units: km


COMPUTATIONAL Grid:

     The computational grid is identical to or a subset of the MET. grid.
     The lower left (LL) corner of the computational grid is at grid point
     (IBCOMP, JBCOMP) of the MET. grid.  The upper right (UR) corner of the
     computational grid is at grid point (IECOMP, JECOMP) of the MET. grid.
     The grid spacing of the computational grid is the same as the MET. grid.

        X index of LL corner (IBCOMP)      No default     ! IBCOMP =  1   !
                  (1 <= IBCOMP <= NX)

        Y index of LL corner (JBCOMP)      No default     ! JBCOMP =  1   !
                  (1 <= JBCOMP <= NY)


        X index of UR corner (IECOMP)      No default     ! IECOMP =  113   !
                  (1 <= IECOMP <= NX)

        Y index of UR corner (JECOMP)      No default     ! JECOMP =  68   !
                  (1 <= JECOMP <= NY)
```

```
SAMPLING Grid (GRIDDED RECEPTORS):

     The lower left (LL) corner of the sampling grid is at grid point
     (IBSAMP, JBSAMP) of the MET. grid.  The upper right (UR) corner of the
     sampling grid is at grid point (IESAMP, JESAMP) of the MET. grid.
     The sampling grid must be identical to or a subset of the computational
     grid.  It may be a nested grid inside the computational grid.
     The grid spacing of the sampling grid is DGRIDKM/MESHDN.

        Logical flag indicating if gridded
        receptors are used (LSAMP)        Default: T     ! LSAMP = T !
        (T=yes, F=no)

        X index of LL corner (IBSAMP)     No default     ! IBSAMP =  1   !
         (IBCOMP <= IBSAMP <= IECOMP)

        Y index of LL corner (JBSAMP)     No default     ! JBSAMP =  1   !
         (JBCOMP <= JBSAMP <= JECOMP)


        X index of UR corner (IESAMP)     No default     ! IESAMP =  113   !
         (IBCOMP <= IESAMP <= IECOMP)

        Y index of UR corner (JESAMP)     No default     ! JESAMP =  68   !
         (JBCOMP <= JESAMP <= JECOMP)


       Nesting factor of the sampling
        grid (MESHDN)                     Default: 1     ! MESHDN =  1  !
        (MESHDN is an integer >= 1)

!END!


-------------------------------------------------------------------------------


INPUT GROUP: 5 -- Output Options
--------------
                                             *                          *
     FILE                       DEFAULT VALUE             VALUE THIS RUN
     ----                       -------------             --------------

   Concentrations (ICON)              1                   !  ICON =  1   !
   Dry Fluxes (IDRY)                  1                   !  IDRY =  1   !
   Wet Fluxes (IWET)                  1                   !  IWET =  0   !
   2D Temperature (IT2D)              0                   !  IT2D =  0   !
   2D Density (IRHO)                  0                   !  IRHO =  0   !
   Relative Humidity (IVIS)           1                   !  IVIS =  0   !
    (relative humidity file is
     required for visibility
     analysis)
   Use data compression option in output file?
   (LCOMPRS)                          Default: T          ! LCOMPRS = T !

   *
    0 = Do not create file, 1 = create file


    QA PLOT FILE OUTPUT OPTION:

       Create a standard series of output files (e.g.
       locations of sources, receptors, grids ...)
       suitable for plotting?
       (IQAPLOT)                      Default: 1          !  IQAPLOT =  1   !
         0 = no
         1 = yes

    DIAGNOSTIC MASS FLUX OUTPUT OPTIONS:
```

```
       Mass flux across specified boundaries
       for selected species reported?
       (IMFLX)                         Default: 0         ! IMFLX =  0  !
         0 = no
         1 = yes (FLUXBDY.DAT and MASSFLX.DAT filenames
                  are specified in Input Group 0)

       Mass balance for each species
       reported?
       (IMBAL)                         Default: 0         ! IMBAL =  0  !
         0 = no
         1 = yes (MASSBAL.DAT filename is
              specified in Input Group 0)


    LINE PRINTER OUTPUT OPTIONS:

       Print concentrations (ICPRT)    Default: 0         ! ICPRT =  0   !
       Print dry fluxes (IDPRT)        Default: 0         ! IDPRT =  0   !
       Print wet fluxes (IWPRT)        Default: 0         ! IWPRT =  0   !
       (0 = Do not print, 1 = Print)

       Concentration print interval
       (ICFRQ) in timesteps            Default: 1         ! ICFRQ =  1   !
       Dry flux print interval
       (IDFRQ) in timesteps            Default: 1         ! IDFRQ =  1   !
       Wet flux print interval
       (IWFRQ) in timesteps            Default: 1         ! IWFRQ =  1   !

       Units for Line Printer Output
       (IPRTU)                         Default: 1         ! IPRTU =  1   !
                       for            for
                  Concentration    Deposition
           1 =       g/m**3         g/m**2/s
           2 =      mg/m**3        mg/m**2/s
           3 =      ug/m**3        ug/m**2/s
           4 =      ng/m**3        ng/m**2/s
           5 =     Odour Units

       Messages tracking progress of run
       written to the screen ?
       (IMESG)                         Default: 2         ! IMESG =  2   !
         0 = no
         1 = yes (advection step, puff ID)
         2 = yes (YYYYJJJHH, # old puffs, # emitted puffs)


     SPECIES (or GROUP for combined species) LIST FOR OUTPUT OPTIONS

                 ---- CONCENTRATIONS ----    ------ DRY FLUXES ------    ------
WET FLUXES ------   -- MASS FLUX --
   SPECIES
   /GROUP        PRINTED?  SAVED ON DISK?   PRINTED?  SAVED ON DISK?   PRINTED?
SAVED ON DISK?   SAVED ON DISK?
   -------       ------------------------   ------------------------   ---------
---------------   ---------------
!          PM10 =      0,            1,            0,            1,            0,
0,           0   !
!           PMC =      0,            1,            0,            1,            0,
0,           0   !

  Note:  Species BCON (for MBCON > 0) does not need to be saved on disk.


     OPTIONS FOR PRINTING "DEBUG" QUANTITIES (much output)

       Logical for debug output
       (LDEBUG)                                 Default: F     ! LDEBUG = F !

       First puff to track
       (IPFDEB)                                 Default: 1     ! IPFDEB =  1  !
```

```
       Number of puffs to track
       (NPFDEB)                            Default: 1     ! NPFDEB =  1  !

       Met. period to start output
       (NN1)                               Default: 1     ! NN1 =  1   !

       Met. period to end output
       (NN2)                               Default: 10    ! NN2 =  10  !

!END!


-------------------------------------------------------------------------------


INPUT GROUP: 6a, 6b, & 6c -- Subgrid scale complex terrain inputs
-------------------------

---------------
Subgroup (6a)
---------------
       Number of terrain features (NHILL)       Default: 0     ! NHILL =  0   !

       Number of special complex terrain
       receptors  (NCTREC)                 Default: 0     ! NCTREC =  0   !

       Terrain and CTSG Receptor data for
       CTSG hills input in CTDM format ?
       (MHILL)                             No Default     ! MHILL =  2   !
       1 = Hill and Receptor data created
           by CTDM processors & read from
           HILL.DAT and HILLRCT.DAT files
       2 = Hill data created by OPTHILL &
           input below in Subgroup (6b);
           Receptor data in Subgroup (6c)

       Factor to convert horizontal dimensions  Default: 1.0   ! XHILL2M = 1.0 !
       to meters (MHILL=1)

       Factor to convert vertical dimensions    Default: 1.0   ! ZHILL2M = 1.0 !
       to meters (MHILL=1)

       X-origin of CTDM system relative to      No Default     ! XCTDMKM = 0 !
       CALPUFF coordinate system, in Kilometers (MHILL=1)

       Y-origin of CTDM system relative to      No Default     ! YCTDMKM = 0 !
       CALPUFF coordinate system, in Kilometers (MHILL=1)

! END !

---------------
Subgroup (6b)
---------------

                      1 **
     HILL information


HILL            XC          YC         THETAH  ZGRID  RELIEF    EXPO 1    EXPO 2
SCALE 1    SCALE 2    AMAX1     AMAX2
 NO.             (km)        (km)       (deg.)    (m)      (m)       (m)        (m)
(m)        (m)        (m)        (m)
----           ----       ----       ------  -----  ------    ------    ------   --
-----    -------    -----     -----

---------------
Subgroup (6c)
---------------

    COMPLEX TERRAIN RECEPTOR INFORMATION

                      XRCT         YRCT        ZRCT          XHH
```

```
                      (km)         (km)         (m)
                     ------        -----      ------         ----


-------------------
1
     Description of Complex Terrain Variables:
          XC, YC  = Coordinates of center of hill
          THETAH  = Orientation of major axis of hill (clockwise from
                    North)
          ZGRID   = Height of the  0  of the grid above mean sea
                    level
          RELIEF  = Height of the crest of the hill above the grid elevation
          EXPO 1  = Hill-shape exponent for the major axis
          EXPO 2  = Hill-shape exponent for the major axis
          SCALE 1 = Horizontal length scale along the major axis
          SCALE 2 = Horizontal length scale along the minor axis
          AMAX    = Maximum allowed axis length for the major axis
          BMAX    = Maximum allowed axis length for the major axis

          XRCT, YRCT = Coordinates of the complex terrain receptors
          ZRCT    = Height of the ground (MSL) at the complex terrain
                    Receptor
          XHH     = Hill number associated with each complex terrain receptor
                    (NOTE: MUST BE ENTERED AS A REAL NUMBER)

   **
     NOTE: DATA for each hill and CTSG receptor are treated as a separate
           input subgroup and therefore must end with an input group terminator.

-------------------------------------------------------------------------------


INPUT GROUP: 7 -- Chemical parameters for dry deposition of gases
--------------

      SPECIES       DIFFUSIVITY        ALPHA STAR        REACTIVITY     MESOPHYLL
RESISTANCE     HENRY'S LAW COEFFICIENT
       NAME        (cm**2/s)                                                (s/cm)
(dimensionless)
      -------     -----------       ----------       ----------    ---------------
-----     -----------------------


!END!


-------------------------------------------------------------------------------


INPUT GROUP: 8 -- Size parameters for dry deposition of particles
--------------

     For SINGLE SPECIES, the mean and standard deviation are used to
     compute a deposition velocity for NINT (see group 9) size-ranges,
     and these are then averaged to obtain a mean deposition velocity.

     For GROUPED SPECIES, the size distribution should be explicitly
     specified (by the 'species' in the group), and the standard deviation
     for each should be entered as 0.  The model will then use the
     deposition velocity for the stated mean diameter.

      SPECIES      GEOMETRIC MASS MEAN        GEOMETRIC STANDARD
       NAME             DIAMETER                   DEVIATION
                        (microns)                  (microns)
      -------      -------------------        ------------------
!          PMC =           3.0,                     2.0   !

!END!


-------------------------------------------------------------------------------
```

```
INPUT GROUP: 9 -- Miscellaneous dry deposition parameters
--------------

     Reference cuticle resistance (s/cm)
     (RCUTR)                          Default: 30    !  RCUTR = 30.0 !
     Reference ground resistance  (s/cm)
     (RGR)                            Default: 10    !    RGR = 10.0 !
     Reference pollutant reactivity
     (REACTR)                         Default: 8     ! REACTR = 8.0 !

     Number of particle-size intervals used to
     evaluate effective particle deposition velocity
     (NINT)                           Default: 9     !   NINT =  9  !

     Vegetation state in unirrigated areas
     (IVEG)                           Default: 1     !   IVEG =  1   !
        IVEG=1 for active and unstressed vegetation
        IVEG=2 for active and stressed vegetation
        IVEG=3 for inactive vegetation

!END!


-------------------------------------------------------------------------------


INPUT GROUP: 10 -- Wet Deposition Parameters
---------------


                      Scavenging Coefficient -- Units: (sec)**(-1)

       Pollutant      Liquid Precip.       Frozen Precip.
       ---------      --------------       --------------

!END!


-------------------------------------------------------------------------------


INPUT GROUP: 11 -- Chemistry Parameters
---------------

     Ozone data input option (MOZ)     Default: 1            ! MOZ =  0   !
     (Used only if MCHEM = 1, 3, or 4)
        0 = use a monthly background ozone value
        1 = read hourly ozone concentrations from
            the OZONE.DAT data file

     Monthly ozone concentrations
     (Used only if MCHEM = 1, 3, or 4 and
      MOZ = 0 or MOZ = 1 and all hourly O3 data missing)
     (BCKO3) in ppb                   Default: 12*80.
     !  BCKO3 = 80.00, 80.00, 80.00, 80.00, 80.00, 80.00, 80.00, 80.00, 80.00,
80.00, 80.00, 80.00 !

     Monthly ammonia concentrations
     (Used only if MCHEM = 1, or 3)
     (BCKNH3) in ppb                  Default: 12*10.
     !  BCKNH3 = 10.00, 10.00, 10.00, 10.00, 10.00, 10.00, 10.00, 10.00, 10.00,
10.00, 10.00, 10.00 !

     Nighttime SO2 loss rate (RNITE1)
     in percent/hour                  Default: 0.2          ! RNITE1 = .2 !

     Nighttime NOx loss rate (RNITE2)
     in percent/hour                  Default: 2.0          ! RNITE2 = 2.0 !

     Nighttime HNO3 formation rate (RNITE3)
```

```
     in percent/hour                  Default: 2.0         ! RNITE3 = 2.0 !

     H2O2 data input option (MH2O2)    Default: 1           ! MH2O2 =  1   !
     (Used only if MAQCHEM = 1)
        0 = use a monthly background H2O2 value
        1 = read hourly H2O2 concentrations from
            the H2O2.DAT data file

     Monthly H2O2 concentrations
     (Used only if MQACHEM = 1 and
      MH2O2 = 0 or MH2O2 = 1 and all hourly H2O2 data missing)
     (BCKH2O2) in ppb                  Default: 12*1.
     !   BCKH2O2 = 1.00, 1.00, 1.00, 1.00, 1.00, 1.00, 1.00, 1.00, 1.00, 1.00,
1.00, 1.00 !


 --- Data for SECONDARY ORGANIC AEROSOL (SOA) Option
     (used only if MCHEM = 4)

     The SOA module uses monthly values of:
          Fine particulate concentration in ug/m^3 (BCKPMF)
          Organic fraction of fine particulate     (OFRAC)
          VOC / NOX ratio (after reaction)         (VCNX)
     to characterize the air mass when computing
     the formation of SOA from VOC emissions.
     Typical values for several distinct air mass types are:

        Month    1    2    3    4    5    6    7    8    9   10   11   12
                Jan  Feb  Mar  Apr  May  Jun  Jul  Aug  Sep  Oct  Nov  Dec

     Clean Continental
        BCKPMF   1.   1.   1.   1.   1.   1.   1.   1.   1.   1.   1.   1.
        OFRAC  .15  .15  .20  .20  .20  .20  .20  .20  .20  .20  .20  .15
        VCNX    50.  50.  50.  50.  50.  50.  50.  50.  50.  50.  50.  50.

     Clean Marine (surface)
        BCKPMF  .5   .5   .5   .5   .5   .5   .5   .5   .5   .5   .5   .5
        OFRAC  .25  .25  .30  .30  .30  .30  .30  .30  .30  .30  .30  .25
        VCNX    50.  50.  50.  50.  50.  50.  50.  50.  50.  50.  50.  50.

     Urban - low biogenic (controls present)
        BCKPMF  30.  30.  30.  30.  30.  30.  30.  30.  30.  30.  30.  30.
        OFRAC  .20  .20  .25  .25  .25  .25  .25  .25  .20  .20  .20  .20
        VCNX     4.   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.   4.

     Urban - high biogenic (controls present)
        BCKPMF  60.  60.  60.  60.  60.  60.  60.  60.  60.  60.  60.  60.
        OFRAC  .25  .25  .30  .30  .30  .55  .55  .55  .35  .35  .35  .25
        VCNX    15.  15.  15.  15.  15.  15.  15.  15.  15.  15.  15.  15.

     Regional Plume
        BCKPMF  20.  20.  20.  20.  20.  20.  20.  20.  20.  20.  20.  20.
        OFRAC  .20  .20  .25  .35  .25  .40  .40  .40  .30  .30  .30  .20
        VCNX    15.  15.  15.  15.  15.  15.  15.  15.  15.  15.  15.  15.

     Urban - no controls present
        BCKPMF 100. 100. 100. 100. 100. 100. 100. 100. 100. 100. 100. 100.
        OFRAC  .30  .30  .35  .35  .35  .55  .55  .55  .35  .35  .35  .30
        VCNX     2.   2.   2.   2.   2.   2.   2.   2.   2.   2.   2.   2.

     Default: Clean Continental
     !   BCKPMF = 1.00, 1.00, 1.00, 1.00, 1.00, 1.00, 1.00, 1.00, 1.00, 1.00,
1.00, 1.00 !
     !   OFRAC  = 0.15, 0.15, 0.20, 0.20, 0.20, 0.20, 0.20, 0.20, 0.20, 0.20,
0.20, 0.15 !
     !  VCNX   = 50.00, 50.00, 50.00, 50.00, 50.00, 50.00, 50.00, 50.00, 50.00,
50.00, 50.00, 50.00 !


!END!
```

```
--------------------------------------------------------------------------------

INPUT GROUP: 12 -- Misc. Dispersion and Computational Parameters
---------------

     Horizontal size of puff (m) beyond which
     time-dependent dispersion equations (Heffter)
     are used to determine sigma-y and
     sigma-z (SYTDEP)                                Default: 550.   ! SYTDEP =
5.5E02 !

     Switch for using Heffter equation for sigma z
     as above (0 = Not use Heffter; 1 = use Heffter
     (MHFTSZ)                                     Default: 0      ! MHFTSZ =  0
!

     Stability class used to determine plume
     growth rates for puffs above the boundary
     layer (JSUP)                              Default: 5      ! JSUP =  5   !

     Vertical dispersion constant for stable
     conditions (k1 in Eqn. 2.7-3)  (CONK1)    Default: 0.01   ! CONK1 = .01 !

     Vertical dispersion constant for neutral/
     unstable conditions (k2 in Eqn. 2.7-4)
     (CONK2)                                   Default: 0.1    ! CONK2 = .1 !

     Factor for determining Transition-point from
     Schulman-Scire to Huber-Snyder Building Downwash
     scheme (SS used for Hs < Hb + TBD * HL)
     (TBD)                                     Default: 0.5    ! TBD = .5 !
        TBD < 0   ==> always use Huber-Snyder
        TBD = 1.5 ==> always use Schulman-Scire
        TBD = 0.5 ==> ISC Transition-point

     Range of land use categories for which
     urban dispersion is assumed
     (IURB1, IURB2)                            Default: 10     ! IURB1 =  10  !
                                                        19     ! IURB2 =  19  !

     Site characterization parameters for single-point Met data files ---------
     (needed for METFM = 2,3,4,5)

        Land use category for modeling domain
        (ILANDUIN)                              Default: 20     ! ILANDUIN =  20
!

        Roughness length (m) for modeling domain
        (Z0IN)                                 Default: 0.25   ! Z0IN = .25 !

        Leaf area index for modeling domain
        (XLAIIN)                               Default: 3.0    ! XLAIIN = 3.0 !

        Elevation above sea level (m)
        (ELEVIN)                               Default: 0.0    ! ELEVIN = .0 !

        Latitude (degrees) for met location
        (XLATIN)                                   Default: -999.  ! XLATIN = -
999.0 !

        Longitude (degrees) for met location
        (XLONIN)                                   Default: -999.  ! XLONIN = -
999.0 !

     Specialized information for interpreting single-point Met data files -----

        Anemometer height (m) (Used only if METFM = 2,3)
        (ANEMHT)                                 Default: 10.    ! ANEMHT = 10.0
!

        Form of lateral turbulance data in PROFILE.DAT file
```

```
        (Used only if METFM = 4,5 or MTURBVW = 1 or 3)
        (ISIGMAV)                                 Default: 1      ! ISIGMAV =  1
!
            0 = read sigma-theta
            1 = read sigma-v

        Choice of mixing heights (Used only if METFM = 4)
        (IMIXCTDM)                               Default: 0      ! IMIXCTDM =  0
!
            0 = read PREDICTED mixing heights
            1 = read OBSERVED mixing heights

     Maximum length of a slug (met. grid units)
     (XMXLEN)                                   Default: 1.0    ! XMXLEN = 1.0 !

     Maximum travel distance of a puff/slug (in
     grid units) during one sampling step
     (XSAMLEN)                                   Default: 1.0    ! XSAMLEN = 1.0
!

     Maximum Number of slugs/puffs release from
     one source during one time step
     (MXNEW)                                       Default: 99     ! MXNEW =  99
!

     Maximum Number of sampling steps for
     one puff/slug during one time step
     (MXSAM)                                       Default: 99     ! MXSAM =  99
!

     Number of iterations used when computing
     the transport wind for a sampling step
     that includes gradual rise (for CALMET
     and PROFILE winds)
     (NCOUNT)                                      Default: 2      ! NCOUNT =  2
!

     Minimum sigma y for a new puff/slug (m)
     (SYMIN)                                    Default: 1.0    ! SYMIN = 1.0  !

     Minimum sigma z for a new puff/slug (m)
     (SZMIN)                                    Default: 1.0    ! SZMIN = 1.0  !

     Default minimum turbulence velocities sigma-v and sigma-w
     for each stability class over land and over water (m/s)
     (SVMIN(12) and SWMIN(12))

                     ----------  LAND  ----------       ---------  WATER  ------
----
        Stab Class :  A    B    C    D    E    F         A    B    C    D    E
F
                     ---  ---  ---  ---  ---  ---       ---  ---  ---  ---  ---
---
     Default SVMIN : .50, .50, .50, .50, .50, .50,      .37, .37, .37, .37, .37,
.37
     Default SWMIN : .20, .12, .08, .06, .03, .016,     .20, .12, .08, .06, .03,
.016

           !  SVMIN  =  0.500,  0.500,  0.500,  0.500,  0.500,  0.500,  0.370,  0.370,
0.370, 0.370, 0.370, 0.370!
           !  SWMIN  =  0.200,  0.120,  0.080,  0.060,  0.030,  0.016,  0.200,  0.120,
0.080, 0.060, 0.030, 0.016!

     Divergence criterion for dw/dz across puff
     used to initiate adjustment for horizontal
     convergence (1/s)
     Partial adjustment starts at CDIV(1), and
     full adjustment is reached at CDIV(2)
     (CDIV(2))                                    Default: 0.0,0.0  ! CDIV = .0,
.0 !

     Minimum wind speed (m/s) allowed for
```

```
     non-calm conditions. Also used as minimum
     speed returned when using power-law
     extrapolation toward surface
     (WSCALM)                                    Default: 0.5    ! WSCALM = .5 !

     Maximum mixing height (m)
     (XMAXZI)                                          Default: 3000.  ! XMAXZI =
3000.0 !

     Minimum mixing height (m)
     (XMINZI)                                     Default: 50.    ! XMINZI = 50.0
!

     Default wind speed classes --
     5 upper bounds (m/s) are entered;
     the 6th class has no upper limit
     (WSCAT(5))                      Default   :
                                     ISC  RURAL  :  1.54,  3.09,  5.14,  8.23,  10.8
(10.8+)

                              Wind Speed Class :  1     2     3     4     5
                                                 ---   ---   ---   ---   ---
                                       ! WSCAT = 1.54, 3.09, 5.14, 8.23, 10.80 !

     Default wind speed profile power-law
     exponents for stabilities 1-6
     (PLX0(6))                       Default   : ISC RURAL values
                                     ISC RURAL : .07, .07, .10, .15, .35, .55
                                     ISC URBAN : .15, .15, .20, .25, .30, .30

                               Stability Class :  A      B      C      D      E
F
                                                 ---    ---    ---    ---    ---   -
--
                                        ! PLX0 = 0.07, 0.07, 0.10, 0.15, 0.35,
0.55 !

     Default potential temperature gradient
     for stable classes E, F (degK/m)
     (PTG0(2))                       Default: 0.020, 0.035
                                        ! PTG0 = 0.020,   0.035 !

     Default plume path coefficients for
     each stability class (used when option
     for partial plume height terrain adjustment
     is selected -- MCTADJ=3)
     (PPC(6))                    Stability Class :  A      B      C      D      E
F
                                 Default   PPC : .50,   .50,   .50,   .50,   .35,
.35
                                                 ---    ---    ---    ---    ---   -
--
                                        !   PPC = 0.50, 0.50, 0.50, 0.50, 0.35,
0.35 !

     Slug-to-puff transition criterion factor
     equal to sigma-y/length of slug
     (SL2PF)                               Default: 10.        ! SL2PF = 10.0 !

     Puff-splitting control variables ------------------------

       VERTICAL SPLIT
       --------------

       Number of puffs that result every time a puff
       is split - nsplit=2 means that 1 puff splits
       into 2
       (NSPLIT)                            Default:   3        ! NSPLIT =  3  !

       Time(s) of a day when split puffs are eligible to
       be split once again; this is typically set once
       per day, around sunset before nocturnal shear develops.
```

```
       24 values: 0 is midnight (00:00) and 23 is 11 PM (23:00)
       0=do not re-split    1=eligible for re-split
       (IRESPLIT(24))                    Default:  Hour 17 = 1
       !  IRESPLIT = 0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,0,1,0,0,0,0,0,0 !

       Split is allowed only if last hour's mixing
       height (m) exceeds a minimum value
       (ZISPLIT)                          Default: 100.       ! ZISPLIT = 100.0
!

       Split is allowed only if ratio of last hour's
       mixing ht to the maximum mixing ht experienced
       by the puff is less than a maximum value (this
       postpones a split until a nocturnal layer develops)
       (ROLDMAX)                           Default: 0.25       ! ROLDMAX = 0.25
!


       HORIZONTAL SPLIT
       ----------------

       Number of puffs that result every time a puff
       is split - nsplith=5 means that 1 puff splits
       into 5
       (NSPLITH)                         Default:   5        ! NSPLITH =  5  !

       Minimum sigma-y (Grid Cells Units) of puff
       before it may be split
       (SYSPLITH)                          Default:  1.0       ! SYSPLITH = 1.0
!

       Minimum puff elongation rate (SYSPLITH/hr) due to
       wind shear, before it may be split
       (SHSPLITH)                          Default:  2.        ! SHSPLITH = 2.0
!

       Minimum concentration (g/m^3) of each
       species in puff before it may be split
       Enter array of NSPEC values; if a single value is
       entered, it will be used for ALL species
       (CNSPLITH)                              Default:  1.0E-07   ! CNSPLITH =
1.0E-07 !

     Integration control variables ------------------------

       Fractional convergence criterion for numerical SLUG
       sampling integration
       (EPSSLUG)                          Default:   1.0e-04  ! EPSSLUG = 1.0E-
04 !

       Fractional convergence criterion for numerical AREA
       source integration
       (EPSAREA)                          Default:   1.0e-06  ! EPSAREA = 1.0E-
06 !

       Trajectory step-length (m) used for numerical rise
       integration
       (DSRISE)                          Default:   1.0      ! DSRISE = 1.0 !

       Boundary Condition (BC) Puff control variables ------------------------

       Minimum height (m) to which BC puffs are mixed as they are emitted
       (MBCON=2 ONLY).  Actual height is reset to the current mixing height
       at the release point if greater than this minimum.
       (HTMINBC)                          Default:   500.     ! HTMINBC = 500.0
!

       Search radius (km) about a receptor for sampling nearest BC puff.
       BC puffs are typically emitted with a spacing of one grid cell
       length, so the search radius should be greater than DGRIDKM.
       (RSAMPBC)                           Default:   10.      ! RSAMPBC = 10.0
!
```

```
       Near-Surface depletion adjustment to concentration profile used when
       sampling BC puffs?
       (MDEPBC)                            Default:   1        ! MDEPBC =  1  !
          0 = Concentration is NOT adjusted for depletion
          1 = Adjust Concentration for depletion

!END!


-------------------------------------------------------------------------------


INPUT GROUPS: 13a, 13b, 13c, 13d -- Point source parameters
--------------------------------

---------------
Subgroup (13a)
---------------

     Number of point sources with
     parameters provided below      (NPT1)  No default  !  NPT1 =  0  !

     Units used for point source
     emissions below                (IPTU)  Default: 1  !  IPTU =   1  !
           1 =        g/s
           2 =       kg/hr
           3 =       lb/hr
           4 =     tons/yr
           5 =     Odour Unit * m**3/s  (vol. flux of odour compound)
           6 =     Odour Unit * m**3/min
           7 =     metric tons/yr

     Number of source-species
     combinations with variable
     emissions scaling factors
     provided below in (13d)        (NSPT1) Default: 0  !  NSPT1 =  0  !

     Number of point sources with
     variable emission parameters
     provided in external file      (NPT2)  No default  !  NPT2 =  0  !

     (If NPT2 > 0, these point
     source emissions are read from
     the file: PTEMARB.DAT)

!END!

---------------
Subgroup (13b)
---------------
                                         a
          POINT SOURCE: CONSTANT DATA
          -----------------------------
                                                                                b
c
  Source       X          Y       Stack    Base     Stack    Exit  Exit    Bldg.
Emission
   No.     Coordinate Coordinate Height Elevation Diameter  Vel.  Temp.   Dwash
Rates
              (km)      (km)       (m)      (m)       (m)  (m/s) (deg. K)
  ------   ---------- ---------- ------   ------   -------- ----- -------- -----
--------

--------

    a
     Data for each source are treated as a separate input subgroup
     and therefore must end with an input group terminator.

     SRCNAM  is a 12-character name for a source
             (No default)
```

```
     X       is an array holding the source data listed by the column headings
             (No default)
     SIGYZI  is an array holding the initial sigma-y and sigma-z (m)
             (Default: 0.,0.)
     FMFAC   is a vertical momentum flux factor (0. or 1.0) used to represent
             the effect of rain-caps or other physical configurations that
             reduce momentum rise associated with the actual exit velocity.
             (Default: 1.0  -- full momentum used)
     ZPLTFM  is the platform height (m) for sources influenced by an isolated
             structure that has a significant open area between the surface
             and the bulk of the structure, such as an offshore oil platform.
             The Base Elevation is that of the surface (ground or ocean),
             and the Stack Height is the release height above the Base (not
             above the platform).  Building heights entered in Subgroup 13c
             must be those of the buildings on the platform, measured from
             the platform deck.  ZPLTFM is used only with MBDW=1 (ISC
             downwash method) for sources with building downwash.
             (Default: 0.0)

    b
     0. = No building downwash modeled
     1. = Downwash modeled for buildings resting on the surface
     2. = Downwash modeled for buildings raised above the surface (ZPLTFM > 0.)
     NOTE: must be entered as a REAL number (i.e., with decimal point)

    c
     An emission rate must be entered for every pollutant modeled.
     Enter emission rate of zero for secondary pollutants that are
     modeled, but not emitted.  Units are specified by IPTU
     (e.g. 1 for g/s).

---------------
Subgroup (13c)
---------------

           BUILDING DIMENSION DATA FOR SOURCES SUBJECT TO DOWNWASH
           -------------------------------------------------------
Source                                                                 a
 No.       Effective building height, width, length and X/Y offset (in meters)
           every 10 degrees.  LENGTH, XBADJ, and YBADJ are only needed for
           MBDW=2 (PRIME downwash option)
------     --------------------------------------------------------------------


--------

    a
     Building height, width, length, and X/Y offset from the source are treated
     as a separate input subgroup for each source and therefore must end with
     an input group terminator.  The X/Y offset is the position, relative to the
     stack, of the center of the upwind face of the projected building, with the
     x-axis pointing along the flow direction.

---------------
Subgroup (13d)
---------------
                                                a
          POINT SOURCE: VARIABLE EMISSIONS DATA
          -------------------------------------

     Use this subgroup to describe temporal variations in the emission
     rates given in 13b.  Factors entered multiply the rates in 13b.
     Skip sources here that have constant emissions.  For more elaborate
     variation in source parameters, use PTEMARB.DAT and NPT2 > 0.

     IVARY determines the type of variation, and is source-specific:
     (IVARY)                             Default: 0
           0 =       Constant
           1 =       Diurnal cycle (24 scaling factors: hours 1-24)
           2 =       Monthly cycle (12 scaling factors: months 1-12)
           3 =       Hour & Season (4 groups of 24 hourly scaling factors,
                                    where first group is DEC-JAN-FEB)
```

```
          4 =       Speed & Stab. (6 groups of 6 scaling factors, where
                                   first group is Stability Class A,
                                   and the speed classes have upper
                                   bounds (m/s) defined in Group 12
          5 =       Temperature   (12 scaling factors, where temperature
                                   classes have upper bounds (C) of:
                                   0, 5, 10, 15, 20, 25, 30, 35, 40,
                                   45, 50, 50+)


--------
    a
     Data for each species are treated as a separate input subgroup
     and therefore must end with an input group terminator.


-------------------------------------------------------------------------------


INPUT GROUPS: 14a, 14b, 14c, 14d -- Area source parameters
--------------------------------

---------------
Subgroup (14a)
---------------

     Number of polygon area sources with
     parameters specified below (NAR1)       No default  !  NAR1 =  3   !

     Units used for area source
     emissions below            (IARU)       Default: 1  !  IARU =   1  !
           1 =        g/m**2/s
           2 =       kg/m**2/hr
           3 =       lb/m**2/hr
           4 =     tons/m**2/yr
           5 =     Odour Unit * m/s  (vol. flux/m**2 of odour compound)
           6 =     Odour Unit * m/min
           7 =     metric tons/m**2/yr

     Number of source-species
     combinations with variable
     emissions scaling factors
     provided below in (14d)        (NSAR1) Default: 0  !  NSAR1 =  0  !

     Number of buoyant polygon area sources
     with variable location and emission
     parameters (NAR2)                      No default  !  NAR2 =  0   !
     (If NAR2 > 0, ALL parameter data for
     these sources are read from the file: BAEMARB.DAT)

!END!

---------------
Subgroup (14b)
---------------
                                            a
          AREA SOURCE: CONSTANT DATA
          ----------------------------
                                                                  b
Source           Effect.    Base      Initial    Emission
 No.             Height   Elevation   Sigma z     Rates
                   (m)       (m)        (m)
-------          ------    ------     --------   ---------

   1! SRCNAM = A1 !
   1! X =           .1,   731.0,          .1,   6.868E-06, 3.79E-05 ! !END!
   2! SRCNAM = A2 !
   2! X =           .1,   728.0,          .1,   6.868E-06, 3.79E-05 ! !END!
   3! SRCNAM = A3 !
   3! X =           .1,   720.0,          .1,   6.868E-06, 3.79E-05 ! !END!
```

```
--------
    a
     Data for each source are treated as a separate input subgroup
     and therefore must end with an input group terminator.
    b
     An emission rate must be entered for every pollutant modeled.
     Enter emission rate of zero for secondary pollutants that are
     modeled, but not emitted.  Units are specified by IARU
     (e.g. 1 for g/m**2/s).

---------------
Subgroup (14c)
---------------

           COORDINATES (km) FOR EACH VERTEX(4) OF EACH POLYGON
           --------------------------------------------------------
Source                                                               a
 No.       Ordered list of X followed by list of Y, grouped by source
------     ------------------------------------------------------------

 1    ! SRCNAM  =   A1 !
 1      !  XVERT = 760.969,    761.053,    761.095,    761.016!
 1      !  YVERT = 6150.561,    6150.606,    6150.522,    6150.475!
!END!
 2    ! SRCNAM  =   A2 !
 2      !  XVERT = 760.924,    760.968,    761.016,    760.923!
 2      !  YVERT = 6150.535,    6150.56,    6150.476,    6150.488!
!END!
 3    ! SRCNAM  =   A3 !
 3      !  XVERT = 760.838,    760.876,    760.873,    760.826!
 3      !  YVERT = 6150.483,    6150.47,    6150.416,    6150.426!
!END!

--------
    a
     Data for each source are treated as a separate input subgroup
     and therefore must end with an input group terminator.


---------------
Subgroup (14d)
---------------
                                                a
          AREA SOURCE: VARIABLE EMISSIONS DATA
          --------------------------------------

     Use this subgroup to describe temporal variations in the emission
     rates given in 14b.  Factors entered multiply the rates in 14b.
     Skip sources here that have constant emissions.  For more elaborate
     variation in source parameters, use BAEMARB.DAT and NAR2 > 0.

     IVARY determines the type of variation, and is source-specific:
     (IVARY)                               Default: 0
           0 =       Constant
           1 =       Diurnal cycle (24 scaling factors: hours 1-24)
           2 =       Monthly cycle (12 scaling factors: months 1-12)
           3 =       Hour & Season (4 groups of 24 hourly scaling factors,
                                    where first group is DEC-JAN-FEB)
           4 =       Speed & Stab. (6 groups of 6 scaling factors, where
                                    first group is Stability Class A,
                                    and the speed classes have upper
                                    bounds (m/s) defined in Group 12
           5 =       Temperature   (12 scaling factors, where temperature
                                    classes have upper bounds (C) of:
                                    0, 5, 10, 15, 20, 25, 30, 35, 40,
                                    45, 50, 50+)



--------
    a
     Data for each species are treated as a separate input subgroup
```

```
     and therefore must end with an input group terminator.


---------------------------------------------------------------------------------

INPUT GROUPS: 15a, 15b, 15c -- Line source parameters
---------------------------

---------------
Subgroup (15a)
---------------

     Number of buoyant line sources
     with variable location and emission
     parameters (NLN2)                            No default  !  NLN2 =  0   !

     (If NLN2 > 0, ALL parameter data for
      these sources are read from the file: LNEMARB.DAT)

     Number of buoyant line sources (NLINES)        No default   ! NLINES =  0
!

     Units used for line source
     emissions below               (ILNU)         Default: 1  !  ILNU =   1  !
           1 =        g/s
           2 =       kg/hr
           3 =       lb/hr
           4 =     tons/yr
           5 =     Odour Unit * m**3/s  (vol. flux of odour compound)
           6 =     Odour Unit * m**3/min
           7 =     metric tons/yr

     Number of source-species
     combinations with variable
     emissions scaling factors
     provided below in (15c)       (NSLN1) Default: 0  !  NSLN1 =  0  !

     Maximum number of segments used to model
     each line (MXNSEG)                             Default: 7   ! MXNSEG =  7
!

     The following variables are required only if NLINES > 0.  They are
     used in the buoyant line source plume rise calculations.

        Number of distances at which                 Default: 6   ! NLRISE =  6
!
        transitional rise is computed

        Average building length (XL)              No default   ! XL = .0 !
                                                  (in meters)

        Average building height (HBL)             No default   ! HBL = .0 !
                                                  (in meters)

        Average building width (WBL)              No default   ! WBL = .0 !
                                                  (in meters)

        Average line source width (WML)           No default   ! WML = .0 !
                                                  (in meters)

        Average separation between buildings (DXL)  No default   ! DXL = .0 !
                                                  (in meters)

        Average buoyancy parameter (FPRIMEL)        No default   ! FPRIMEL = .0
!
                                                  (in m**4/s**3)

!END!

---------------
Subgroup (15b)
---------------
```

```
          BUOYANT LINE SOURCE: CONSTANT DATA
          ----------------------------------

a
Source       Beg. X        Beg. Y        End. X     End. Y      Release     Base
Emission
 No.       Coordinate   Coordinate   Coordinate Coordinate   Height      Elevation
Rates
            (km)        (km)        (km)       (km)       (m)       (m)
------   ----------  ----------  ---------  ----------  -------   ---------    -
--------

--------

    a
     Data for each source are treated as a separate input subgroup
     and therefore must end with an input group terminator.

    b
     An emission rate must be entered for every pollutant modeled.
     Enter emission rate of zero for secondary pollutants that are
     modeled, but not emitted.  Units are specified by ILNTU
     (e.g. 1 for g/s).

---------------
Subgroup (15c)
---------------
                                                       a
          BUOYANT LINE SOURCE: VARIABLE EMISSIONS DATA
          ----------------------------------------------

     Use this subgroup to describe temporal variations in the emission
     rates given in 15b.  Factors entered multiply the rates in 15b.
     Skip sources here that have constant emissions.

     IVARY determines the type of variation, and is source-specific:
     (IVARY)                               Default: 0
           0 =       Constant
           1 =       Diurnal cycle (24 scaling factors: hours 1-24)
           2 =       Monthly cycle (12 scaling factors: months 1-12)
           3 =       Hour & Season (4 groups of 24 hourly scaling factors,
                                    where first group is DEC-JAN-FEB)
           4 =       Speed & Stab. (6 groups of 6 scaling factors, where
                                    first group is Stability Class A,
                                    and the speed classes have upper
                                    bounds (m/s) defined in Group 12
           5 =       Temperature   (12 scaling factors, where temperature
                                    classes have upper bounds (C) of:
                                    0, 5, 10, 15, 20, 25, 30, 35, 40,
                                    45, 50, 50+)



--------
    a
     Data for each species are treated as a separate input subgroup
     and therefore must end with an input group terminator.


-------------------------------------------------------------------------------


INPUT GROUPS: 16a, 16b, 16c -- Volume source parameters
---------------------------

---------------
Subgroup (16a)
---------------

     Number of volume sources with
     parameters provided in 16b,c (NVL1)     No default  !  NVL1 =  0   !
```

```
     Units used for volume source
     emissions below in 16b       (IVLU)     Default: 1  !  IVLU =   1  !
           1 =        g/s
           2 =       kg/hr
           3 =       lb/hr
           4 =     tons/yr
           5 =     Odour Unit * m**3/s  (vol. flux of odour compound)
           6 =     Odour Unit * m**3/min
           7 =     metric tons/yr

     Number of source-species
     combinations with variable
     emissions scaling factors
     provided below in (16c)      (NSVL1)    Default: 0  !  NSVL1 =  0  !

     Number of volume sources with
     variable location and emission
     parameters                   (NVL2)     No default  !  NVL2 =   0   !

     (If NVL2 > 0, ALL parameter data for
      these sources are read from the VOLEMARB.DAT file(s) )

!END!

---------------
Subgroup (16b)
---------------
                                        a
           VOLUME SOURCE: CONSTANT DATA
           ------------------------------
                                                                               b
         X           Y         Effect.    Base     Initial    Initial    Emission
     Coordinate  Coordinate   Height   Elevation  Sigma y    Sigma z     Rates
        (km)       (km)        (m)       (m)        (m)       (m)
     ----------  ----------   ------    ------    --------   --------   --------


--------
    a
     Data for each source are treated as a separate input subgroup
     and therefore must end with an input group terminator.

    b
     An emission rate must be entered for every pollutant modeled.
     Enter emission rate of zero for secondary pollutants that are
     modeled, but not emitted.  Units are specified by IVLU
     (e.g. 1 for g/s).

---------------
Subgroup (16c)
---------------
                                                 a
          VOLUME SOURCE: VARIABLE EMISSIONS DATA
          ----------------------------------------

     Use this subgroup to describe temporal variations in the emission
     rates given in 16b.  Factors entered multiply the rates in 16b.
     Skip sources here that have constant emissions.  For more elaborate
     variation in source parameters, use VOLEMARB.DAT and NVL2 > 0.

     IVARY determines the type of variation, and is source-specific:
     (IVARY)                              Default: 0
           0 =       Constant
           1 =       Diurnal cycle (24 scaling factors: hours 1-24)
           2 =       Monthly cycle (12 scaling factors: months 1-12)
           3 =       Hour & Season (4 groups of 24 hourly scaling factors,
                                    where first group is DEC-JAN-FEB)
           4 =       Speed & Stab. (6 groups of 6 scaling factors, where
                                    first group is Stability Class A,
                                    and the speed classes have upper
                                    bounds (m/s) defined in Group 12
```

```
          5 =       Temperature   (12 scaling factors, where temperature
                                   classes have upper bounds (C) of:
                                   0, 5, 10, 15, 20, 25, 30, 35, 40,
                                   45, 50, 50+)


--------
    a
     Data for each species are treated as a separate input subgroup
     and therefore must end with an input group terminator.


-------------------------------------------------------------------------------

INPUT GROUPS: 17a & 17b -- Non-gridded (discrete) receptor information
-----------------------

---------------
Subgroup (17a)
---------------

     Number of non-gridded receptors (NREC)  No default  !  NREC =  12   !

!END!

---------------
Subgroup (17b)
---------------
                                                    a
           NON-GRIDDED (DISCRETE) RECEPTOR DATA
           ------------------------------------

                      X            Y          Ground       Height   b
Receptor         Coordinate   Coordinate    Elevation   Above Ground
  No.               (km)         (km)          (m)          (m)
--------         ----------   ----------    ---------   ------------
     1 ! X =      760.228,   6151.514,     680.000,       0.000!   !END!
     2 ! X =      761.651,    6151.37,     686.000,       0.000!   !END!
     3 ! X =      762.139,   6150.744,     711.000,       0.000!   !END!
     4 ! X =      761.462,   6150.102,     712.000,       0.000!   !END!
     5 ! X =      761.867,   6149.127,     722.000,       0.000!   !END!
     6 ! X =      761.498,   6149.174,     731.000,       0.000!   !END!
     7 ! X =      761.328,   6149.496,     723.000,       0.000!   !END!
     8 ! X =      761.158,   6149.595,     710.000,       0.000!   !END!
     9 ! X =      760.526,   6149.513,     725.000,       0.000!   !END!
    10 ! X =      760.356,   6149.461,     733.000,       0.000!   !END!
    11 ! X =       760.76,   6149.789,     714.000,       0.000!   !END!
    12 ! X =      760.654,   6149.947,     714.000,       0.000!   !END!



-------------
    a
     Data for each receptor are treated as a separate input subgroup
     and therefore must end with an input group terminator.

    b
     Receptor height above ground is optional.  If no value is entered,
     the receptor is placed on the ground.
```

AIR QUALITY MONITORING PLAN
FOR ARGYLE (NSW) PTY LTD
TIYCES LANE, BOXERS CREEK

Prepared for: Argyle (NSW) Pty Ltd
Peter Miller – Director and Secretary

Prepared by: Katie Trahair, Environmental Scientist
R T Benbow, Principal Consultant

Report No: 161048-02_AQ-Rev2
May 2016
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Benbow ENVIRONMENTAL

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1. INTRODUCTION

Benbow Environmental has been commissioned by Argyle (NSW) Pty Ltd to prepare an air quality monitoring plan for the proposed quarry situated at Curlewin Lane, Boxers Creek NSW.

Condition P1.1 of the Deferred Commencement Conditions states,

> *'the licensee must prepare and implement an Air Quality Monitoring Plan and submit this to the EPA prior to commencement of operations at the premises. This plan must detail air quality monitoring locations (for at least two dust deposition gauges and one high volume air sampler (HVAS)) and provide justification of the locations'*

The objective of this report is to develop a dust monitoring plan to be implemented as a mechanism to assess ongoing compliance with the relevant criteria to ensure the health of the local environment is maintained with particular consideration for adjacent sensitive land uses including residential dwellings.

1.1 Scope of Works

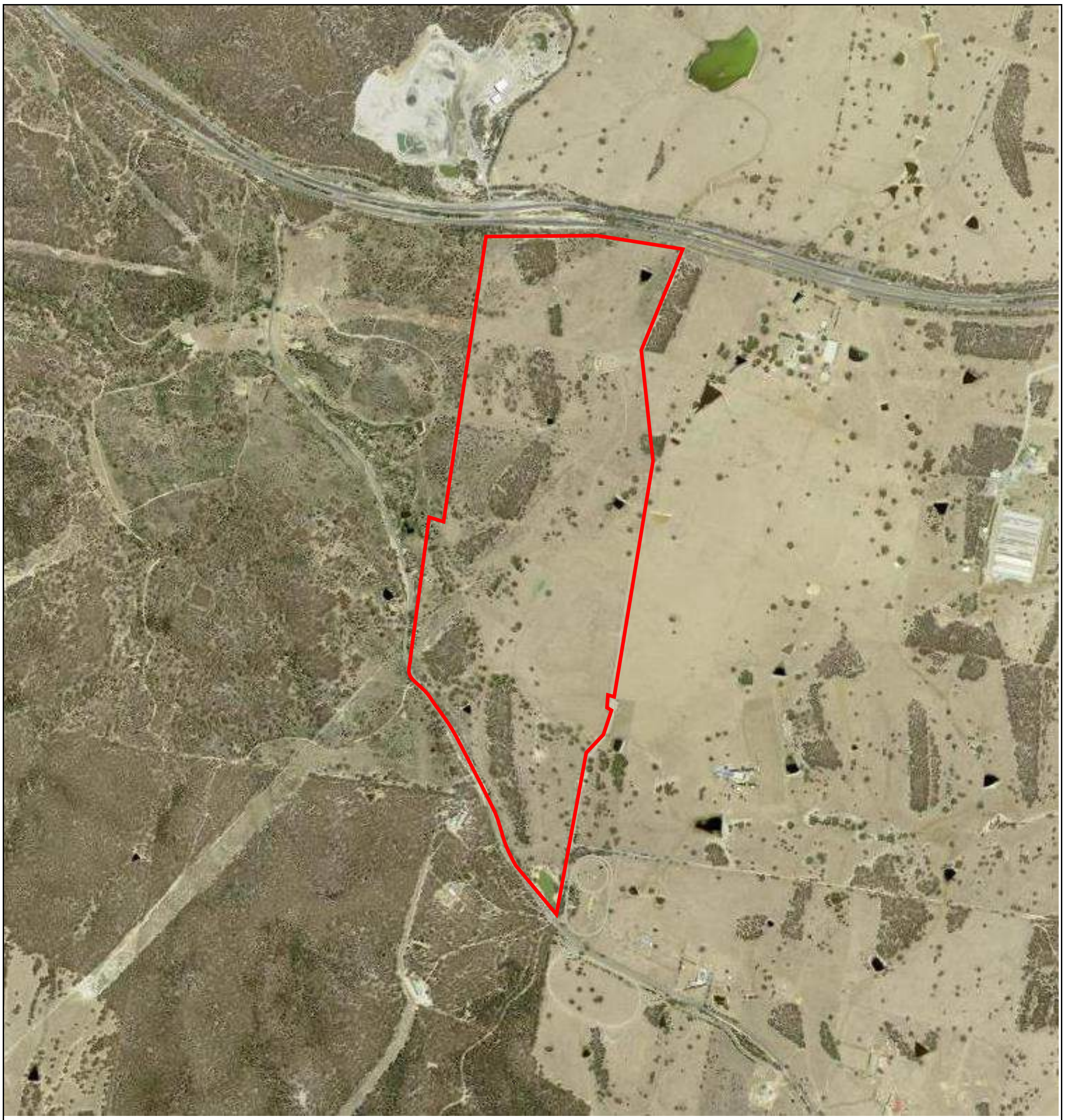
The scope of this report is limited to the following:

- Outline relevant legislation and guidelines;
- Identification of potential sources of dust emissions from associated site activities;
- Review relevant air quality standards to be achieved;
- Detail selection of monitoring locations;
- Provide dust sampling and analysis methods; and
- Outline general strategies to control dust and mitigate air quality impacts of site activities on surrounding land uses.

2. SITE LOCATION OF THE PROPOSED DEVELOPMENT

The subject site is located at 288 Tiyces Lane, Boxers Creek, NSW (Figure 2-1). The site plan is shown in Figure 2-2.

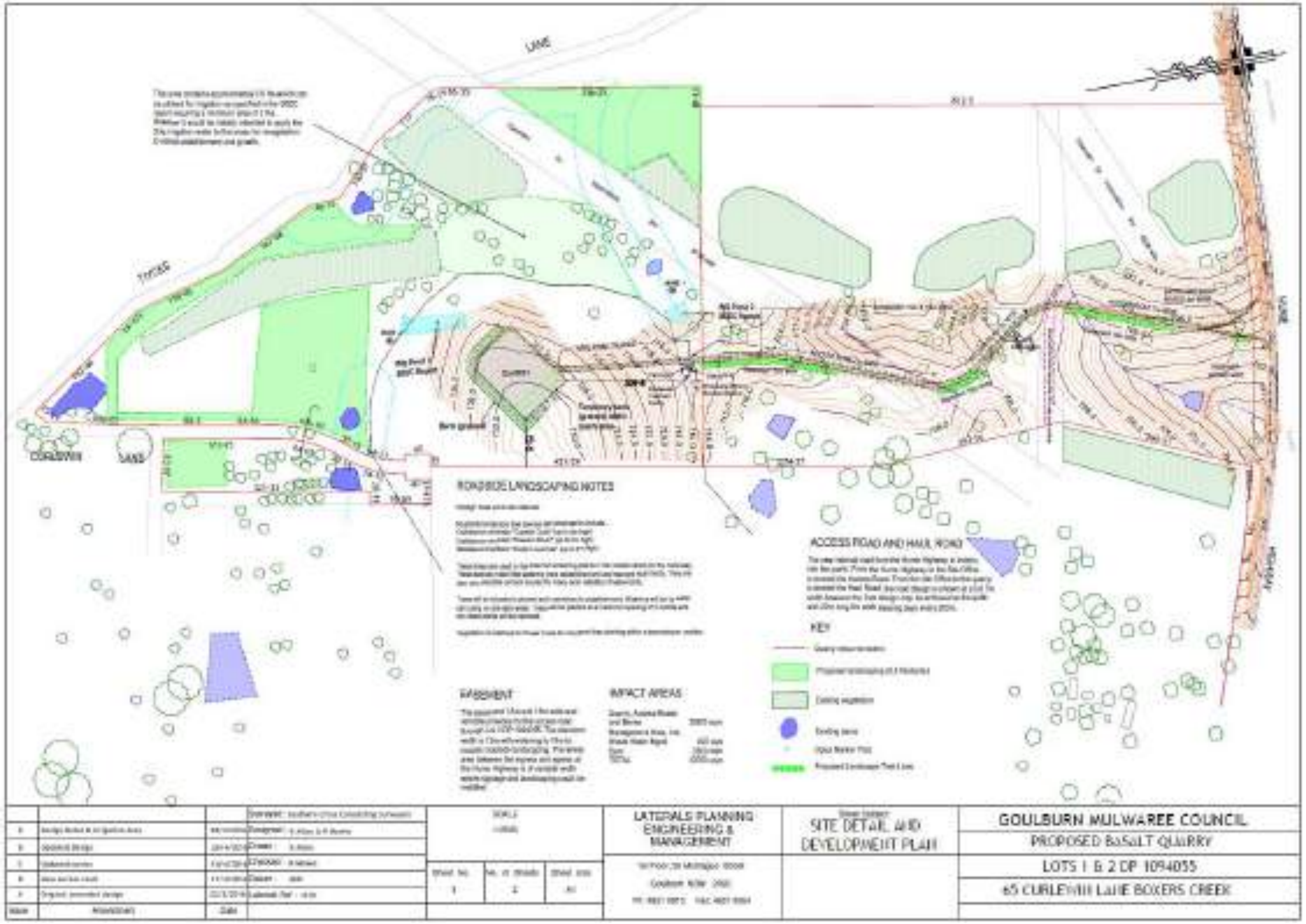
Figure 2-1: Aerial View of Site



Source: www.maps.six.nsw.gov.au

↑N	LEGEND: Site Boundary	Benbow Environmental 13 Daking Street, North Parramatta NSW 2151

Figure 2-2: Site Plan



2.1 LOCALITY AND SURROUNDING LAND USE

The site is currently vacant and mostly cleared of vegetation. The area immediately west of the site is mostly unoccupied and vegetated. There are scattered rural premises within the vicinity of the subject site. The Hume Highway is adjacent to the northern site perimeter. The land directly north west of the site is currently occupied by Divall's Earthmoving & Bulk Haulage.

2.2 RELEVANT LEGISLATION AND PLANNING INSTRUMENTS

Key environmental legislation relating to air quality management includes:

- *NSW Environment Planning and Assessment Act1979* (EP&A Act).
- *NSW Protection of the Environment Operations Act 1997* (POEO Act).
- *NSW Protection of the Environment Operations (Clean Air) Regulation 2010.*

The following guidelines provided by the NSW EPA have been considered in the development of this monitoring plan:

- Approved Methods for the Sampling and Analysis of Air Pollutants in New South Wales (2006).
- Approved Methods for the Modelling and Assessment of Air Pollutants in New South Wales (2005).

3. SOURCES OF DUST

There are a number of potential emission sources of dust related to quarry activities. Particulate matter or 'dust' emitted can range in composition and size. Emissions from particular sources may only occur during certain stages of operation of the facility, while emissions from other sources may occur continuously or at regular intervals throughout the operational period. It is important to note that local meteorological conditions play a significant role in the liberation of particles into the air.

Typical sources of dust relating to quarry sites include:

- General site wind erosion – liberation of surface dusts into the air;
- Earthworks and excavation (stripping of overburden) involving the removal of vegetation and disturbance of soils increases potential for particles to become airborne;
- Fugitive dust emissions from stockpiled materials on site;
- Wheel generated and diesel exhaust emissions from on-site vehicle traffic on un-sealed roads/ haul routes;
- Mechanical processing including blasting, drilling, crushing, screening; and
- Transport of materials via hoppers, chutes, conveyors.

4. LOCAL WIND TRENDS

Wind rose plots show the direction from which the wind is coming from with triangles known as "petals". The petals of the plots in the figure summarise wind direction data into 8 compass directions i.e. north, north-east, east, south-east, etc. The length of the triangles, or "petals", indicates the frequency that the wind blows from the direction presented. Longer petals for a given direction indicate a higher frequency of wind from that direction. Each petal is divided into segments, with each segment representing one of the six wind speed classes. Thus, the segments of a petal show what proportion of wind for a given direction falls into each class. The proportion of time, for which wind speed is less than speeds in the first class (i.e. 0.5 $m.s^{-1}$), when speed is negligible, is referred to as calm hours or "calms". Calms are not shown on a wind rose as they have no direction, but the proportion of time that form part of the period under consideration is noted under each wind rose.

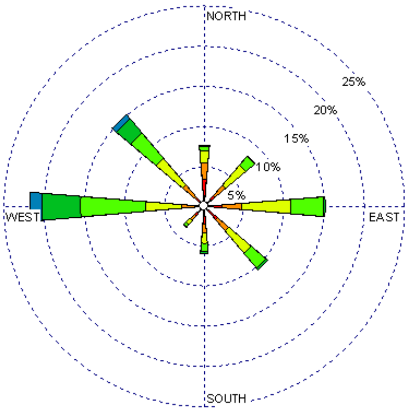
The concentric circles in each wind rose are the axis, which denote frequencies. In comparing the plots it should be noted that the axis varies between wind roses, although all wind roses are the similar in size. The frequencies denoted on the axes of the wind rose are indicated beneath each wind rose.

The nearest BoM monitoring station found within proximity to the subject site is the Goulburn Automatic Weather Station (AWS) (Station No. 070330). This was used as a basis of comparison with the TAPM-generated meteorological file.

Wind Rose Plots for Goulburn AWS Dataset and the 2007 TAPM-Generated Towrang Meteorological File are shown in Figure 4-1 and Figure 4-2.

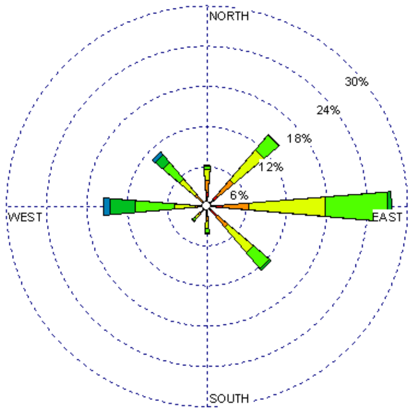
Figure 4-1: Annual Wind Rose Plots from the 2004-2008 Goulburn BoM Station Dataset

All Seasons



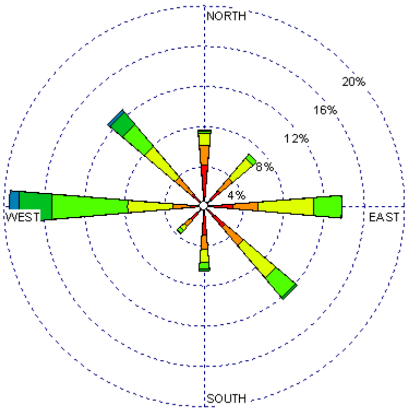
Average Wind Speed: 4.43 m/s
Calms Frequency: 12.07 %
Axis Frequencies: 5%, 10%, 15%, 20%, 25%

Summer (December – February)



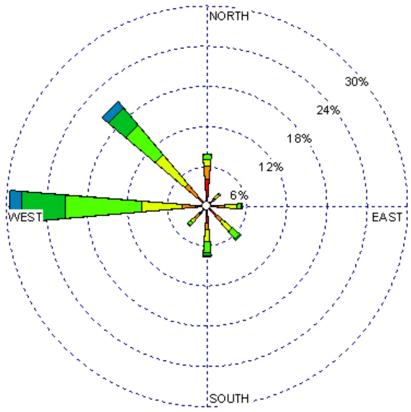
Average Wind Speed: 4.69 m/s
Calms Frequency: 5.97 %
Axis Frequencies: 6%, 12%, 18%, 24%, 30%

Autumn (March – May)



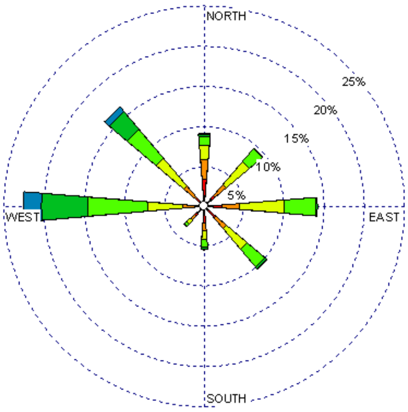
Average Wind Speed: 3.71 m/s
Calms Frequency: 17.32 %
Axis Frequencies: 4%, 8%, 12%, 16%, 20%

Winter (June – August)



Average Wind Speed: 4.52 m/s
Calms Frequency: 15.72 %
Axis Frequencies: 6%, 12%, 18%, 24%, 30%

Spring (September – November)



Average Wind Speed: 4.78 m/s
Calms Frequency: 9.12 %
Axis Frequencies: 5%, 10%, 15%, 20%, 25%

Legend

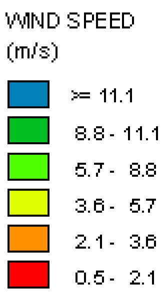
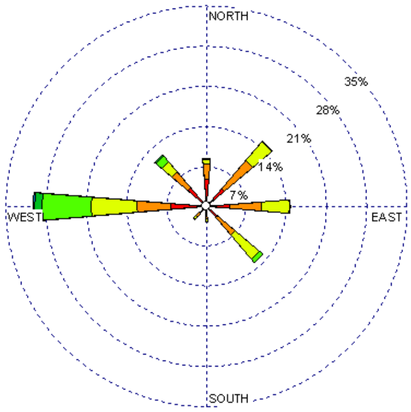


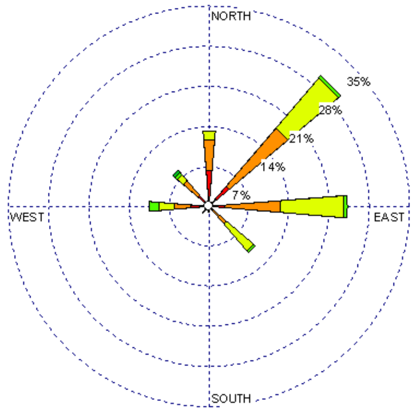
Figure 4-2: Annual Wind Rose Plots from the 2007 TAPM-Generated Meteorological File

All Seasons



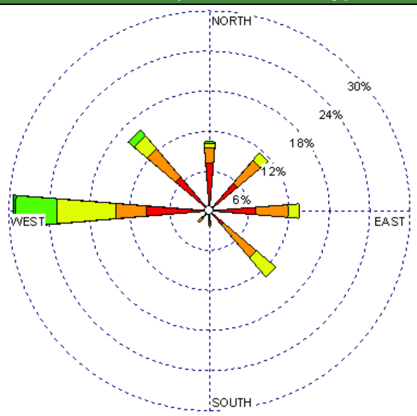
Average Wind Speed: 3.48 m/s
Calms Frequency: 0.87%
Axis Frequencies: 7%, 14%, 21%, 28%, 35%

Summer (December – February)



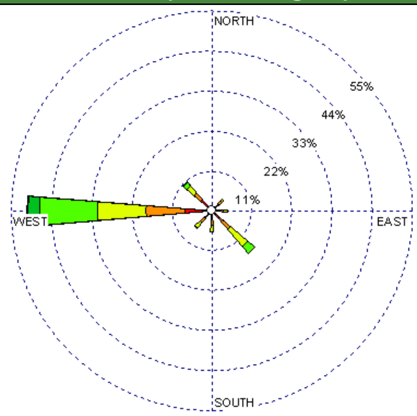
Average Wind Speed: 3.34 m/s
Calms Frequency: 0.32 %
Axis Frequencies: 7%, 14%, 21%, 28%, 35%

Autumn (March – May)



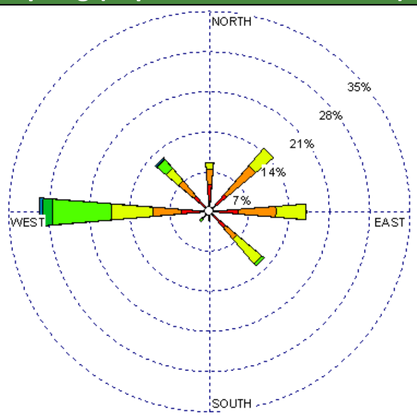
Average Wind Speed: 2.88 m/s
Calms Frequency: 1.54 %
Axis Frequencies: 6%, 12%, 18%, 24%, 30%

Winter (June – August)



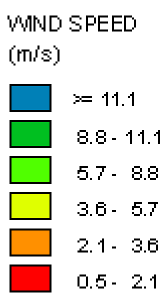
Average Wind Speed: 4.06 m/s
Calms Frequency: 0.59 %
Axis Frequencies: 11%, 22%, 33%, 44%, 55%

Spring (September – November)



Average Wind Speed: 3.62 m/s
Calms Frequency: 1.01 %
Axis Frequencies: 7%, 14%, 21%, 28%, 35%

Legend



5. DUST MONITORING PROGRAM

This section details the proposed dust monitoring program.

5.1 ADOPTED AIR QUALITY STANDARDS

As per the Deferred Commencement Conditions dust is to be assessed as deposited dust and PM_{10}. The Clean Air Regulations do not specify concentration limits for deposited dust or PM_{10} from diffuse plant sources.

Note PM_{10} is defined as particulate matter having a diameter of 10 micrometres or less.

The EPA technical document document '*Approved Methods for the Modelling and Assessment of Air Pollutants in NSW*' provides the following impact assessment for deposited dust[1] and PM_{10}. This criteria is to be applied at the **nearest existing or likely future off-site sensitive receptor**. Where monitoring locations are situated on site, it is not appropriate to apply this criteria.

Table 5-1: AMMAAP Assessment Criteria

Pollutant	Averaging Period	Percentile	Concentration	
			pphm	µg/m³
			pphm	**µg/m³**
PM_{10}	24 hours	100th	-	50
	Annual	100th	-	30
			g/m²/month[a]	**g/m²/month[b]**
Deposited Dust	Annual	100th	2	4

[a] Maximum Increase in Deposited Dust Level
[b] Maximum Total Deposited Dust Level

[1] Dust is assessed as insoluble solids as defined by AS 3580.10.1–1991. It should be noted that the current version of this Australian Standard is AS 3580.10.1–2003.

5.2 MONITORING LOCATIONS

Monitoring sites are classified into three types: peak, neighbourhood and background. For long term routine monitoring, it is not typically feasible to place monitors at sensitive receptors. As such all routine dust monitoring will be conducted within the boundary of the subject site, considered peak monitoring locations and thus the AMMAAP criteria is not applicable but rather monitoring results will be recorded used for inclusion within the Annual Return documents detailed in the Deferred Commencement Conditions.

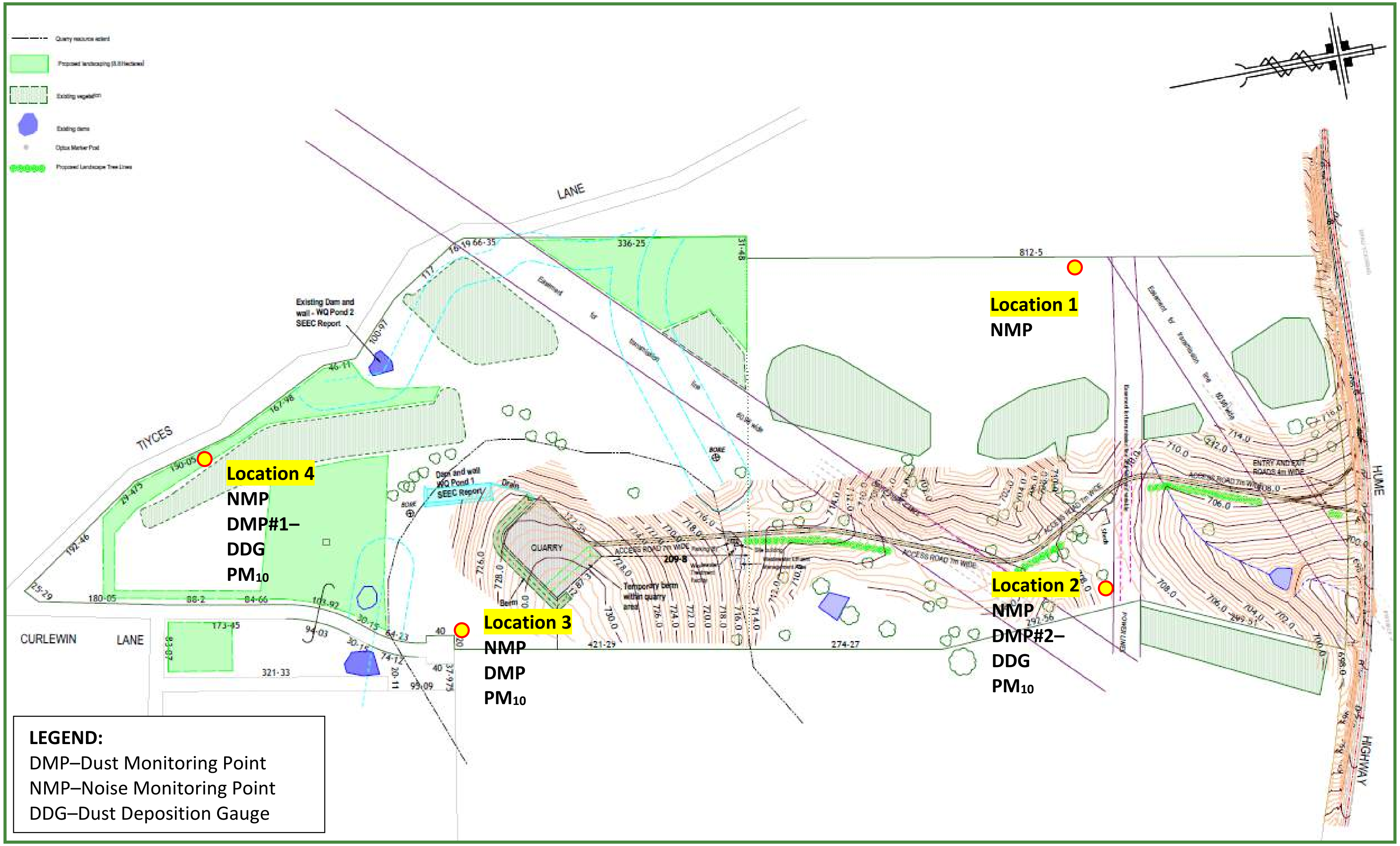
5.2.1 Selection of Monitoring Locations

The approach adopted is to have fixed locations for the two dust deposit gauges (DDG) and three locations used throughout the year for PM_{10}. After the first year's sampling the results would be analysed and a decision made as to a permanent location of the PM_{10} monitoring point is justifiable. The locations of the Dust Deposit Gauges are based on the wind roses. These show a predominance of highest strength winds either from the westerly sectors or the easterly sectors. The locations selected are also in the directions of the nearest receptors in the wind directions.

Wind is the predominant factor as wind provides the mechanism to cause the travel of dust or particulates that may be released from the predominant sources.

The proposed monitoring locations are shown in Figure 5-1.

Figure 5-1: Noise and Dust Monitoring Locations Site Map



5.3 Dust Monitoring Methods

This section summarises the relevant Australian Standard testing methods to be used. It is recommended that the proponent obtain a copy of the referenced standards to assist in the undertaking of the monitoring. Records of all monitoring shall be kept and as required, the results of the monitoring plan should be formatted and prepared for inclusion in the Annual Return documents as per the specified reporting conditions.

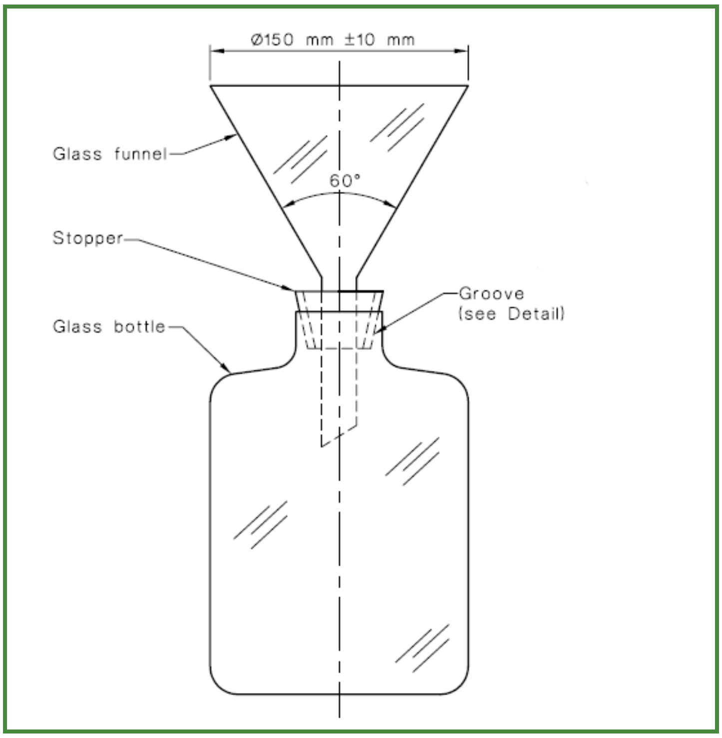
5.3.1 Deposited Dust

Dust monitoring is to be performed using dust gauges conforming to Australian Standard AS 3580.10.1–2003. Over a given sampling period, particles that settle from the ambient air are collected in a vessel and retained together with any rainwater. The sample is passed through a sieve to remove any extraneous matter (e.g. leaves, insects) and the sieved sample containing the deposited matter is transferred to a filtration apparatus. The insoluble and soluble materials are separated by filtration and the mass of the dried insoluble solids is gravimetrically determined.

Equipment:

- Grade A volumetric glass bottle (minimum 4L volume capacity) containing amount of copper sulfate solution (as prepared by NATA accredited laboratory). Bottle to be fitted with tight sealing lid during transport. Lid to be mad of an impermeable material that does not react with the expected constituents of the collected deposited matter.
- Glass funnel of 150 ±10mm diameter (nominal angle of cone sides 60 degrees). The internal diameter of the funnel stem needs to be sufficient to permit a passage of particulate matter during washing. The funnel is to be supported firmly in the neck of the glass bottle with a rubber or plastic stopper.
- A stand which supports the dust gauge such that the horizontal plane of the funnel is approximately 2 ±0.2m above ground level. The stand is to be sufficiently sturdy to prevent any noticeable sway and ensure the funnel aperture is maintained in a horizontal position. The stand should incorporate a container to protect the bottle contents from sunlight. This container should be provided with a drainage hole at the base to prevent rainwater build-up.

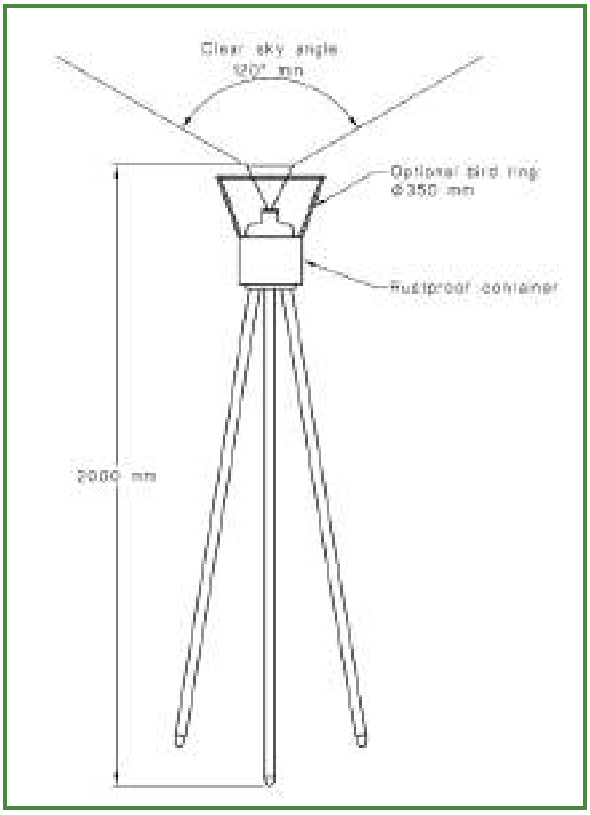
Figure 5-2: Typical Deposit Gauge



Positioning:

The height of the funnel aperture above the surface of the immediately surrounding area is to be 2 ± 0.2m. The funnel aperture plane must be horizontal. The funnel is to be positioned away from nearest higher obstacles so as to achieve a recommended 120^{o} clear sky angle.

Figure 5-3: Typical Stand with Deposit Gauge



Procedure:

- For routine monitoring programs, the period of exposure is typically 30 ±2 days.
- At the end of the exposure period wash any deposited matter adhering to the inside of the funnel into the deposit gauge bottle using a minimum volume of distilled water from a wash bottle.
- Remove the funnel and stopper and seal the bottle with a lid.
- Identify the bottle with a label detailing the site location, period of exposure and funnel diameter to the nearest mm.
- Return bottled samples to a NATA accredited laboratory as soon as possible (laboratory analysis for insoluble solids must be completed within 30 days of collection). During storage/transport to laboratory, deposit bottles to be tightly sealed, and kept in a cool dark environment to prevent the growth of algae, fungi and other microorganisms. Results of laboratory analysis to be provided as g/m^2/month.
- Insert the clean funnel with attached stopper into a fresh bottle containing copper sulfate solution and leave exposed for the next sampling period. Ensure that the funnel is firmly held in the neck of the bottle and that the funnel aperture plane is horizontal.

Where there are likely existing high background concentrations of dust deposition, Benbow Environmental recommends monitoring to occur prior to the operation of the site in order to gauge the incremental dust impacts of the sites activities.

5.3.2 PM_{10}

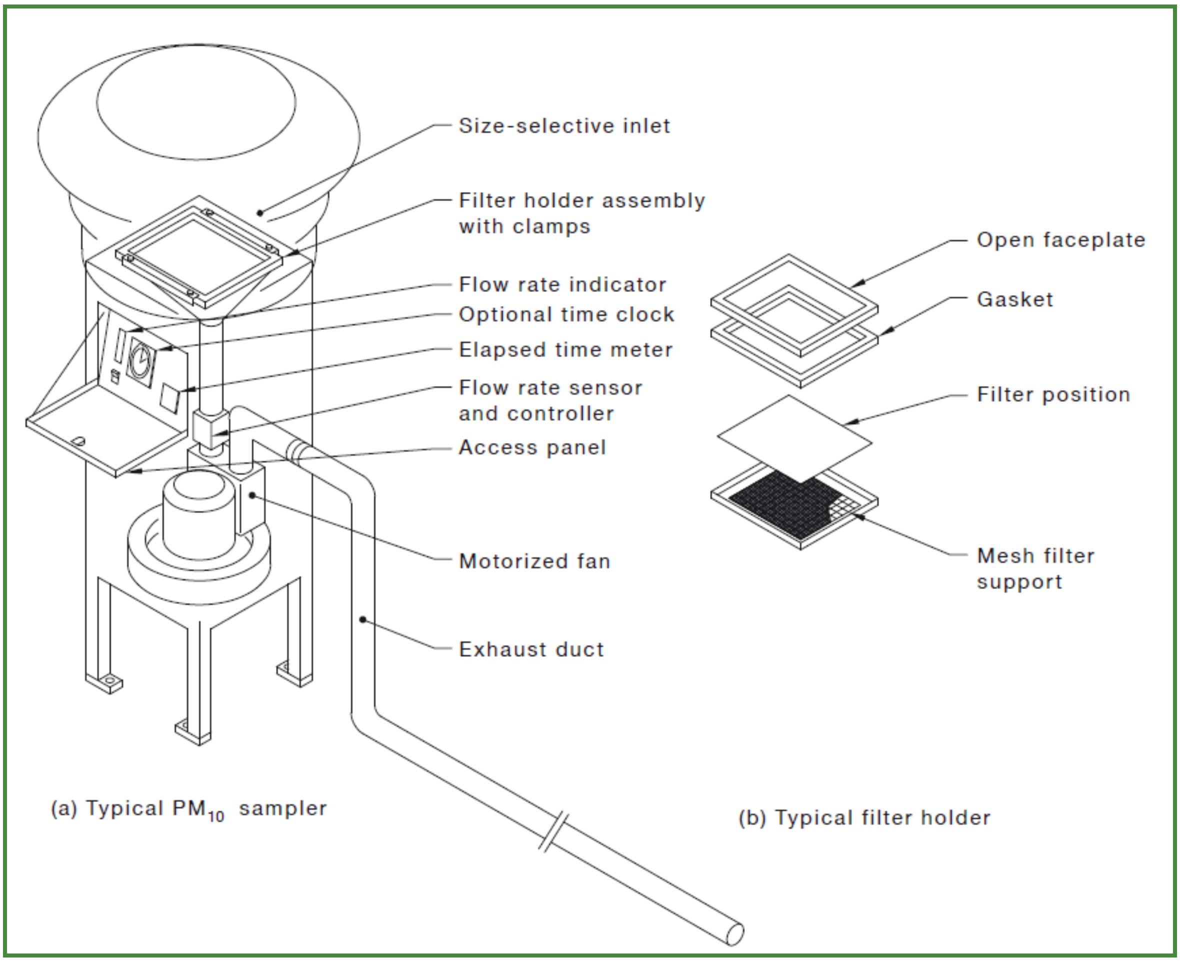
PM_{10} monitoring is to be performed using a high volume sampler conforming to Australian Standard AS 3580.9.6–2015. Ambient air is drawn at a constant flow rate through a prepared filter via a PM_{10} size-selective inlet where the suspended particulate matter is inertially separated, with particles larger than PM_{10} being retained on a layer of grease. The PM_{10} fraction of the suspended particulate matter is collected on a prepared filter mounted in the high volume sampler filter holder and subsequently weighed (gravimetric method). The PM_{10} concentration is determined by dividing the mass of collected particulate matter by the sample volume, which is calculates from the sample duration and either the average or totalised flow rate.

Equipment:

The PM_{10} sampler is to consist of a PM_{10} size-selective inlet fitted to a high volume sampler. Performance compliance required as per the US Code of Federal Regulations.

- The PM_{10} size-selective inlet to be designed to collect particles of equivalent aerodynamic diameter (EAD) 10 ±0.5 µm at a 50% efficiency, on a mass basis, at a flow rate of 1.13 m^3/min ±10%.
- The high volume sampler to consist of a filter holder, a motorised fan, a shelter, an air flow measuring device and an elapsed time meter that measure the actual sampling duration to within ±1% U95 (uncertainty at a confidence interval of 95% according to ISO/IEC Guide 98). Samplers to have a programmable time clock capable of controlling operation of the sampler to within 2% of the selected time period.
- Sampler must be capable of passing ambient air at all times during the sampling period at a constant flow rate within the 1.13 m^3/min ±10% range.
- The motor must be capable of continuous operation over the range of expected environmental conditions for periods of at least 24 hours. The shelter and size-selective inlet to be constructed of materials capable of withstanding extremes of temperature, relative humidity and the air pollutants to which they will be exposed.
- The filter holder to be horizontally mounted in the high volume sampler so that the sample air is drawn downwards through the filter. The filter holder to be clamped firmly to provide an airtight seal against the high volume sampler.
- Filters made from quartz, glass, PTFE or PTFE-coated glass fibre filters of approximately 200mm × 250 mm to be used. The filters to have a specified collection efficiency of at least 99% for particles 0.3µm EAD and permit an air flow rate of 1.24 m^3/min. Filters to be free from pinholes or other defects.
- The high volume sampler and its installation to comply with relevant statutory electrical requirements.
- An exhaust muffler or other noise reducing technique should be used where noise pollution is of concern.
- The exhaust from the sampler to be dispersed to minimise re-entertainment of filtered air and stirring up dust from the ground.
- The high volume sampler to be firmly secured to prevent it from being blown over.
- The high volume sampler's air flow measuring device must be capable of being calibrated.

Figure 5-4: PM_{10} Sampler Apparatus



Procedure:

All equipment is to be fully calibrated prior to use.

Filter preparation –
A laboratory environment with a controlled atmosphere is required for conditioning and weighing filters for the entire conditi0oning period with a mean temperature between 15°C and 30°C controlled within the limits of ±3°C from the mean, and a mean relative humidity (RH) between 20% and 50% controlled within the limits of ±5% RH from the mean. Filters are to be weighed to the nearest 0.1mg using a calibrated microbalance and record the initial filter mass along with filter identification number. Store each weighed filter in separate, labelled, dustproof container.

Sampling –
- Set up sampler according to manufacturer's instructions.
- Remove a pre weighed filter from its container and place in filter holder. Filters only top be handled using clean, non-serrated forceps or by hand using clean non-powdered gloves.
- Set sampler flow rate. Operate the sampler for 5 minutes and record the initial flow rate as indicated on the sampler flow rate indicator.

- Set the high volume sampler time clock to commence running at a predetermined time and for a predetermined period. For routine monitoring, sampling is carried out every sixth day for 24 hours from midnight to midnight.
- Return to collect the exposed filter within three days of the sample period. Before removing the exposed filter, operate the sampler for 5 minutes and record the final flow rate. If the final flow rate differs from the initial flow rate by more than 10%, the sample obtained is to be rejected.
- Carefully remove the filter from the holder, touching only the outer edges. Reject the sample if there is evidence of misalignment, blockage or breakthrough. The filter shall be folded so that only surfaces with collected particulate matter are in contact. Replace the filter in its suitably labelled dustproof container. The sample should not be exposed to extremes if temperature that could result in loss of semi-volatile compounds o the filter. The period between sampling and final weighing shall not exceed 20 days (or 30 days at <4^{o}C).
- Record all relevant details in a log book including date sample was taken, date exposed filter was removed, filter identification number, site location, sampler model and serial number, elapsed sampling time, any relevant comments including meteorological conditions, local construction activity, fire or dust storms that may affect PM_{10} concentration.
- Before final weighing equilibrate the exposed filter and any blank filters in the conditioning environment for at least 24 hours under the same temperature and humidity conditions used for pre-sampling filter equilibrium.
- Weigh each filter to the nearest 0.1 mg. Record the mass of each filter.

Analysis–
The PM_{10} concentration can be calculated as a

$$C = \frac{\left(M_f - M_i\right) \times 10^3}{V}$$

Where
C = concentration of PM_{10} in micrograms per cubic metre
M_f = final mass of filter in milligrams
M_i = initial mass of filter in milligrams
V = volume of air sampled, in cubic metres, corrected to reference conditions of 0^{o}C and 101.3kPa

Note: if the site does not have a suitable laboratory, filters can be prepared and analysed by an external laboratory.

6. CONTROL MEASURES

Dust generating activities from quarry sites should be reasonably and practicably managed so as to minimise / negate potential environmental impacts and risk to human health. Control strategies may involve prevention, suppression or containment measures in order to limit the potential for dust particles to become airborne.

Table 6-1 provides a range of control measures for consideration. These are provided as suggestions only and may be implemented where appropriate. Local weather conditions should be taken into account in determining the level and suitability of controls required.

Continual visual observation of dust levels is required by site workers in order to determine the appropriate measure of dust control necessary for the particular site activities being undertaken under the prevailing meteorological conditions. If results of the dust monitoring indicate unacceptable levels of dust being generated and emitted from the site, more stringent controls should be enforced.

Table 6-1: Dust Control Measures for Typical Quarry Site Activities

Source	Control Measures
General Site	• Install a wind vane and a wind speed monitor so that the Quarry Manager or his supervisor is aware of wind gusts or wind conditions that exceed 15 km/hr. Under these conditions increased use of water sprays at stockpiles and increased use of the water truck would be needed. • Towards the end of the day shift, ensure stockpiles have water sprays activated to promote the formation of a crust. • Retain existing vegetation where possible and through the use of overburden, form berms and vegetate these as a windbreak where practicable around the perimeter of the quarry. • Stage works to minimise areas of disturbance at any one time. • Stabilise access point/s– to be installed and maintained at ingress/egress to prevent dust, dirt and mud being transported by vehicles from the site • Further encourage the growth of dense vegetation consisting of native species with a dense vegetation to 3 m in height and then trees around the perimeter of the site.
Earthworks and Excavation (stripping of overburden)	• Minimise area of soil disturbance. • Suppression using water sprays or dust suppression surfactants to ensure no visible dust emissions. • Ensure that earthmoving vehicles do not operate at excessive speeds. • Minimise drop heights of materials. • Stabilise disturbed areas as soon as practicable.

Table 6-1: Dust Control Measures for Typical Quarry Site Activities

Source	Control Measures
Stockpiling	• Minimise the time materials are stockpiled on site. • Limit stockpile height and size e.g. 6 m height. • Locate stockpiles away from sensitive receptors, drainage paths, easement, kerb or road surface. • Position stockpiles near existing wind breaks such as trees, and vegetated earth berms. • Wet suppression of stockpiled materials as needed to ensure no visible dust emissions. • At the end of each day shift, ensure that stockpile surfaces are sprayed with water and surfactant to form a crust.
On-site Vehicle Traffic	• Minimise movement of traffic around the site by restricting vehicles to specific routes. • Enforce appropriate speed limits for vehicle on site. Recommended speed limit is <15km/hr. • Avoid unpaved haul routes where possible in favour of existing hard surface routes. • Apply gravel or bitumen seal to unsealed trafficable areas of the site. • Regular use of the quarry water truck. This will aid in preventing the build-up of fine particulate matter on site road surfaces. • Ensure proper maintenance of vehicle engines. • Limit idling time of vehicles – engines should be switched off.
Mechanical Processing	• Use of dust extraction hoods and cyclones and/or bag filters for drilling rigs, crushers etc. • Locate processing activities so as to shelter from prevailing wind conditions • Use of water / chemical suppression systems on materials processed by equipment. • Enclosure of screens.
Transport of Materials	• Cover all loads leaving the site. • Vehicles leaving the site to be cleaned of dirt and other materials to avoid tracking these materials onto public roads. • Enclosure of conveyors and chutes to transfer materials where possible.

7. CONCLUDING REMARKS

This monitoring plan outlines the monitoring location selection, sampling methodologies and analysis for dust deposition and PM_{10} to be undertaken in line with the relevant Australian Standards in accordance with the requirements of the Deferred Commencement Condition P1.1.

Results of the monitoring should be recorded, formatted and prepared for inclusion in the Annual Return documents as per the specified reporting conditions.

To assist with site dust management, Benbow Environmental has provided a list of general dust control measures that may be implemented where appropriate at the discretion of the proponent. It is the intention of Benbow Environmental that this adequately provides the proponent with the appropriate guidance required to ensure the health of the local environment is maintained and to minimise any potential risks to human health.

This concludes the report.

Katie Trahair
Environmental Scientist

R T Benbow
Principal Consultant

8. LIMITATIONS

Our services for this project are carried out in accordance with our current professional standards for site assessment investigations. No guarantees are either expressed or implied.

This report has been prepared solely for the use of Argyle (NSW) Pty Ltd, as per our agreement for providing environmental services. Only Argyle (NSW) Pty Ltd is entitled to rely upon the findings in the report within the scope of work described in this report. Otherwise, no responsibility is accepted for the use of any part of the report by another in any other context or for any other purpose.

Although all due care has been taken in the preparation of this study, no warranty is given, nor liability accepted (except that otherwise required by law) in relation to any of the information contained within this document. We accept no responsibility for the accuracy of any data or information provided to us by Argyle (NSW) Pty Ltd for the purposes of preparing this report.

Any opinions and judgements expressed herein, which are based on our understanding and interpretation of current regulatory standards, should not be construed as legal advice.

'N' - PART 1.

QUANTITATIVE AIR ASSESSMENT FOR MARIAN VALE PASTORAL CO PTY LTD 63 TIYCES LANE, TOWRANG, NSW

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ATTACHMENTS

1. INTRODUCTION

Benbow Environmental (BE) was commissioned by Laterals Planning on behalf of Figtree Reserve Pty Ltd to prepare a quantitative air assessment for the proposed quarry in 63 Tiyces Lane, Towrang NSW.

The proposed development includes the construction of an office, machinery storage shed, operation of an extractive area, access road, and on-going rehabilitative and site screening involving tree planting. The subject site will be used to perform an open pit excavation of material, where it would be transported off-site as per demand. The extracted material would be crushed and screened to provide a range of materials for use in construction.

This report presents a brief description of the existing site and its operations, the surrounding environment, the proposed development, and a quantitative assessment of potential dust impacts of the proposed development. The assessment has been carried out in accordance with the requirements listed in the document, "Approved Methods for the Modelling and Assessment of Air Pollutants in NSW" published by the Department of Environment and Climate Change NSW (DECC NSW 2005).

1.1 Scope of Assessment

The scope of this assessment includes the following:

- Review of the proposed development's operations and activities;
- Identification of potential dust impacts associated with the construction and operational phases of the proposed development;
- Predict ground level concentration dust impacts from the proposed development at the nearest potentially affected receptors using air dispersion modelling;
- Assessment of potential dust impacts against relevant legislation and guidelines; and
- Provide a statement of potential air quality impacts, as well as recommendations if necessary.

2. SITE DESCRIPTION

2.1 SITE DESCRIPTION AND LOCALITY

The subject site is located in a rural setting about 1 km south of the Hume Highway at Tiyces Lane, Towrang NSW, in the Southern Highlands. The resource covers an area of approximately 12.64 ha on a 44 ha site. The population of Towrang has just exceeded 400 people, where 90% of the population lived in the northern direction from the site, divided by Hume Highway. The site is predominantly surrounded by undeveloped land. A few rural residences exist within the vicinity of the site.

The road that veers from the Hume Highway leading to the start of Tiyces Lane is partly gravelled. Access from the site is from Tiyces Lane which is being sealed up to the entry point of the site.

Figure 2-1 and Figure 2-2 provides the topographical and aerial site plan (respectively) outlining the details of the proposed quarry. The proposal is to develop a basalt quarry (area coverage of 1.13 ha) and a gravel quarry (area coverage of 0.21 ha).

Figure 2-1: Topographical Site Plan

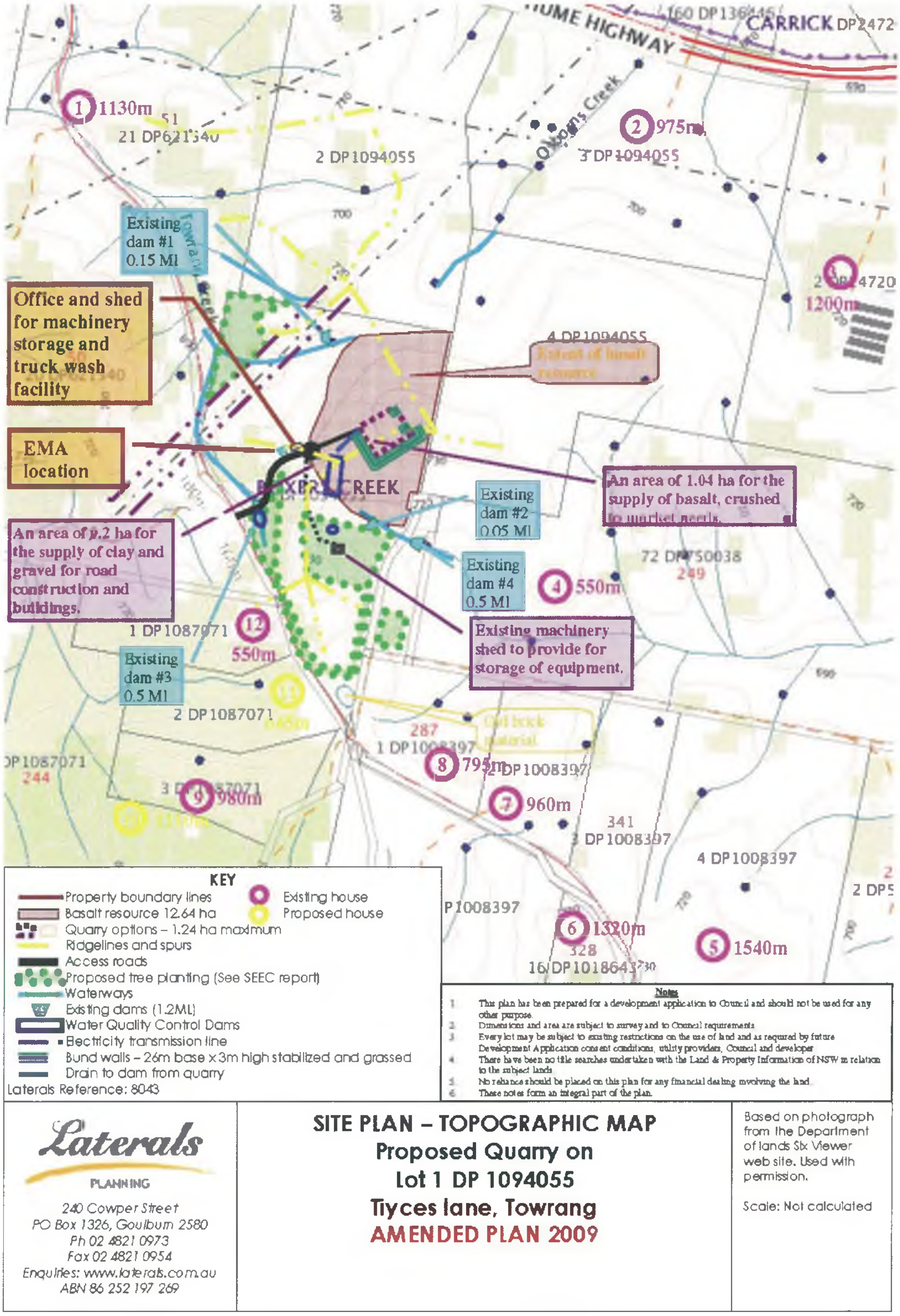


Figure 2-2: Site Plan - Aerial Photograph

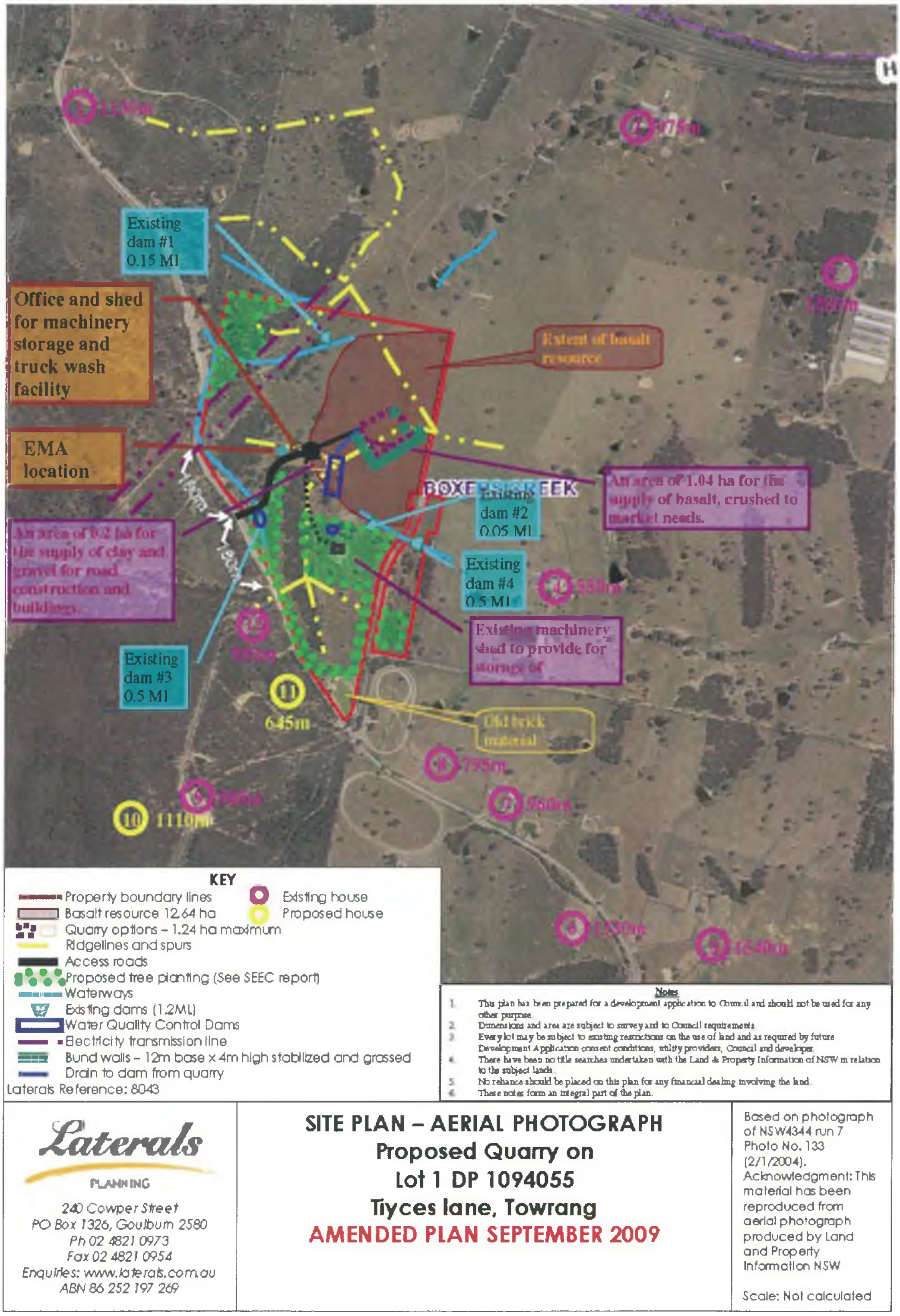


Figure 2-3: Site Plan

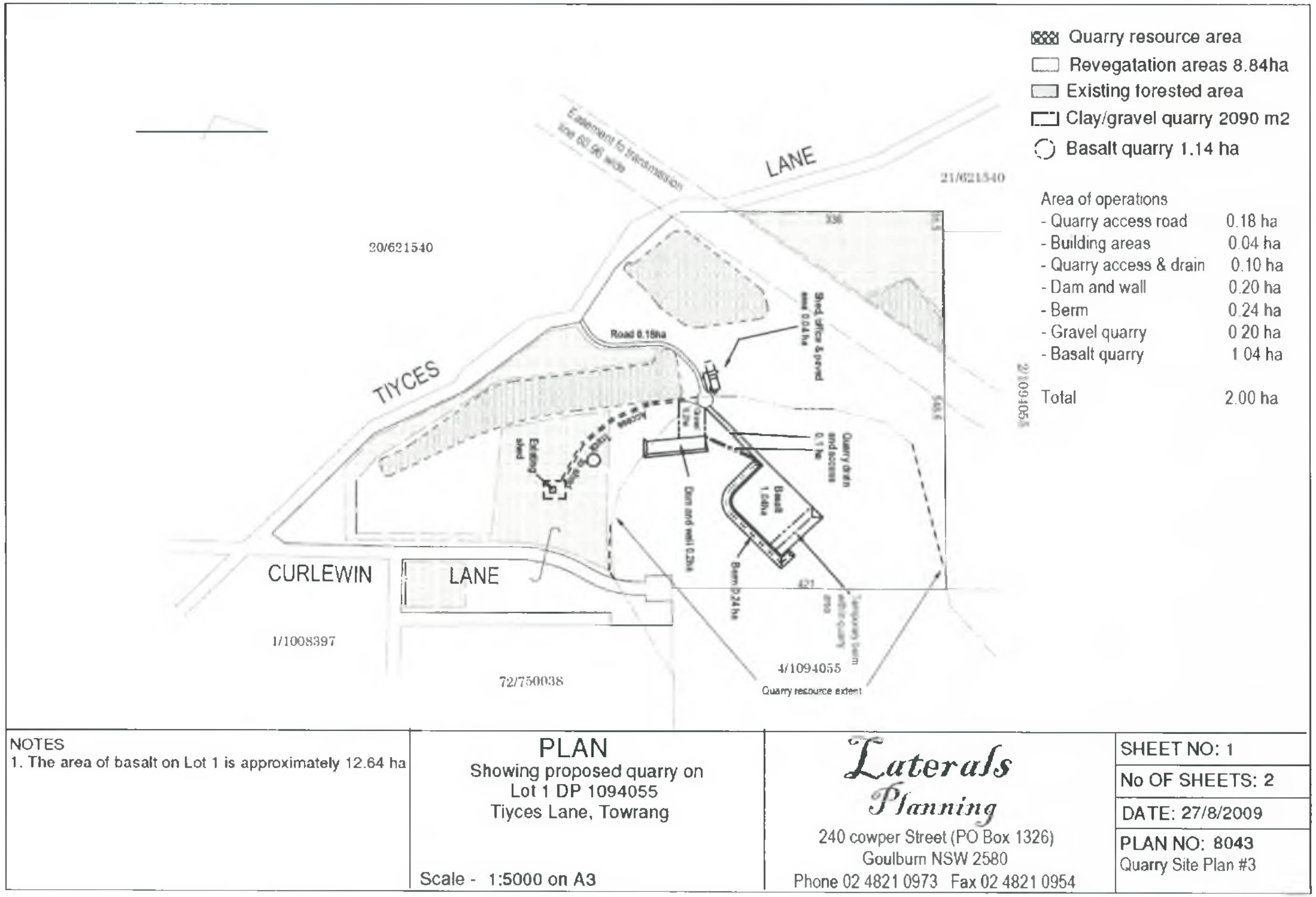
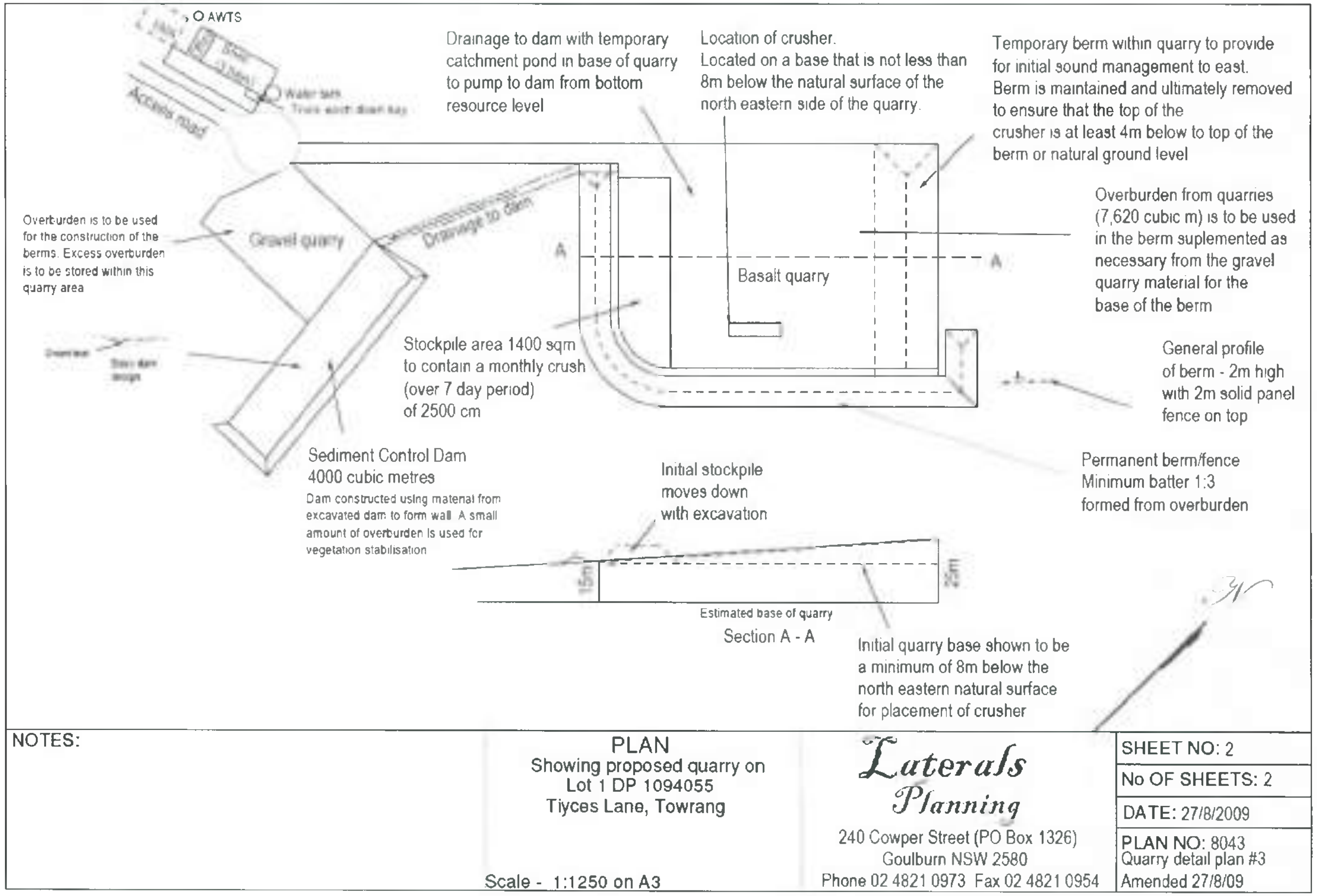


Figure 2-4: Detailed Site Plan



2.2 DESCRIPTION OF SITE AND SURROUNDS

The site is currently defined as Rural Zone 1(a) under the current Goulburn Local Environmental Plan. The site is surrounded in all directions by undeveloped land. The proposed zoning for the site is Rural Landscape Zone RU2 under the Draft Goulburn Mulwaree LEP2008. The proposed site would require construction of access road, connecting to Tiyces Lane, for approximately 250 m. The site is located south of ridge line, thus minimising dust emission impact on residences in a Northern direction from the site.

On the western direction of the proposed site, lies the forest region of Mount Towrang and Mount Towrang itself, while to the immediate east, the lands are cleared for approximately 2 km, followed by the forest region.

To the west, there is Towrang Creek, parallel with the western site border together with an un-named drainage depression commencing at and perpendicular with the eastern boundary.

To the north, lies Osborne Creek, running at a perpendicular axis to the northern site border. Further to the south is an un-named drainage depression.

Electrical easement is located to the north-west of the proposed site.

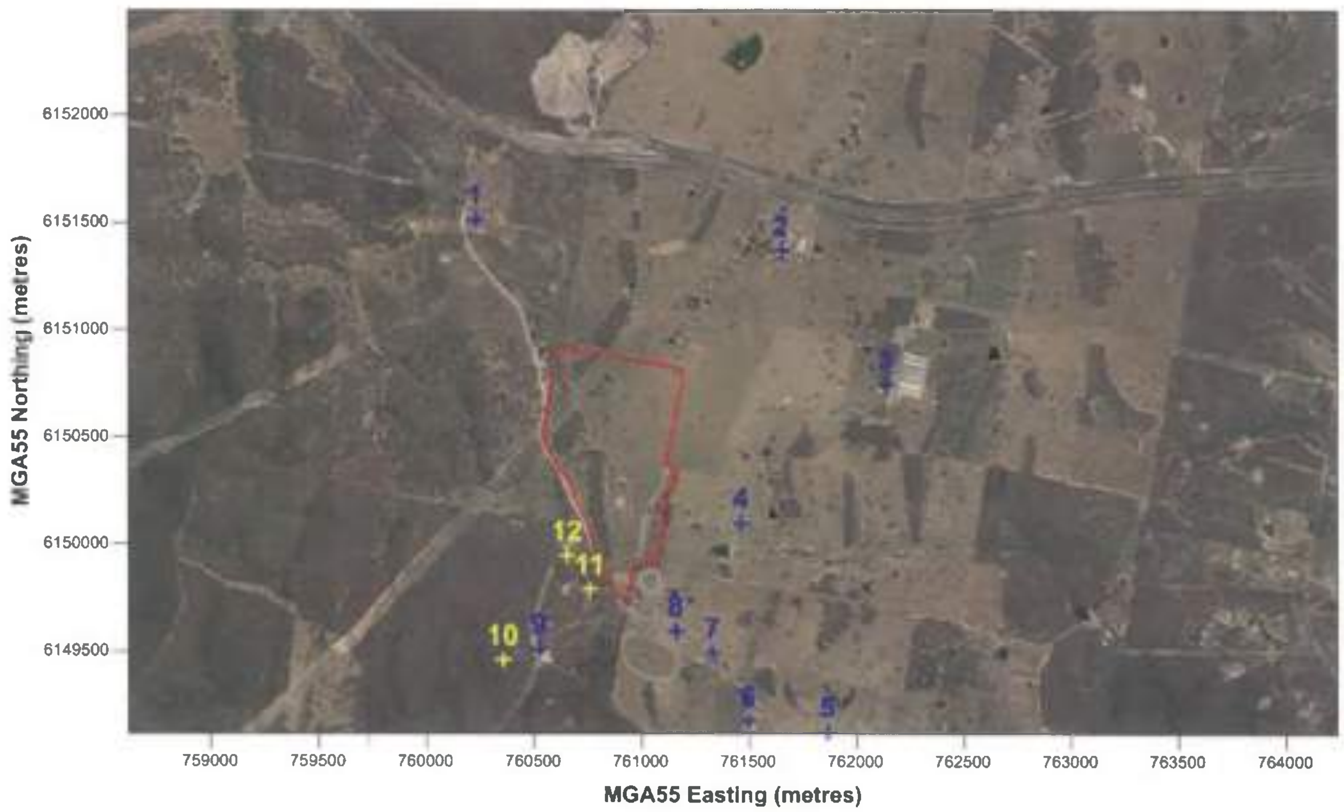
2.3 SENSITIVE RECEPTORS

Table 2-1 lists the nearby receptors that might be affected with the proposed development. The locations of the residences are shown as aerial photo in Figure 2-5.

Table 2-1: Potentially Sensitive Receptors

Receptors	Address	Direction	Distance from Site Boundary (m)
1	51 Tiyces Lane, Boxers Creek 2580 Lot 21 DP 621540	NW	700
2	Hume Highway, Boxers Creek 2580 Lot 3 DP 10904055	NE	723
3	Boxers Creek 2580 Lot 2 DP 247200	E	968
4	249 Tiyces Lane, Boxers Creek 2580 Lot 72 DP 750038	E	358
5	Tiyces Lane, Boxers Creek 2580 Lot 16 DP 1018643	SE	1,143
6	328 Tiyces Lane, Boxers Creek 2580 Lot 16 DP 1018643	SE	807
7	Boxers Creek 2580 Lot 2 DP 1008397	SE	486
8	287 Tiyces Lane, Boxers Creek 2580 Lot 1 DP 1008397	SE	268
9	244 Tiyces Lane, Towrang 2580 Lot 3 DP 1087071	SW	448
10	244 Tiyces Lane, Towrang 2580 Lot 4 DP 1087071	SW	622
11	Tiyces Lane, Towrang 2580 Lot 2 DP 1087071	SW	97
12	Tiyces Lane, Towrang 2580 Lot 1 DP 1087071	W	132

Figure 2-5: Site Location



Legend:
Subject Site Boundary
Receptors – Existing Residences
Receptors – Proposed Residences

Source: © Department of Lands

2.4 SURROUNDING LAND USE

The area surrounding the proposed site is undeveloped land with several rural settlements to the east, and south-east direction. The only available access road is Tiyces Lane, which connected to the Hume Highway from a Southern direction.

Due to the nature of the area, the existing sources of air pollution would come from motor vehicle emissions, dust from non-grassed areas, residential activity and the horse training facility. These sources would mainly consist of combustion gasses, such as oxides of nitrogen, carbon and sulphur, and dust from unsealed roads or areas and would be considered to be minimal due to the size and frequency of each of these activities.

3. THE PROPOSAL

3.1 PROPOSED DEVELOPMENT

The proposed development has two quarry pits. The final location of the quarry will depends on the exposed nature of the resources. The proposed development would involve construction of offices, machinery shed, the use of the premises to quarry construction materials and provide a stockpile area for loading onto trucks to transport the materials. The proposal would require construction of access roadways, parking areas, landscaping, storage areas and security fencing.

3.2 BUILDING CONSTRUCTION AND SITE DEVELOPMENT

Within the boundary of the proposed site, currently one machinery shed for equipment storage, and four water dams exists. The proposed site would be required to build the offices and another shed for machinery storage.

3.3 REVIEW OF OPERATIONS

The preliminary equipment list for the site is presented below.

Machinery List for Extractive Activity

- Crusher (mobile) (1);
- Material sizing screen (1);
- Bulldozer (1);
- Front end loader (1);
- Backhoe (1);
- Trucks (estimate average of 3); and
- Water truck (1).

Site Infrastructure

- Office (including staff amenities) (1);
- Machinery shed (1);
- Equipment shed (Dangerous goods storage (fuel/oil) existing);
- On site waste water management facility;
- Access roads to office site (@ 6m width) and central quarry (@4m width);
- Security compound fencing around infrastructure (including lockable access gate to Tiyces lane);
- Electricity extension to security compound;
- Telephone extension to security compound;
- Water supply – existing dams on site; and
- Bore (proposed).

4. CURRENT LEGISLATION AND GUIDELINES

4.1 DIRECTOR GENERAL'S REQUIREMENTS

Director General's Requirements for the proposed development in relation to air quality are presented as follows:

> ***Key Issues:*** *The EIS must assess the following potential impacts of the proposal during construction and operation, and describe what measures would be implemented to avoid, minimise, mitigate, offset, manage and /or monitor these potential impacts:*
> *• Air quality (dust) in accordance with relevant Department of Environment and Climate Change guidelines. This assessment must consider any potential impacts on nearby sensitive environments and private receptors.*

A qualitative study has been undertaken to identify the receptors and the controls that one needed.

4.2 LEGISLATION

4.2.1 Protection of the Environment Operations Act, 1997

The Protection of the Environment Operations Act, 1997 (POEO Act) applies the following definitions relating to air pollution:

> ***"Air pollution"*** *means the emission into the air of any air impurity.*
>
> *While "air impurity" includes smoke, dust (including fly ash), cinders, solid particles of any kind, gases, fumes, mists, odours and radioactive substances*

The following clauses of this Act have most relevance to the site:

> *• Clause 124 (Operation of Plant)*
>
> *The occupier of any premises who operates any plant in or on those premises in such a manner as to cause air pollution from those premises is guilty of an offence if the air pollution so caused, or any part of the air pollution so caused, is caused by the occupier's failure:*
>
> *(a) to maintain the plant in an efficient condition, or*
>
> *(b) to operate the plant in a proper and efficient manner,*

• *Clause 126 (Dealing with Materials)*

(1) The occupier of any premises who deals with materials in or on those premises in such a manner as to cause air pollution from those premises is guilty of an offence if the air pollution so caused, or any part of the air pollution so caused, is caused by the occupiers failure to deal with those materials in a proper and efficient manner.

(2) In this section:

***Deal** with materials means process, handle, move, store or dispose of the materials.*

***Materials** include raw materials, materials in the process of manufacture, manufactured materials, by-products or waste materials.*

• *Clause 127 Proof of causing pollution*

To prove that air pollution was caused from premises within the meaning of Sections 124 – 126,it is sufficient to prove that air pollution was caused on the premises, unless the defendant satisfies the court that the air pollution did not cause air pollution outside the premises.

• *Clause 128 Standards of air impurities not to be exceeded*

(1) The occupier of any premises must not carry on any activity, or operate any plant, in or on the premises in such a manner as to cause or permit the emission at any point specified in or determined in accordance with the regulations of air impurities in excess of:

(a) The standard of concentration and the rate, or

(b) The standard of concentration or the rate.

Prescribed by the regulations in respect of any such activity or any such plant.

(2) Where neither such a standard nor rate has been so prescribed, the occupier of any premises must carry on any activity, or operate any plant, in or on the premises by such practicable means as may be necessary to prevent or minimise air pollution

The proposed development would be required to meet the above stated requirements.

4.2.2 The Protection of the Environment Operations (Clean Air) Regulation 2002

The proposed activity is considered to be "scheduled" as it would require an Environmental Protection Licence with the NSW DECC, due to the proposed production capacity approximately being close to the criteria of 60,000 tonnes per annum (which approximately equivalent to 30,000 m^3 per annum). Schedule 6 of the Protection of the Environment Operations (Clean Air) Regulation 2002 (Clean Air Regulation) provides standards of concentration for non-scheduled premises for general activities and plant. Group 6 would be the appropriate classification for the new development. Group 6 relates to an activity that has *commenced to be carried on, or to operate, on or after 1 September 2005, as a result of an environment protection licence granted under the Protection of the Environment Operations Act 1997 pursuant to an application made on or after 1 September 2005* under the regulation.

Table 4-1: Excerpt from Protection of the Environment Operations (Clean Air) Regulation 2002, Schedule 6 – *Standards of concentration for scheduled premises: General activities and plant*

Air Impurity	Activity or Plant	Group 6 Standard of Concentration
Solid Particles (Total)	Any activity or plant (except as listed below)	50 mg/m^3

Sources of dust associated with the proposed development would be required to meet the above listed requirements.

4.3 AMBIENT AIR QUALITY GOALS

The National Environment Protection Council sets uniform standards for ambient air quality. The standards relevant to this study are shaded in the following table.

Table 4-2: NEPM Standards and Goals for Ambient Air Quality

Pollutant	Averaging Period	Maximum Concentration	Goal within 10 years Maximum Allowable Exceedances
Particle as PM_{10}	1 day	50 $\mu g/m^3$	1 day a year

The National Environmental Protection Measure for Ambient Air Quality: Air Monitoring Plan for NSW established a goal for six air pollutants: carbon monoxide, photochemical oxidants (as ozone), nitrogen dioxide, sulphur dioxide, lead and particles as PM_{10}.

4.4 ESTABLISHMENT OF ASSESSMENT CRITERIA

Relevant air quality assessment criteria have been primarily adopted from the DECC NSW document "Approved Methods for the Modelling and Assessment of Air Pollutants in NSW" (DECC NSW 2005). These criteria are presented in Table 4-3.

Table 4-3: DECC NSW Air Quality Standards/Goal (Dust)

Pollutant	Descriptor	Standard	Averaging Time
Particulate Matter < 10µm (PM_{10})	Concentration	30 µg/m³ 50 µg/m³	Annual 24-hour
Total Suspended Particulates (TSP)	Concentration	90 µg/m³	Annual
Deposited Dust	Deposition	2 g/m²/month y a 4 g/m²/month y b	Annual

Notes:

µg/m³	-	micrograms/cubic meter
<10µg	-	less than 10 microns in aerodynamic diameter
a	-	maximum increase in deposited dust level
b	-	maximum total deposited dust level
1	-	background levels are to be considered when reporting potential impacts
2	-	total impact (incremental impact plus background) may require reporting and comparison with the impact assessment criteria

4.5 PROJECT SPECIFIC AIR QUALITY CRITERIA

The air quality criteria considered most relevant for this project would be PM_{10}, TSP and deposited dust as outlined in Table 4-3. These criteria are the most stringent of that detailed in this section and therefore would be applied in a quantitative dust study.

Modelling results of a quantitative study would be subjected to criteria in Table 4-2 and Table 4-3. Therefore, the use of the air quality criteria is considered to be the most reasonable means of ensuring that the activities of the proposed development do not adversely impact on the air quality amenity of residents.

5. QUANTITATIVE AIR ASSESSMENT

The quantitative air impact assessment comprises of the analysis of the following aspects:

- Meteorology and suitable site-representative meteorological data;
- Terrain elevation within proximity to the subject site;
- Local background air quality;
- Site representative emission sources and emission factors; and
- Air dispersion modelling methodology utilised for the assessment.

These aspects are discussed in further detail in the following sub-sections.

5.1 METEOROLOGY AND SITE-SPECIFIC METEOROLOGICAL DATA

A site-specific meteorological data specifically made for the region of Towrang was generated for the subject site using the computer simulation program "The Air Pollution Model" (TAPM). TAPM is a three-dimensional meteorological and air pollution model developed by the CSIRO Division of Atmospheric Research. TAPM uses databases of terrain, vegetation, soil, type, sea surface temperature and synoptic-scale meteorological analyses for Australia. The TAPM-generated Towrang meteorological file contained values for temperature, wind speed, wind direction, mixing height, stability class and standard wind deviation parameters.

To validate the use of the developed TAPM-generated meteorological file, its wind patterns were compared to a 5-year (long term) meteorological data from the nearest Bureau of Meteorology (BoM) monitoring station. This is discussed in further detail in Section 5.1.2.

5.1.1 Wind Speed and Stability Class

The "stability" of the atmosphere is a classification used to describe the structure of the atmosphere in terms of temperature, specifically, how temperature changes in the atmosphere with altitude. Classification is often in accordance with the Pasquill-Gifford classification system that consists of six stability class groups, shown in Table 5-1. The class "A" describes an atmosphere where the air is well mixed and there is little hindrance of dispersion into the atmosphere. At the other end of the scale is class "F", which describes conditions under which temperature inversions would occur, where winds are calm or absent and air close to the earth's surface cannot rise into the atmosphere due to the presence of warmer air layers above. The classes in between A and F indicate changing degrees of stability due to variations in temperature in the atmosphere.

Table 5-1: Pasquill-Gifford Stability Class System	
Stability Class	**Description**
A	Extremely Unstable
B	Unstable
C	Slightly Unstable
D	Neutral
E	Slightly Stable
F	Very Stable

Table 5-2 and Table 5-3 present the statistical information of the TAPM-generated Camden meteorological file. An annual average wind speed of 3.48 $m.s^{-1}$ was determined for the 2007 TAPM-generated meteorological file. The tables show that the primary wind directions were from the south-west followed closely by winds from the south direction. Winds were least likely to originate from the north-west.

Worst case dispersion conditions for emissions would occur during F-class stability conditions – generally associated with still / light winds and clear skies during the night time or early morning period (stable conditions). Analysis of the referenced site-specific meteorological data indicates the F-class dispersion conditions were present for approximately 15.8% of the time in the TAPM-Generated Towrang meteorological file, suggesting a reasonable low-risk of enhanced impacts due to this weather condition.

Looking at Table 5-3, it can be seen that stability class frequencies in the meteorological file are not biased towards giving enhanced dispersive conditions. Stability class D is the most frequent, with an occurrence of 51.4%. Stability classes A, B, C, which offer the best dispersion conditions, occur with frequencies of 0.4%, 3.8% and 15.5% respectively.

Table 5-2: Wind Direction / Stability Class Frequency Distribution (Count) for Referenced Meteorological Data Input File – TAPM-Generated Meteorological File 2007

Frequency Distribution (Count)							
Direction (Blowing From)	Stability Class						
	A	B	C	D	E	F	Total
N	4	47	114	231	89	258	743
NE	1	96	256	472	275	228	1328
E	8	59	249	686	195	97	1294
SE	4	38	130	829	91	53	1145
S	6	15	27	120	62	20	250
SW	4	16	68	130	30	43	291
W	6	36	364	1521	314	415	2656
NW	2	28	150	513	93	267	1053
Total	35	335	1358	4502	1149	1381	8760

Table 5-3: Wind Direction / Stability Class Frequency Distribution (Percentage) for Referenced Meteorological Data Input File – TAPM-Generated Towrang Meteorological File 2007

Frequency Distribution (Percentage %)							
Direction (Blowing From)	Stability Class						
	A	B	C	D	E	F	Total
N	0.05	0.54	1.30	2.64	1.02	2.95	8.48
NE	0.01	1.10	2.92	5.39	3.14	2.60	15.16
E	0.09	0.67	2.84	7.83	2.23	1.11	14.77
SE	0.05	0.43	1.48	9.46	1.04	0.61	13.07
S	0.07	0.17	0.31	1.37	0.71	0.23	2.85
SW	0.05	0.18	0.78	1.48	0.34	0.49	3.32
W	0.07	0.41	4.16	17.36	3.58	4.74	30.32
NW	0.02	0.32	1.71	5.86	1.06	3.05	12.02
Total	0.40	3.82	15.50	51.39	13.12	15.76	100.00

5.1.2 Wind Rose Plots

Wind rose plots show the direction from which the wind is coming from with triangles known as "petals". The petals of the plots in the figure summarise wind direction data into 8 compass directions i.e. north, north-east, east, south-east, etc. The length of the triangles, or "petals", indicates the frequency that the wind blows from the direction presented. Longer petals for a given direction indicate a higher frequency of wind from that direction. Each petal is divided into segments, with each segment representing one of the six wind speed classes. Thus, the segments of a petal show what proportion of wind for a given direction falls into each class. The proportion of time, for which wind speed is less than speeds in the first class (i.e. 0.5 $m.s^{-1}$), when speed is negligible, is referred to as calm hours or "calms". Calms are not shown on a wind rose as they have no direction, but the proportion of time that form part of the period under consideration is noted under each wind rose.

The concentric circles in each wind rose are the axis, which denote frequencies. In comparing the plots it should be noted that the axis varies between wind roses, although all wind roses are the similar in size. The frequencies denoted on the axes of the wind rose are indicated beneath each wind rose.

The nearest BoM monitoring station found within proximity to the subject site is the Goulburn Automatic Weather Station (AWS) (Station No. 070330). This was used as a basis of comparison with the TAPM-generated meteorological file.

Wind Rose Plots for Goulburn AWS Dataset and the 2007 TAPM-Generated Towrang Meteorological File are shown in Figure 5-1 and Figure 5-2.

5.1.3 Local Wind Trends

Figure 5-1 and Figure 5-2 indicate that wind characteristics for both the Goulburn AWS and TAPM-generated meteorological file show a high degree of similarity. Whilst the wind speeds vary – the TAPM-generated Towrang meteorological file wind speeds are consistently lower than Goulburn AWS.

Over the course of a year, westerly winds dominate for both the Goulburn AWS and the Towrang data at approximately 21% and 22% respectively. All other directions contribute wind with frequencies less than or equal to 15%. The Towrang data shows the next dominant winds from the north-east, east and south-east at approximately 14% whilst the Goulburn AWS data shows the second most-dominant winds from the east and north-west at approximately 15%.

In summer at Towrang, winds frequently blow from the north-east (30%), followed closely by easterly (25%), and northerly (14%). Goulburn AWS data indicates that the easterly (27%), westerly (15%), north-easterly (15%) and south-easterly (16%) are dominant. Calms for Towrang and Goulburn in this season are 0.32% and 5.97% respectively.

During autumn, the Towrang file shows dominance from the west direction (30%), followed by winds from the north-west (16%), east (14%) and south-east (14%). The Goulburn AWS data file shows that winds from this region dominantly blow from the west (20%), followed by winds from the east (14%), north-west (13%) and south-east (12%). Calms for Towrang and Goulburn in this season are 1.54% and 17.32% respectively.

For the region of Towrang, winter winds dominantly come from the west only (49%) with little contribution from the south-east (16%) and north-west (11%). Westerly winds (30%) also dominate in the Goulburn AWS data, followed by winds from north-west (20%). Calms for Towrang and Goulburn in this season are 0.59% and 15.72% respectively.

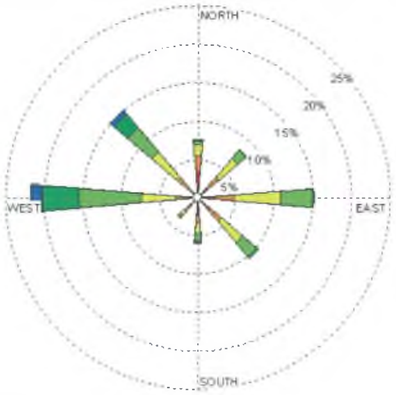
In spring at Towrang, westerly winds remain dominant (30%) followed by winds from the east (17%), north-east (13%) and south-east (13%). The Goulburn AWS data also shows dominance of winds from the west (23%) with significant contributions from the north-west (16%), east (14%) and south-east (10%).

Average wind speed values range from 2.88 m/s (autumn) up to 4.06 m/s (winter) at Towrang whilst the Goulburn AWS data shows a range of values from 3.71 m/s (autumn) up to 4.78 (spring).

As outlined above, there are some differences between the wind patterns of the TAPM-generated meteorological data and the long term Goulburn AWS data, which is to be expected. However, the similarities between the two data sets suggest that the TAPM-generated Towrang meteorological file is suitable for use in the dispersion modelling of this assessment.

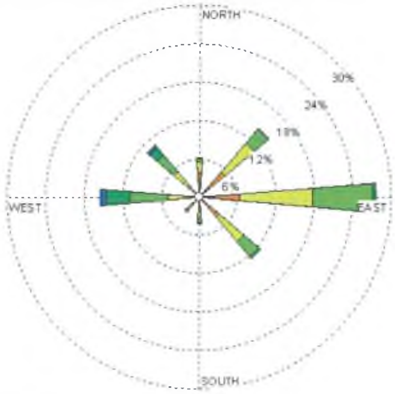
Figure 5-1: Annual Wind Rose Plots from the 2004-2008 Goulburn BoM Station Dataset

All Seasons



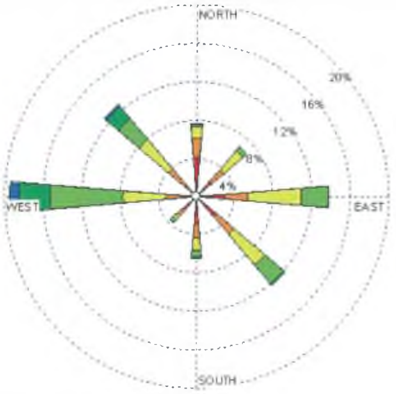
Average Wind Speed: 4.43 m/s
Calms Frequency: 12.07 %
Axis Frequencies: 5%, 10%, 15%, 20%, 25%

Summer (December – February)



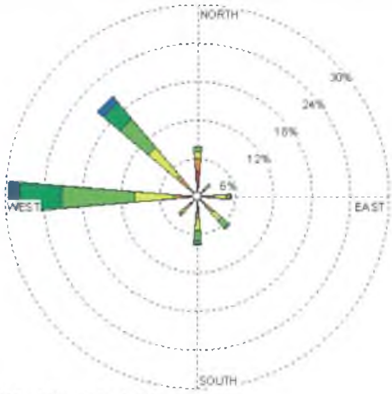
Average Wind Speed: 4.69 m/s
Calms Frequency: 5.97 %
Axis Frequencies: 6%, 12%, 18%, 24%, 30%

Autumn (March – May)



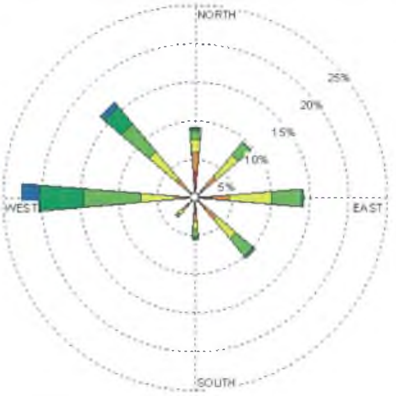
Average Wind Speed: 3.71 m/s
Calms Frequency: 17.32 %
Axis Frequencies: 4%, 8%, 12%, 16%, 20%

Winter (June – August)



Average Wind Speed: 4.52 m/s
Calms Frequency: 15.72 %
Axis Frequencies: 6%, 12%, 18%, 24%, 30%

Spring (September – November)



Average Wind Speed: 4.78 m/s
Calms Frequency: 9.12 %
Axis Frequencies: 5%, 10%, 15%, 20%, 25%

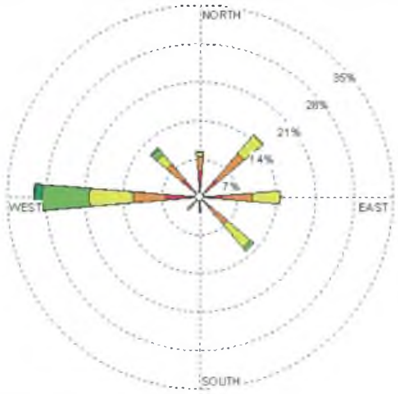
Legend

WIND SPEED
(m/s)

- >= 11.1
- 8.8 - 11.1
- 5.7 - 8.8
- 3.6 - 5.7
- 2.1 - 3.6
- 0.5 - 2.1

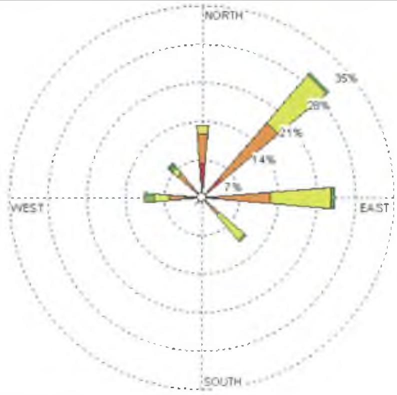
Figure 5-2: Annual Wind Rose Plots from the 2007 TAPM-Generated Meteorological File

All Seasons



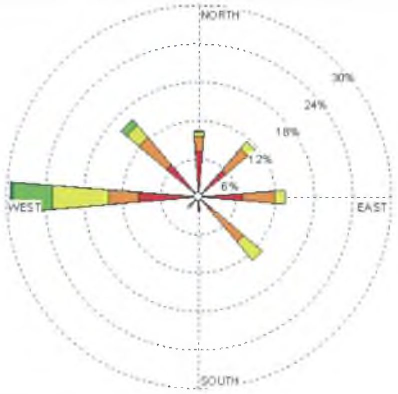
Average Wind Speed: 3.48 m/s
Calms Frequency: 0.87%
Axis Frequencies: 7%, 14%, 21%, 28%, 35%

Summer (December – February)



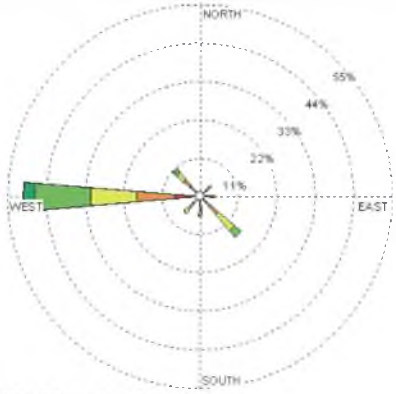
Average Wind Speed: 3.34 m/s
Calms Frequency: 0.32 %
Axis Frequencies: 7%, 14%, 21%, 28%, 35%

Autumn (March – May)



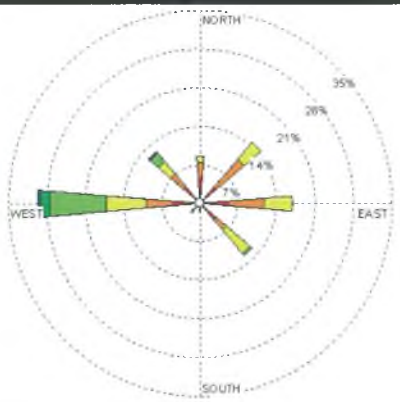
Average Wind Speed: 2.88 m/s
Calms Frequency: 1.54 %
Axis Frequencies: 6%, 12%, 18%, 24%, 30%

Winter (June – August)



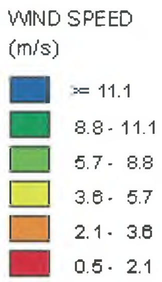
Average Wind Speed: 4.06 m/s
Calms Frequency: 0.59 %
Axis Frequencies: 11%, 22%, 33%, 44%, 55%

Spring (September – November)



Average Wind Speed: 3.62 m/s
Calms Frequency: 1.01 %
Axis Frequencies: 7%, 14%, 21%, 28%, 35%

Legend



5.2 Terrain of the Region

An assessment of the 1:25,000 topographic map for the region indicates the subject site and surrounding landscapes are subject to minor changes in elevation. The elevation of the area ranges between 670 metres to approximately 830 metres within the regional area of the site location. The terrain of the subject site location is approximately 720 to 730 metres in Australian Height Datum (AHD) Elevation and is seen to decrease towards the north-west and south-east section of the subject boundary indicated in Figure 2-5. The terrain further decreases towards this direction, outside the indicated site boundary. A further decrease in elevation is seen towards the north-east whilst the south-east region shows an increase in elevation of approximately 100 metres compared to the subject site elevation.

A terrain information file was consequently constructed by digitising the 1:25,000 topographic contour map with 10 m contour intervals for the region of interest. This was incorporated into the air dispersion modelling to take into account the terrain effects on the emissions from the subject site.

Two 3-dimensional views of the site have been provided as Figure 5-3 and Figure 5-4. The first figure shows the terrain with the z-axis (i.e. vertical axis) exaggerated by a factor of 5 (i.e. a given distance on the x-axis or y-axis appears 5 times as great on the z-axis). This figure helps to present the terrain features and how they are shaped. It should be noted that these figures are an approximation of the actual terrain, based on terrain information taken from maps of the area.

5.3 Local Background Air Quality

No monitoring station has been found to provide representative background air quality measurements for the subject site. However, the local background air quality can be defined based on the surrounding land use.

The region of subject site location is predominantly occupied by heavy vegetation (i.e. forests) with residential homes scattered across the regional area. These homes are expected to increase in the near future. No major sources of emissions such as industrial facilities are found to be within the region of interest. Emissions from road vehicle travel and activities from the nearby horse training facility are expected to provide minor contribution to the background air quality. With these, it is expected that the levels of PM_{10}, TSP and Dust Deposition are low to negligible.

For this assessment, it has then been considered and assumed that background levels of PM_{10}, TSP and Dust Deposition are negligible.

Figure 5-3: 3-Dimensional Terrain Surface View for the Site Location (Z Axis Exaggerated by a Factor of 5)

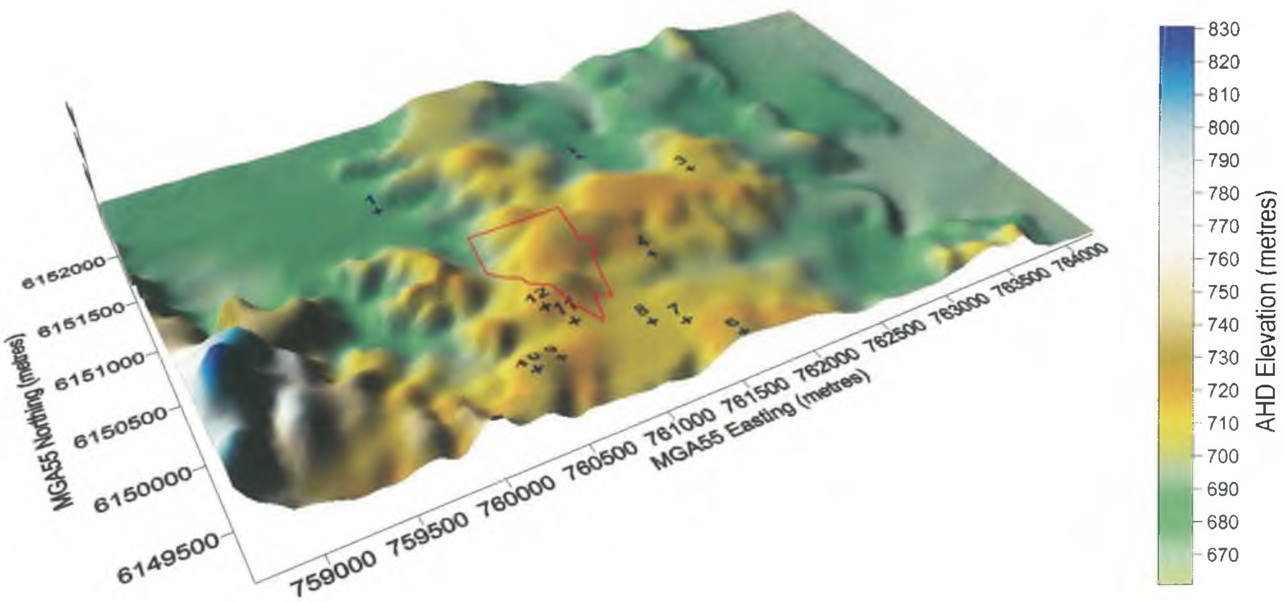
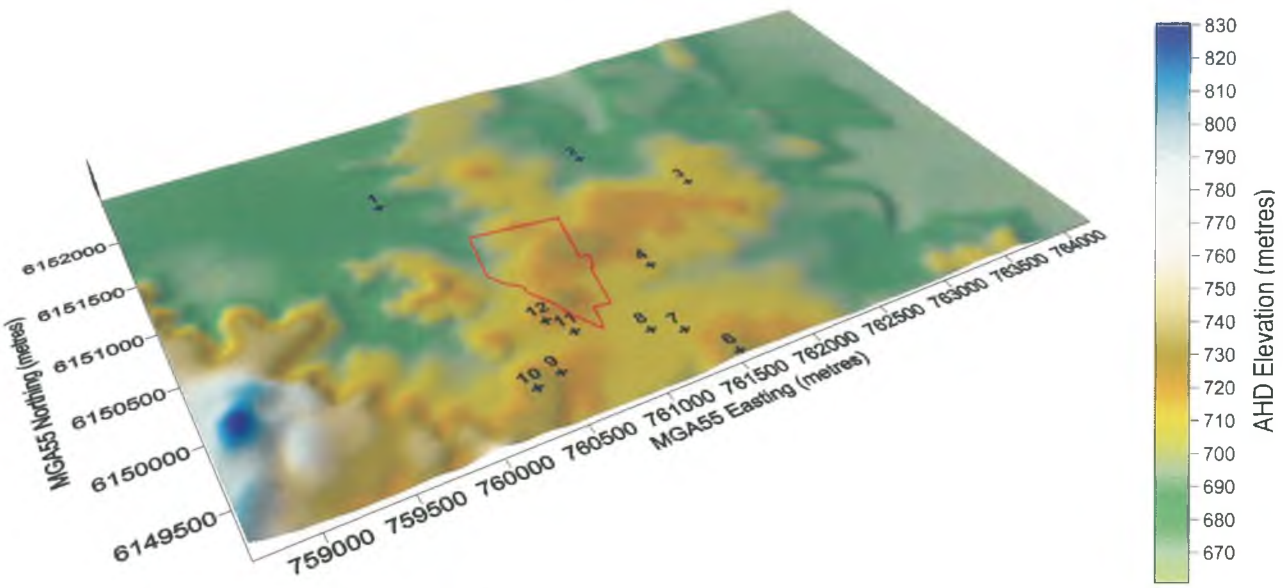


Figure 5-4: 3-Dimensional Terrain Surface View for the Site Location (Unexaggerated Z-Axis)



5.4 EMISSION SOURCES AND EMISSION RATES

The following emission sources were considered in the assessment:

- Vehicle Travel Emissions;
- Loading, Unloading and Material Handling Emissions;
- Wind Erosion from Stockpiles;
- Crushing and Screening Emissions; and
- Excavation Emissions.

5.4.1 Vehicle Travel Emissions

"*Dust Emissions* " written by F.W. Parrett (Parrett 1992) contains a methodology of calculating dust emission rates from vehicle travel on paved roads based on the dust suspension, exhaust emissions and tyre usage. Compared to generic emission factors, the referenced equation focuses on developing a site-specific emission factor based on site-specific conditions and properties, shown as Equation 5-1. Calculated emission factors are shown in Table 5-4.

Equation 5-1

$$E = 0.81PS\left(\frac{V}{30}\right)\left(\frac{365-R}{365}\right)\left(\frac{T}{4}\right)$$

Where

E = emission factor in lb/vehicle mile
P = fraction of particles from surface which will remain suspended
E_x = particle emissions from vehicle exhausts
Y = wear from tyres
T = number of tyres per vehicle

Table 5-4: Adopted Emission Factors for Vehicle Travel on Paved Roads

Activity	PM_{10} Emission Factor	TSP Emission Factor	Units
Dust loss from staff vehicle movements on unpaved roads	8.38×10^{-2}	1.64×10^{-1}	lb/vehicle mile
Dust loss from truck travel movements on unpaved roads	1.26×10^{-1}	2.46×10^{-1}	lb/vehicle mile

Note: TSP emission factors were conservatively estimated using the PM_{10}-to-TSP ratio of 0.5 referenced from the NPI EETM emission factors.
These emission factors are converted into the SI units of g/s for use in the modelling.

5.4.2 Loading, Unloading and Material Handling Emissions

Particulate emission rates for loading, unloading and material handling activities were estimated based on correlations listed in the National Pollutant Inventory (NPI) guidelines "*Emission Estimation Technique Manual (EETM) for Mining*" (NPI DEH 2001). The referenced equations focus on developing a site-specific emission factors based on the site-specific conditions and properties, shown as Equation 5-2 and Equation 5-3.

Equation 5-2: $$E = k0.0016\left(\frac{U}{2.2}\right)^{1.3}\left(\frac{M}{2}\right)^{-1.4}$$

Where

E = emission factor for loading and unloading emissions in kg/ton
k = 0.74 for TSP
0.35 for PM_{10}
U = mean wind speed in m/s
M = material moisture content in %

Equation 5-3: $$E = h(s^r)(M^{-X})$$

Where

E = emission factor for material handling emissions in kg/hr
h = 2.60 for TSP
0.34 for PM_{10}
s = silt content in %
r = 1.2 for TSP
1.5 for PM_{10}
M = material moisture content in %
x = 1.3 for TSP
1.4 for PM_{10}

The calculated emission factors are for uncontrolled emissions and are listed in Table 5-5.

Table 5-5: Adopted Emission Factors from NPI EETM Guidelines

Activity	PM_{10} Emission Factor	TSP Emission Factor	Units
Loading and Unloading Emissions	0.40	2.21	kg/tonne
Material Handling Emissions	2.82×10^{-4}	5.96×10^{-4}	kg/hr

Source: NPI DEH (2001)

5.4.3 Wind Erosion Emissions from Stockpiles

"*Dust Emissions*" written by F.W. Parrett (Parrett 1992) contains a methodology of calculating dust emission rates from wind eroded stockpiles based on the parameters of silt content, wind speed and moisture. Compared to generic emission factors, the referenced equation focuses on developing a site-specific emission factor based on site-specific conditions and properties, shown as Equation 5-4.

Equation 5-4: $E_w = 0.05(S/5)(D/90)(d/235)(f/15)$

Where

E_w = emission factor for wind erosion in lb/ton of material stored
S = silt content (weight percent of material stored)
D = number of days material is stored
d = number of dry days per year
f = percentage of time wind speed exceeds 12 mph (equivalent to 5.36 m/s)

Table 5-6: Adopted Emission Factors for Wind Erosion

Activity	PM_{10} Emission Factor	TSP Emission Factor	Units
Wind Erosion	3.89×10^{-3}	7.62×10^{-3}	kg/tonne

5.4.4 Crushing and Screening Emissions

Fine particulate emission factors for the main activities of the site were estimated based on factors listed in the U.S. EPA AP 42 Emission Factors "*Chapter 11.19 - Introduction to Construction and Aggregate Processing, Section 2 - Crushed Stone Processing and Pulverised Mineral Processing*" (USEPA 2004). The referenced AP 42 emission factors were used as representative emission factors for the crushing and screening activities of the subject site, which are listed in Table 5-7. It is to be noted that these emission factors are for uncontrolled emissions.

Table 5-7: Adopted Emission Factors from AP 42 Emission Factors

Activity	PM_{10} Emission Factor	TSP Emission Factor	Units
Crushing (Fines)	0.0075	0.0195	kg/tonne
Screening	0.0043	0.0125	kg/tonne

Source: USEPA (2004)

5.4.5 Excavation Emissions

Emissions from loading, unloading and material handling were estimated based on methodology listed in the National Pollutant Inventory (NPI) guidelines "*Emission Estimation Technique Manual (EETM) for Mining*" (NPI DEH December 2001). The referenced equations focus on developing a site-specific emission factors based on the site-specific conditions and properties, shown as Equation 5-5. It is to be noted that Equation 5-5 is similar to the "Loading, Unloading and Material Handling" emission equation.

Equation 5-5:

$$E_w = k(0.0016)\frac{(U/2.2)^{1.3}}{(M/2)^{1.4}}$$

Where

E_w = Emission factor using a front end loader or an Excavator in kg/tonne
k = 0.74 for particles less than 30 micrometres aerodynamic diameter
0.35 for particles less than 10 micrometres aerodynamic diameter
U = Mean wind speed in m/s
M = Moisture content in %

Table 5-8: Adopted Emission Factors from NPI EETM Guidelines

Activity	PM_{10} Emission Factor	TSP Emission Factor	Units
Excavator	2.82×10^{-4}	5.94×10^{-4}	kg/tonne
Front End Loader	2.82×10^{-4}	5.94×10^{-4}	kg/tonne

Source: NPI DEH (2001)