

19 April 2010

WM Project Number: 01127-EW
Our Ref: ROC190410DB BarnOwl
Email: paul.slough@rocla.com.au

Mr Paul Slough
Calga Quarry
72 Orchardleigh Street
GUILDFORD NSW 2161

Dear Paul

**Re: Investigation of Noise Complaint from Australia Walkabout Wildlife Park
- Noise Monitoring 26 Feb - 5 Mar 2010**

1 INTRODUCTION

Wilkinson Murray was commissioned to monitor and assess operational noise levels from the Calga Sand Quarry from the Gerald & Tassin Barnard residence at Australia Walkabout Wildlife Park in pursuit of the following goals:

- a) to investigate a noise complaint received from Tassin Barnard in relation to quarry noise during the period 5-7am, and
- b) to determine the compliance of the quarry's noise emissions at all times.

The monitoring was undertaken at the request of Rocla which operates Calga Sand Quarry and comprised both short-term attended and long-term unattended noise monitoring. This report assesses the quarry's noise emission levels in relation to the noise criteria stipulated in the development consent (DA 94-4-2004) for the Calga Sand Quarry. Consideration is also given to the appropriateness of the current noise criteria (when compared to the *Industrial Noise Policy [INP]*).

2 BACKGROUND INFORMATION

Approved Operations

DA 94-4-2004 approves limited "Delivery and Distribution" activities only during night periods (defined by DECCW as the period 10.00pm-7.00am). In practice, this manifests as the arrival to site of in the order of ten trucks for loading by front-end loader between the hours 5.00am-7.00am, Monday to Saturday (inclusive). DA 94-4-2004 approves extraction and excavation activities during daytime hours (7.00am-6.00pm Monday to Friday and 7.00am-4.00pm Saturday). As heard from the Barnard residence at the Australia Walkabout Wildlife Park, the potential sources of noise from the quarry would be:

- 5.00am-7.00am Trucks being loaded by front-end loader;
- 7.00am-6.00pm Wash plant and screen, mortar sand plant, loaders, dozer, trucks;
- 6.00pm-10.00pm Trucks being loaded by front-end loader.

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Existing Noise Criteria

The criteria governing operational noise emissions from the Calga Sand Quarry are expressed in Table 1 of Condition 2 (Schedule 3) of DA 94-4-2004. Condition 2 requires that noise from the Calga Sand Quarry is not to exceed the following limits when measured at the Barnard residence:

- 35dBA $L_{eq,15min}$ at any time, Day, Evening or Night, nor
- 45 $L_{A1,1min}$ during Night (10.00pm-7.00am) periods.

(Note that for the purposes of this assessment, the $L_{A1,1min}$ and L_{Amax} noise descriptors may be considered to be equivalent and interchangeable.)

Notably, the 35dBA $L_{eq,15min}$ operational noise criterion for the Barnard residence is based on an assumed Rating Background Level (RBL) of 30dBA which the Environment Protection Licence deemed to apply to "all other residences" in the absence of measured background noise monitoring data. The accuracy of this assumption, and therefore the suitability of the noise criteria, is considered in light of the monitoring undertaken.

3 MONITORING METHODOLOGY

3.1 Unattended Monitoring using BarnOwl Directional Noise Monitoring System

Noise levels from existing quarrying operations at Calga Sand Quarry were monitored from the Barnard residence using the "BarnOwl" directional noise monitor, which allows for the detection of the loudness and direction of all noise sources surrounding the monitor. For this project, the BarnOwl monitor was set up to identify the level of noise arriving to the residence from the direction of the Calga Quarry, and also from all sources in all other directions (and in particular, from the F3 Motorway to the south).

The Barnard residence is situated at the top of a ridge, approximately 1km south of Calga Sand Quarry and approximately 600m north-west of the F3 Motorway. It is located approximately 1,130m from the wash plant, 1,290m from the active extraction area and 1,070m from the mortar sand plant. As indicated in the site location map shown in Figure 1, the angle of view from the residence to the operational area of the quarry subtends a 45° arc from angles 300°-345° with respect to Magnetic North (0°). (Magnetic North is orientated 13 degrees east of True North.) The angles of view to adjacent section of Peats Ridge Road and the F3 Motorway are also indicated in Figure 1. The BarnOwl monitor was pre-programmed to discriminate between noise arriving to the monitor from each of these sectors.

In addition to the recording of the level and direction of noise, the BarnOwl monitor was programmed to also record audio samples of the total noise (note: not directionally-discriminated noise) every minute between 5.00-7.00am each day. This facility was utilised to assist in positively identifying intermittent noise events during that section of the night period for which the quarry operates (ie, 5.00-7.00am). This is often referred to by DECCW as the "morning shoulder period" given that at many sites, background noise levels increase sharply from the night time lows to levels more characteristic of daytime periods.

In addition, the Barnowl unit was programmed to simultaneously monitor the $L_{A90,15min}$ background noise level (from all sources in all directions) for the entire week of monitoring. This capability is identical to the function served by a conventional noise logger.

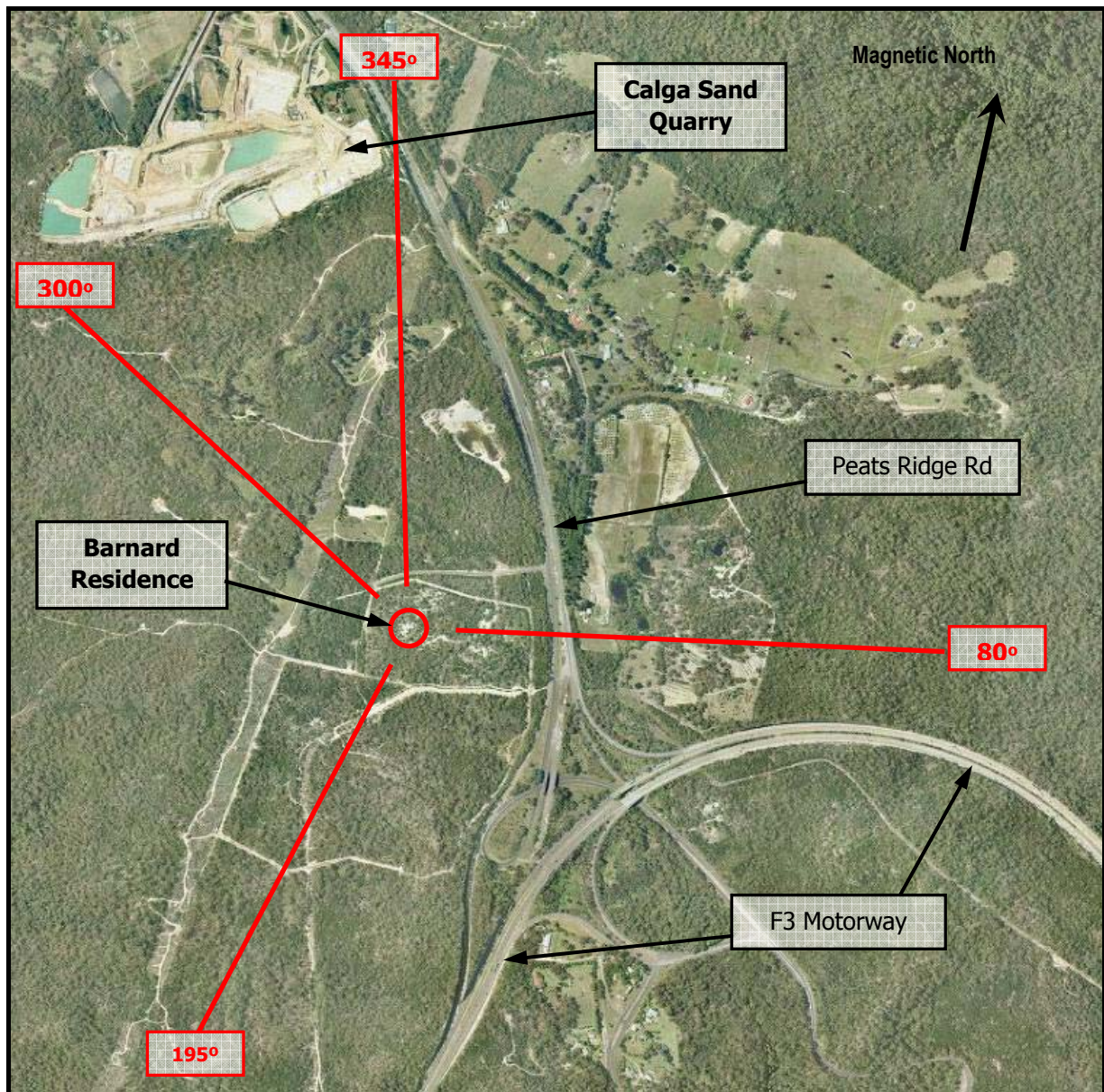


Figure 1 Site Location Map showing Angles of Views (from 0° Magnetic North) used for Directional Noise Monitoring

The real-time unattended, directional noise monitoring was conducted from Friday, 26 February to Friday, 5 March 2010. The BarnOwl monitor was positioned approximately 7 metres from the eastern end of the residential dwelling as shown in Figure 2. (The view north to Calga Quarry from the BarnOwl monitor is shown in Figure 3.) The BarnOwl calibration was checked before and after the survey and no significant drift occurred. In the analysis of the data, noise data was excluded for periods during which winds were above 3m/s and/or it has rained during the 15-minute measurement period based on meteorological data acquired from the Quarry's weather station.



Figure 2 Location of BarnOwl monitoring position at eastern end of residence

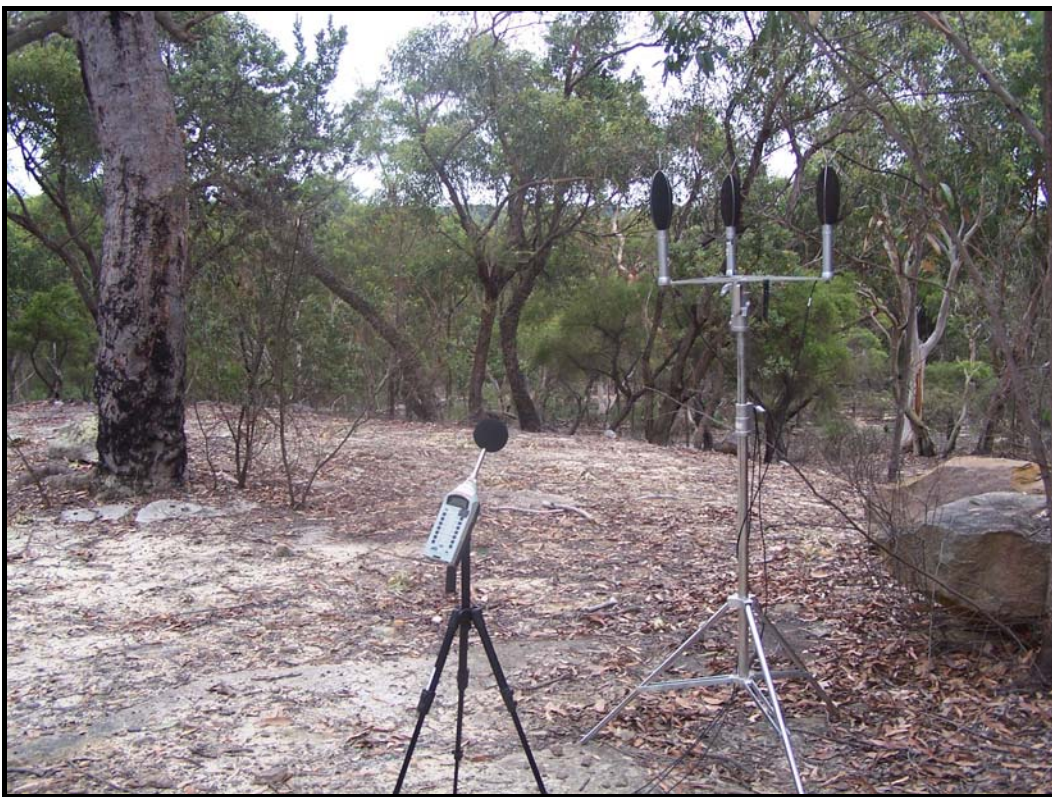


Figure 3 View north to the Quarry from BarnOwl monitoring location

3.2 Attended Monitoring of Quarry Operational Noise

As a means of confirming the accuracy of the unattended noise monitoring results, and also for the purpose of positively identifying the contribution from various noise sources, attended monitoring of the quarry's operational noise was undertaken from the residence on the morning of Friday, 26 February 2010 between the hours of 5.45am-8.30am. This period was chosen so as to be able to monitor noise from both the quarry's night (5.00-7.00am) and daytime (7.00am-6.00pm) operations according to the definition of those periods used by the DECCW.

During this monitoring period, noise levels from all sources - including the quarry and the F3 Motorway - were monitored over 15-minute periods using Bruel and Kjaer Type 2231 Sound Level Meter. This sound level meter conforms to Australian Standard 1259 *Acoustics - Sound Level Meters* as a Type 1 Precision Sound Level Meter which has accuracy suitable for field and laboratory use. The A-Weighting filter of the meter was selected and the time weighting was set to "Fast". The calibration of the meter was checked before and after the measurements with a Bruel and Kjaer Type 4231 sound level calibrator and no significant drift was noted. The weather during this period was fine, overcast and without wind.

3.3 Operating Hours of Quarry Wash Plant during Noise Monitoring Period

Quarry noise to the Barnard residence results primarily (although not necessarily exclusively) from the operation of the wash plant located at the eastern end of the quarry. The operational hours of the quarry wash plant during the week of unattended noise monitoring was as follows:

Friday 26 Feb 2010	07:00-17:49 hrs
Monday 1 Mar 2010	10:25-17:50 hrs
Tuesday 2 Mar 2010	07:20-17:40 hrs
Wednesday 3 Mar 2010	07:20-16:00 hrs
Thursday 4 Mar 2010	11:46-15:49 hrs

In addition, for the purpose of assessing the wash plant's worst case noise emissions, the wash plant was set to process the densest grade aggregate during the period 07:22-08:23 hours on the day of the attended noise monitoring (Friday 28 February 2010).

4 RESULTS OF NOISE MONITORING

4.1 Results of Unattended BarnOwl Directional Noise Monitoring

The results of the directional noise monitoring using the BarnOwl unit are displayed in Appendices A-C. The explanation of each of the outputs is detailed below. The analyses of these data are presented in Section 5.

Appendix A – L_{Aeq} Noise from the Direction of the Quarry

Graphs include four plots as follows:

- Red Line: the total $L_{Aeq,15min}$ noise level from the direction of the quarry (between angles 300°-345°) only;
- Green Line: the total $L_{Aeq,15min}$ noise level from all identified noise sources (including the quarry) in ALL directions (between angles 0°-360°);
- Blue Line: The background, $L_{A90,15min}$ noise level. This arises from sources in all directions, and includes noise from sources that cannot be assigned to any particular direction;
- Black Line: Criterion Limit for noise from quarry (red line) for Day, Evening and Night periods (ie 35dBA $L_{Aeq,15min}$).

Appendix B – L_{Aeq} Noise from the Direction of the F3 Motorway

Graphs include three plots as follows:

- Red Line: the total $L_{Aeq,15min}$ noise level from the direction of the F3 Motorway (between angles 80°-195°) only;
- Green Line: the total $L_{Aeq,15min}$ noise level from all identified sources (including, but not limited to the F3 Motorway, Peats Ridge Rd and the quarry) in ALL directions (between angles 0°-360°);
- Blue Line: The background, $L_{A90,15min}$ noise level. This arises from sources in all directions, and includes noise that cannot be assigned to any particular direction.

Appendix C – Directional Maximum L_{Amax} Noise Levels

Graphs include four plots as follows:

- Red Line: the L_{Amax} noise level from the direction of the quarry (between angles 300°-340°) only. The values shown in Appendix C represent the energy-average of five 1-minute L_{Amax} levels, for clarity of presentation and to represent short periods of consistently repeatable maximum levels;
- Green Line: the L_{Amax} noise level from the direction of the F3 Motorway (between angles 80°-195°), presented on the same basis as above;
- Blue Line: The background, $L_{A90,15min}$ noise level. This arises from sources in all directions, and includes noise that cannot be assigned to any particular direction.
- Black Line: "Sleep Disturbance" Limit for maximum noise levels from the quarry for night period (ie 45dBA L_{Amax}). Note that this limit applies only to operational noise within the period 10.00pm-7.00am.

4.2 Results of Attended Noise Monitoring

Attended monitoring of the quarry's noise emissions was undertaken from two locations adjacent to the Barnard residence in the early morning hours of Friday, 26 February 2010. Most attended measurements (those from 5.45am-7.45am) were undertaken from a position 1m away from the BarnOwl monitor at the north-eastern end of the dwelling. The last three 15-minute attended measurements (7.45am-8.30am) were undertaken from a point 1.5m external to the bedroom facade at the north-western end of the dwelling.

It was confirmed after the monitoring session that during the period 5.00am-7.00am, early-morning "delivery and distribution" activity at the quarry was "as normal", involving one front-end loader loading eleven road trucks (arriving separately) with sand products. Quarry activity in the period 7.00am-8:30am was also "as normal" with the exception that the wash/screen plant was set to process the coarsest grade sandstone during the period 07:22-08:23 hrs, in order that the quarry's worst case noise emissions could be monitored.

The results of the attended monitoring are presented in Table 1.

Table 1 Results of Attended Noise Monitoring of Quarry Emissions (26 Feb 2010)

Time	Noise from Direction of Quarry		Noise from ALL Sources	Background Noise Level	Comments
	dB(A)L _{Aeq,15min}	dB(A)L _{Amax}	dB(A)L _{Aeq,15min}	dB(A)L _{A90,15min}	
0545-0600 hrs	Inaudible <31	Inaudible <31	44	41	Quarry inaudible. Ambient L _{eq} noise: F3 Motorway Truck passbys: 46-49 dBAL _{max}
0600-0615 hrs	Inaudible <32	Inaudible <32	44	42	Quarry inaudible. Ambient L _{eq} noise: F3 Motorway Truck passbys: 47-51 dBAL _{max}
0615-0630 hrs	Inaudible <34	Inaudible <34	46	44	Quarry inaudible. Ambient L _{eq} noise: F3 Motorway/birds Bird chorus: 53-54 dBAL _{max} Truck passbys: 47-52 dBAL _{max}
0630-0645 hrs	Inaudible <36	Inaudible <36	49	46	Quarry inaudible. Ambient L _{eq} noise: F3 Motorway/birds Bird chorus: 57-64 dBAL _{max} Truck passbys: 49-53 dBAL _{max}
0645-0700 hrs	Inaudible <34	Inaudible <34	48	44	Quarry inaudible. Ambient L _{eq} noise: F3 Motorway/birds Bird chorus: 63 dBAL _{max} Truck passbys: 50-52 dBAL _{max}
0700-0715 hrs	Inaudible <34	Inaudible <34	51	44	Quarry inaudible. Ambient L _{eq} noise: F3 Motorway/birds Bird chorus: 60-62 dBAL _{max} Truck passbys: 49-50 dBAL _{max}

Time	Noise from Direction of Quarry		Noise from ALL Sources	Background Noise Level	Comments
	dB(A)L _{Aeq,15min}	dB(A)L _{Amax}	dB(A)L _{Aeq,15min}	dB(A)L _{A90,15min}	
0715-0730 hrs	Inaudible <33	Inaudible <33	46	43	Quarry noise audible momentarily (<1min), but otherwise inaudible. Ambient L _{eq} noise: F3 Motorway/birds Bird chorus: 60-61 dBAL _{max} Truck passbys: 52-53dBAL _{max}
0730-0745 hrs	-	-	-	-	No measurement undertaken – discussion with residents
0745-0800 hrs ⁽¹⁾	40 ⁽¹⁾ (estimate)	41 ⁽¹⁾ (estimate)	45 ⁽¹⁾	38 ⁽¹⁾	Quarry audible amongst other ambient sources (F3). Bird chorus: 56-67 dBAL _{max} Truck passbys: 45-51dBAL _{max}
0800-0815 hrs ⁽¹⁾	38 ⁽¹⁾ (estimate)	38 ⁽¹⁾ (estimate)	42 ⁽¹⁾	37 ⁽¹⁾	Quarry audible amongst other ambient sources (F3). Bird chorus: 54-57 dBAL _{max} Truck passbys: 43-47dBAL _{max}
0815-0830 hrs ⁽¹⁾	38 ⁽¹⁾ (estimate)	43 ⁽¹⁾	42 ⁽¹⁾	38 ⁽¹⁾	Quarry audible amongst other ambient sources (F3). Bird chorus: 54-61 dBAL _{max} Plane passby: 55dBAL _{max} Quarry noise in wind gust: 43 dBAL _{max}

Note: (1) Noise monitoring undertaken 1.5m from northern façade of bedroom at western end of Barnard dwelling.
Noise measurements shown in Table 3 are façade-corrected values (ie, -2dB correction applied to monitored level).

5 ANALYSIS OF RESULTS

5.1 Analysis of Unattended BarnOwl Noise Monitoring Results

The analyses of the BarnOwl monitoring data is presented below with respect to the directional noise monitoring charts presented in Appendices A, B and C respectively.

5.1.1 Analysis of Appendix A Data – L_{Aeq} Noise from the Direction of the Quarry

During the week's monitoring, there were some 15-minute periods during which the $L_{Aeq,15min}$ noise level from the quarry direction (red line) exceeded the consent criterion (black line). These are indicated by numbered markers (numbers 1 to 27) in Appendix A. Comments relating to these numbered events are presented in Table 2, including comments based on analysis of the corresponding BarnOwl audio files where available.

Table 2 Summary of BarnOwl-Measured $L_{Aeq,15min}$ Noise Levels from Direction of Quarry

Marker No.	Day / Date	Time Period	L_{eq} from Direction of Quarry $dBAL_{eq,15min}$ (Red Line)	L_{eq} from ALL Sources $dBAL_{eq,15min}$ (Green Line)	Background $dBAL_{90,15min}$ (Blue Line)	Exceedance of Criterion ($35dBAL_{eq,15min}$)	Comments
1		04:45-05:00	40	45	44	5	Analysis of BarnOwl audio indicates that L_{eq} noise level resulted from F3 Traffic & footsteps of BarnOwl operators (setting up Barnowl auxiliary equipment). Quarry was inaudible during this 15 minute period.
1		05:00-05:15	43	47	Not available	8	Analysis of BarnOwl audio indicates that L_{eq} noise level resulted from voices of BarnOwl operators (setting up BarnOwl auxiliary equipment). Quarry was inaudible during this 15 minute period.
1	Friday 26 Feb 2010	05:15-05:30	40	50	43	5	Analysis of BarnOwl audio indicates that L_{eq} noise level resulted from F3 Traffic. Quarry was inaudible during this 15 minute period
2		08:15-08:30	49	57	42	14	No audio available. Sound level from all directions also increases. Quarry-direction noise level is higher than background L_{90} by 7dB.
3		11:45-12:00	38	46	36	3	No audio available. Sound level from "all directions" also increases. Quarry-direction noise level is higher than background L_{90} by 2dB.
4		16:30-16:45	43	52	46	8	No audio available. Sound level from "all directions" also increases. Quarry-direction noise is lower than background L_{90} noise level.
4		16:45-17:00	45	53	46	10	No audio available. Sound level from "all directions" also increases. Quarry-direction noise is lower than background L_{90} noise level.

Marker No.	Day / Date	Time Period	L_{eq} from Direction of Quarry dBAL _{eq,15min} (Red Line)	L_{eq} from ALL Sources dBAL _{eq,15min} (Green Line)	Background dBAL _{90,15min} (Blue Line)	Exceedance of Criterion (35dBAL _{eq,15min})	Comments on Noise from Quarry Direction
5		17:45-18:00	46	56	45	11	No audio available. Sound level from "all directions" also increases. Quarry-direction noise is higher than background L ₉₀ noise level by 1dB.
5		18:00-18:15	45	54	45	10	No audio available. Sound level from "all directions" also increases. Quarry-direction noise is equal to background L ₉₀ noise level.
5		18:15-18:30	43	53	46	8	No audio available. Sound level from "all directions" also increases. Quarry-direction noise is lower than background L ₉₀ noise level.
5		18:30-18:45	39	49	46	4	
5		19:00-19:15	37	50	46	2	
6		06:30-06:45	39	49	37	4	Analysis of BarnOwl audio indicates that L_{eq} noise level resulted from F3 Traffic and birds. Quarry was inaudible during this 15 minute period
6		07:00-07:15	47	56	39	12	Analysis of BarnOwl audio indicates that L_{eq} noise level resulted from operation of F3 traffic and birds. Quarry was inaudible during this 15 minute period
6	Saturday 27 Feb 2010	07:30-07:45	40	52	38	5	No audio available. Sound level from "all directions" also increases. Quarry-direction noise is higher than background L ₉₀ noise level by 2dB.
7		08:30-08:45	41	49	36	6	No audio available. Sound level from "all directions" also increases. Quarry-direction noise is higher than background L ₉₀ noise level by 5dB
7		08:45-09:00	43	54	37	8	No audio available. Sound level from "all directions" also increases. Quarry-direction noise is higher than background L ₉₀ noise level by 6dB

Marker No.	Day / Date	Time Period	L_{eq} from Direction of Quarry dBAL_{eq,15min} (Red Line)	L_{eq} from ALL Sources dBAL_{eq,15min} (Green Line)	Background dBAL_{90,15min} (Blue Line)	Exceedance of Criterion (35dBAL_{eq,15min})	Comments on Noise from Quarry Direction
8		15:45-16:00	39	51	41	4	No audio available. Sound level from "all directions" also increases. Quarry-direction noise is lower than background L ₉₀ noise level
8		16:00-16:15	39	51	44	4	
-	Sunday 28 Feb 2010	Quarry does not operate on Sundays					
9		08:30-08:45	41	51	38	6	No audio available. Sound level from "all directions" also increases. Quarry-direction noise is higher than background L ₉₀ noise level by 3dB.
9		09:15-09:30	37	50	38	2	No audio available. Sound level from "all directions" also increases. Quarry-direction noise is lower than background L ₉₀ noise level.
10		11:00-11:45	50	58	42	15	No audio available. Sound level from "all directions" also increases. Quarry-direction noise is higher than background L ₉₀ noise level by 8dB.
10	Monday 1 Mar 2010	12:15-12:30	42	51	40	7	No audio available. Sound level from "all directions" also increases. Quarry-direction noise is higher than background L ₉₀ noise level by 2dB.
11		15:00-15:15	40	51	47	5	No audio available. Sound level from "all directions" also increases. Quarry-direction noise is lower than background L ₉₀ noise level.
11		15:30-15:45	39	50	48	4	
12		16:15-16:30	40	52	46	5	
12		16:30-16:45	41	53	51	6	
12		16:45-17:00	40	51	52	5	
12		16:45-17:00	40	51	52	5	
13		19:45-20:00	37	49	46	2	

Marker No.	Day / Date	Time Period	L _{eq} from Direction of Quarry dBAL _{eq,15min} (Red Line)	L _{eq} from ALL Sources dBAL _{eq,15min} (Green Line)	Background dBAL _{90,15min} (Blue Line)	Exceedance of Criterion (35dBAL _{eq,15min})	Comments on Noise from Quarry Direction
14		07:15-07:30	43	53	45	8	
14		08:00-08:15	41	53	43	6	
15		08:45-09:00	38	49	44	3	
15	Tuesday	09:00-09:15	37	48	42	2	No audio available. Sound level from "all directions" also increases. Quarry-direction noise is lower than background L ₉₀ noise level.
16	2 Mar 2010	09:45-10:00	39	52	50	4	
17		13:15-13:30	41	50	49	6	
18		17:45-18:00	37	48	47	2	
18		18:30-18:45	38	49	47	3	
19		06:45-7:00	39	51	46	4	Analysis of BarnOwl audio indicates that L _{eq} noise level resulted from F3 traffic. Quarry was inaudible during this 15 minute period
19		07:45-08:00	37	48	46	2	
20	Wednesday	08:15-08:30	40	51	48	5	
20	3 Mar 2010	08:45-09:00	39	50	49	4	No audio available. Sound level from "all directions" also increases. Quarry-direction noise is lower than background L ₉₀ noise level.
20		09:15-09:30	40	50	48	5	
21		11:15-11:30	37	49	46	2	
22		13:45-14:00	39	49	47	4	
22		14:15-14:30	37	48	47	2	

Marker No.	Day / Date	Time Period	L_{eq} from Direction of Quarry $dBAL_{eq,15min}$ (Red Line)	L_{eq} from ALL Sources $dBAL_{eq,15min}$ (Green Line)	Background $dBAL_{90,15min}$ (Blue Line)	Exceedance of Criterion ($35dBAL_{eq,15min}$)	Comments
23	Thursday	06:30-06:45	37	50	50	2	Analysis of BarnOwl audio indicates that L_{eq} noise level resulted from F3 traffic. Quarry was inaudible during this 15 minute period
24	4 Mar 2010	07:30-07:45	42	52	50	7	No audio available. Sound level from "all directions" also increases. Quarry-direction noise is less than or equal to background L_{90} noise level.
25		09:30-09:45	38	47	38	3	
26		14:15-14:30	36	49	48	1	
27	Friday 5 Mar 2010	06:30-06:45	45	55	47	10	Analysis of BarnOwl audio indicates that L_{eq} noise level resulted from bird chorus. Quarry was inaudible during this 15 minute period

With emphasis on the distinction between “quarry noise” and “noise from the *direction* of the quarry” (which may include noise contributed from non-quarry sources such as traffic or bird chorus) the following observations results from the data presented in Appendix A (referring to L_{Aeq} noise from the direction of the quarry):

- In some instances, the noise from the *direction* of the quarry exceeds the operational noise criterion of 35dBA. These exceedances range from 2-15dB. These exceedances often occur as isolated events (single peaks in the graph) rather than being maintained for consecutive 15-minute periods. Where BarnOwl audio tracks were available, analysis indicates that these peak L_{Aeq} noise levels resulted from the near-field chorus of birds positioned in the direction of the quarry, rather than any quarry-related source. In other cases it is notable that the increase in noise from the quarry direction is associated with an increase in noise from all directions, indicating that the source of the noise level increase is not associated specifically with the quarry.
- Even at its loudest, the $L_{Aeq,15min}$ noise level from the direction of the quarry (red line) is almost always less than 5dB above the corresponding level of background L_{A90} noise. (Exceptions to this rule are indicated by markers 2, 7 and 10 in Table 2.) The results of the BarnOwl monitoring strongly suggest that quarry noise would comply with a “background + 5dB” noise criterion based on the *measured* L_{A90} noise levels, which are significantly higher than the values assumed in the Consent criteria.

5.1.2 Analysis of Appendix B Data – L_{Aeq} Noise from the Direction of the F3 Motorway

In reference to the L_{Aeq} graphs included in Appendix B (Noise from the direction of the F3 Motorway), the two salient points to be observed from these charts are:

- the tight bunching of the three plots which indicates how both the total $L_{Aeq,15min}$ noise level from all sources (green line) and the background, $L_{A90,15min}$ noise level from ALL sources (blue line) are significantly influenced by noise from the F3 Motorway (red line), and
- the absolute values of the background, $L_{A90,15min}$ noise level (blue line) during the quarry’s operational hours (5.00am-10.00pm Monday-Friday, 5.00am-4.00pm Saturday) are generally 5-10dB higher (and in some day periods, consistently up to 16dB higher) than the 30dBA background noise levels assumed by the Consent criteria for this residence.

5.1.3 Analysis of Appendix C Data – L_{Amax} Noise from the Direction of the Quarry

These plots include numbered markers (numbers 28 to 30) to indicate where noise from the direction of the quarry (red line) is higher than the night-time Sleep Disturbance Criterion of 45dBAL $_{Amax}$ (black line). Comments relating to these numbered events are presented in Table 3, including comments based on analysis of the corresponding BarnOwl audio files.

Table 3 Summary of BarnOwl-Measured L_{Amax} Noise Levels from Direction of Quarry

Marker No.	Day / Date	Time Period	Max Noise from Direction of Quarry $dBAL_{Amax}^{(1)}$ (Red Line)	Max Noise from ALL Sources $dBAL_{Amax}^{(1)}$ (Green Line)	Background $dBAL_{90,5min}$ (Black Line)	Exceedance of Sleep Dist Criterion ($45dBAL_{Amax}$)	Comment on Noise from Quarry Direction
28	Friday 26 Feb 2010	06:35-06:40	47	49	45	2	Analysis of BarnOwl audio indicates that L_{max} noise levels result from dog barks. Quarry was inaudible during this 5min period
29	Saturday 27 Feb 2010	06:40-06:45	45	52	37	No Exceedance	Analysis of BarnOwl audio indicates that L_{max} noise levels result from bird chorus. Quarry was inaudible during this 5min period
-	Sunday 28 Feb 2010	Quarry does not operate on Sundays					
30		06:20-06:25	47	55	48	2	Analysis of BarnOwl audio indicates that L_{max} noise levels result from bird chorus. Quarry was inaudible during this 5min period
30	Friday 5 Mar 2010	06:30-06:35	47	57	47	2	Analysis of BarnOwl audio indicates that L_{max} noise levels result from bird chorus. Quarry was inaudible during this 5min period
30		06:45-06:50	46	52	42	1	Analysis of BarnOwl audio indicates that L_{max} noise levels result from bird chorus. Quarry was inaudible during this 5min period

Note: (1) 1-minute maximum levels energy-averaged over 5 minutes, between 5.00-7.00am only.

With emphasis on the distinction between “quarry noise” and “noise from the *direction* of the quarry” (which may include noise contributed from non-quarry sources such as traffic or bird chorus) the following observations results from the data in Appendix C:

- At most times, maximum noise levels from the *direction* of the quarry (red line) in the hours preceding 7.00am are lower than the sleep disturbance criterion of 45dBAL_{Amax}. This is true even when considering individual 1-minute maximum noise levels;
- As indicated in Table 3, in a few instances, the noise from the direction of the quarry exceeds the sleep disturbance criterion of 45dBAL_{Amax}. Analysis of the corresponding BarnOwl audio files indicates that in all cases, L_{Amax} noise levels were caused by sources not related to the quarry, which itself was inaudible in the referenced samples;
- Notably, the peak L_{Amax} noise levels identified in Table 3 are never more than 15dB above the L_{A90} background noise level for the corresponding period. Analysis of individual 1-minute L_{Amax} noise levels from the quarry direction indicates that this is also true in this case, with one exception – a single peak at 6:40am on 27 February, corresponding to the time of marker 29. Investigation of the corresponding BarnOwl audio file indicates that this peak noise event resulted from loud bird chorus, and not from any event associated with the quarry. This suggests (but does not prove) that there would be no exceedance of a sleep disturbance criterion based on the *actual* background noise levels at this residence. (The Consent sleep disturbance criterion is based on the assumption that the background noise level at the Barnard residence is 30dBAL_{A90}).

5.1.4 Analysis of L_{A90} Background Noise Levels recorded by BarnOwl

In addition to monitoring the directional noise levels, the BarnOwl monitor also constantly monitors the L_{A90,15min} background noise level (from all directions). From this data, it is possible to derive the Rating Background Level (RBL), which is the noise metric defined by the DECCW as representing the background noise level. The RBL is used by DECCW to derive operational noise criteria for industrial land uses such as quarries.

Table 4 outlines the calculated RBL values for the Barnard residence based on the BarnOwl L_{A90,15min} background noise level data acquired over the entire monitoring period.

Table 4 **Calculated Rating Background Level (RBL) based on BarnOwl-Measured L_{A90,15min} Noise Level Data**

Period	Calculated RBL (dBA)
Day (7.00am-6.00pm)	38
Evening (6.00pm-10.00pm)	43
Night (10.00pm-7.00am)	37
Shoulder Period (5.00-7.00am)	42

Long-term background noise monitoring has also previously been undertaken (in December 2006) at the Barnard residence as part of the Noise Impact Assessment of the Calga Sand Quarry Southern Extension (Wilkinson Murray, Feb 2008). The RBL values based on this previous monitoring are presented in Table 5.

Table 5 Rating Background Levels (RBL) derived in Calga Sand Quarry "Southern Extension" Noise Impact Assessment

Period	Calculated RBL (dBA)
Day (7.00am-6.00pm)	41
Evening (6.00pm-10.00pm)	40
Night (10.00pm-7.00am)	33
Shoulder Period (5.00-7.00am)	37

A comparison of results of Table 4 and Table 5 indicates that there is good agreement between the two sets of data for the daytime period, but that there is some variance for evening, night and shoulder periods. Analysis of the audio files recorded by BarnOwl indicate that bird chorus is a major contributor to noise at the Barnard residence in the dawn and dusk periods. The difference in the evening, night and shoulder period values across the two monitoring data sets is likely due to the variability in the level of contributed noise from bird chorus across different days. Indeed, this variability is also played out over the shoulder periods of the BarnOwl monitoring week (for which the single, representative shoulder period (5.00-7.00am) background noise level for each day ranges from 35-48dBAL_{A90}).

Regardless of the difference between them, these data sets present strong evidence that the Consent's operational noise criteria (35dBAL_{eq,15min} Day/Eve/Night and 45dBAL_{Amax} Night) for the Barnard residence are too onerous. Adopting the lowest RBL values of either data set would result in the operational noise criteria for the Barnard residence presented in Table 6. (Note that any new INP-based criteria for the Barnard residences would be dictated by the Intrusiveness Criterion, rather than the Amenity Criterion, as the former is the more stringent control for day, evening and night periods.)

Table 6 Operational Noise Criteria for Barnard Residence that would result where BarnOwl-derived Rating Background Levels are adopted

Period	Criterion (dBAL _{eq,15min})
Day (7.00am-6.00pm)	45
Evening (6.00pm-10.00pm)	45
Night (10.00pm-7.00am)	38
Shoulder Period (5.00-7.00am)	42

Additionally, a sleep disturbance criterion of 52dBAL_{Amax} would apply to operational noise in the period 5.00-7.00am.

5.2 Analysis of Unattended BarnOwl Noise Monitoring Results

The attended monitoring revealed that, as measured from the northern side of the Barnard residence, noise from the quarry's early morning activities was inaudible above the existing levels of background noise (which ranged from 41-46dBAL_{A90,15min}) during the period 5.00am-7.00am. On this basis, it was not possible to definitively confirm from these attended measurements that the quarry complies with the Consent's night time criteria of 35dBAL_{eq,15min} and 45dBAL_{max} although based on observations made during the attended measurements, the likelihood for annoyance from any continuous noise from the quarry is low and the likelihood of sleep disturbance is negligible.

During the three monitoring periods from 07:45 to 08:30, noise from the quarry was audible at times, and estimates of its L_{Aeq} noise emission level over the entire 15 minutes were attempted (as indicated in Table 1). These estimates suggest that operational noise to the Barnard residence can at times exceed the daytime Consent criterion (35dBAL_{Aeq,15min}) during its noisiest operating activities (eg. during times of processing dense-graded sand products).

The attended monitoring revealed that due to the shielding of noise from the F3 Motorway, daytime L_{A90} background noise levels external to the northern façade of the western bedroom of the Barnard dwelling are approximately 4dB lower than the level of L_{A90} background noise at the BarnOwl monitoring location for the corresponding period.

6 CONCLUSIONS

Based on the noise monitoring completed at the Barnard residence, the following conclusions have been drawn:

1. At most times during the quarry's operational hours, the level of L_{A90} background noise at the Barnard residence is already higher than the 35dB(A) criterion of development consent DA 94-4-2004;
2. When considering noise from the direction of the quarry, 27 periods were identified when the L_{Aeq(15 minute)} noise level from this direction exceeded the 35dB(A) criterion.

Three periods were identified when the L_{A1,1min} noise level exceeded the 45dB(A) criterion for night time periods;
3. The level of ambient noise at the Barnard residence is dictated by traffic carried on the F3 Motorway and not by noise from the direction of the quarry;
4. The noise contribution from the direction of the quarry was further examined to assess the contribution of quarry operations to those periods when the L_{Aeq(15 minute)} and L_{A1,1min} criteria were exceeded.

In relation to the 35dBA $L_{Aeq(15\text{ minute})}$ criterion:

- Attended monitoring identified noise from the quarry to be audible and in excess of the 35dBA $L_{Aeq,15min}$ criterion at the Barnard residence only during daytime periods (ie. after 7.00am) when the wash plant was known to be processing coarser-grade sandstone. (During such times, noise from the quarry was estimated to range up to 40dBA $L_{Aeq,15min}$.) The quarry was inaudible for the remaining period of attended monitoring;
- When the level of noise from the direction of the quarry was found to exceed the noise criterion, analysis of the corresponding BarnOwl audio files indicated the quarry to be inaudible with the dominant noise source identified as bird chorus or traffic noise;
- In instances of exceedances where there was not accompanying BarnOwl audio files, it was observed from the noise level graphs that the increase in noise from the quarry direction was always associated with an increase in noise from all directions, indicating that the source of the "exceeding" noise was not associated specifically with the quarry.

On the basis of the evaluation of the noise monitoring data, it is evident that when the coarsest-grade sandstone is processed, the quarry exceeds the 35dB(A) criterion at the Barnard residence. While it cannot be definitively stated, the evidence suggests that during standard operational activities, the quarry is likely to comply with the noise criterion.

In relation to the 45dBA L_{Amax} criterion:

The L_{Amax} noise level from the direction of the quarry during night periods (10.00pm-7.00am) was examined to assess the contribution of quarry operations to those periods when the 45dB(A) criterion was exceeded. In all cases, analysis of the corresponding BarnOwl audio files indicated that the exceedances were caused by sources not related to the quarry, which itself was inaudible in the referenced samples;

5. The noise monitoring data also identifies that the noise criterion nominated for the Barnard residence does not conform to the *Industrial Noise Policy*. The *INP* provides for the rating background level + 5dB(A). Considering the most conservative calculation of the Rating Background Level (RBL) at the Barnard residence, this would provide for noise criteria as follows:
 - Day (7.00am-6.00pm) 45dB(A);
 - Evening (6.00am-10.00pm) 45dB(A);
 - Night (10.00pm-5.00am) 38dB(A);
 - Day Shoulder (5.00am-7.00am) 42dB(A).
6. It is recommended that Rocla implement further mitigation measures to reduce the noise generated by the processing of the coarsest-grade sandstone.
7. The successful implementation of these mitigation measures should be confirmed during ongoing quarterly noise monitoring programs.

I trust this information is sufficient. Please contact me should you have any further queries.

Yours faithfully

WILKINSON MURRAY (SYDNEY) PTY LIMITED

David Borella

Senior Acoustic Engineer

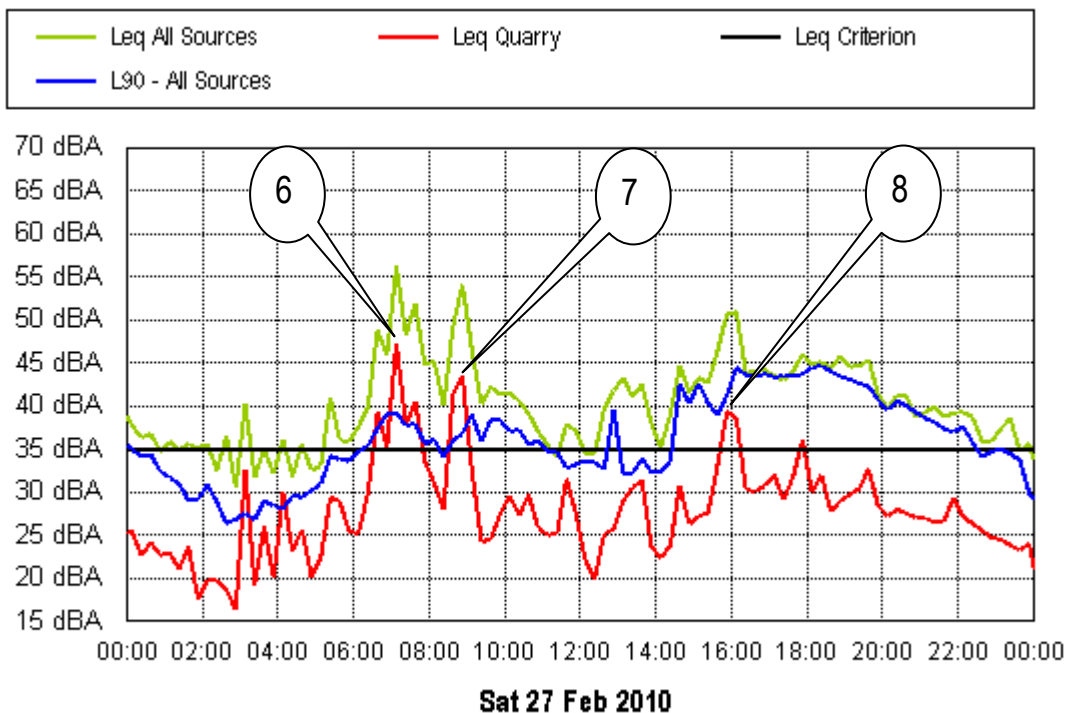
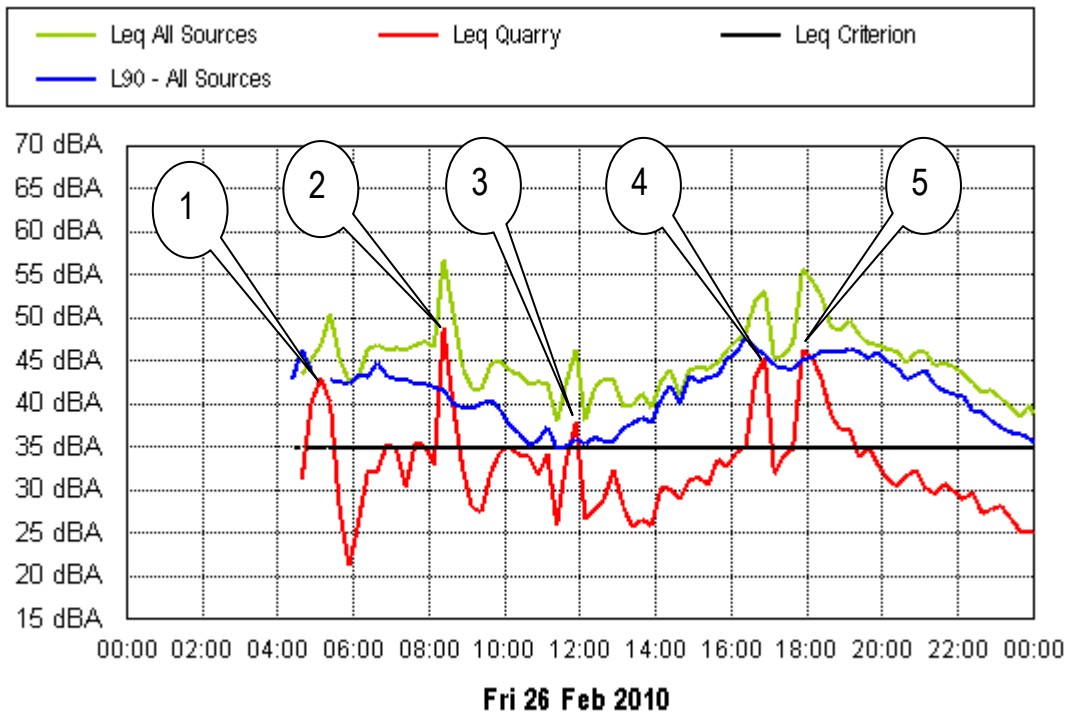
APPENDIX A

BARNOWL DIRECTIONAL NOISE MONITORING RESULTS

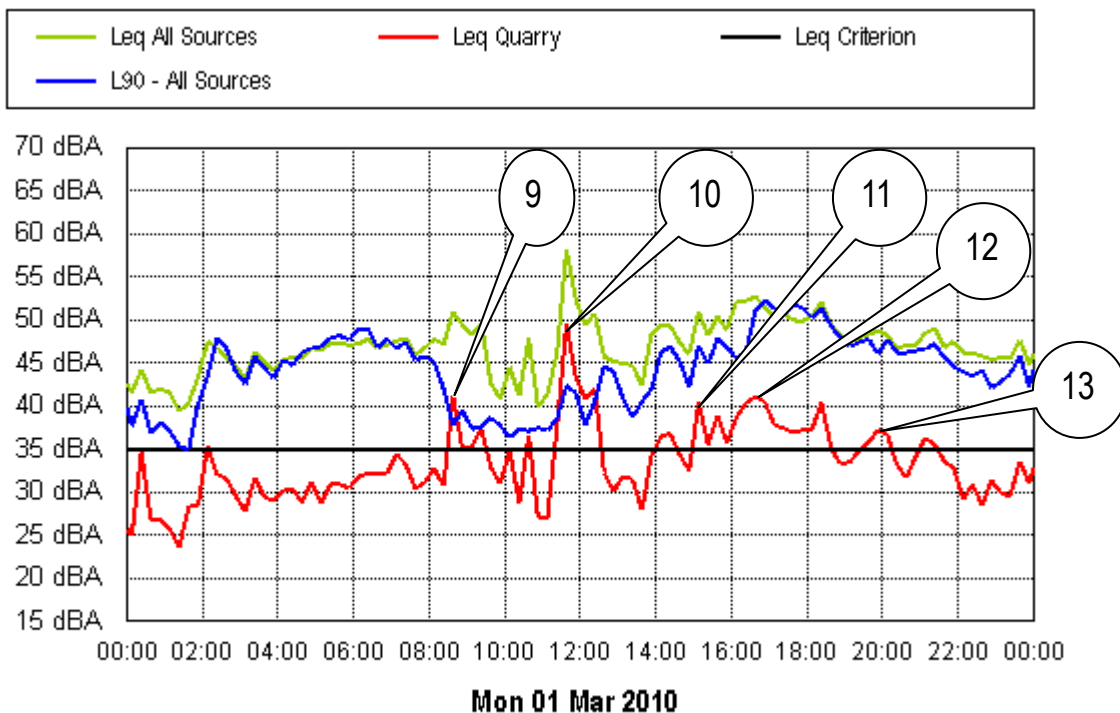
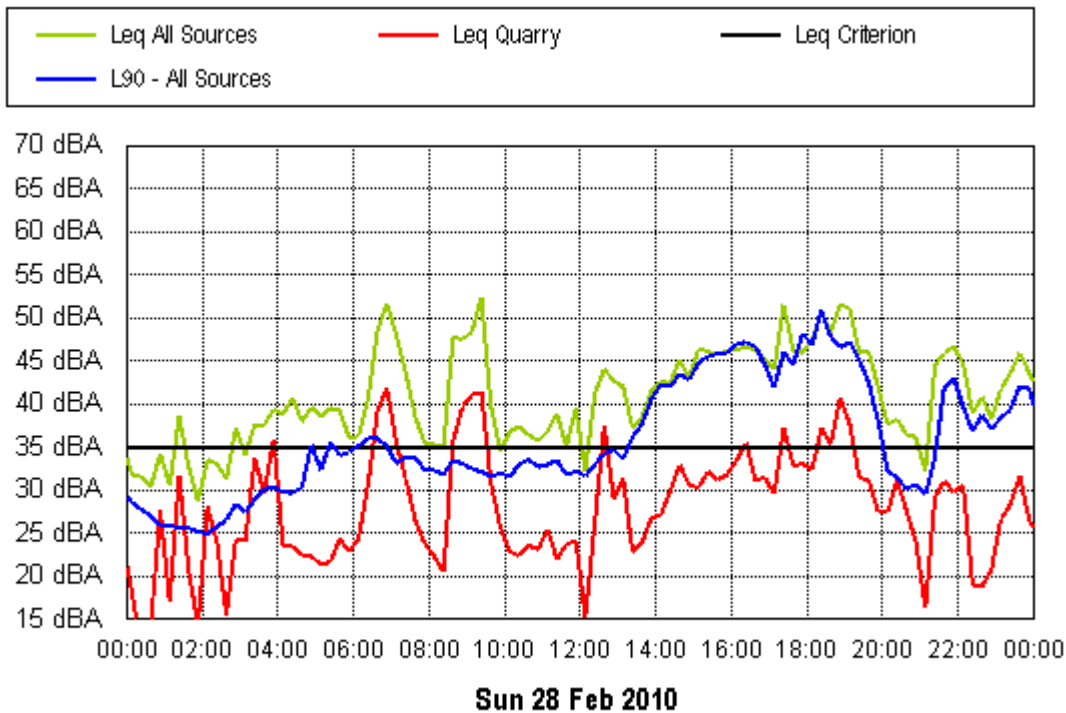
$L_{Aeq,15min}$ Noise Levels from Direction of Quarry



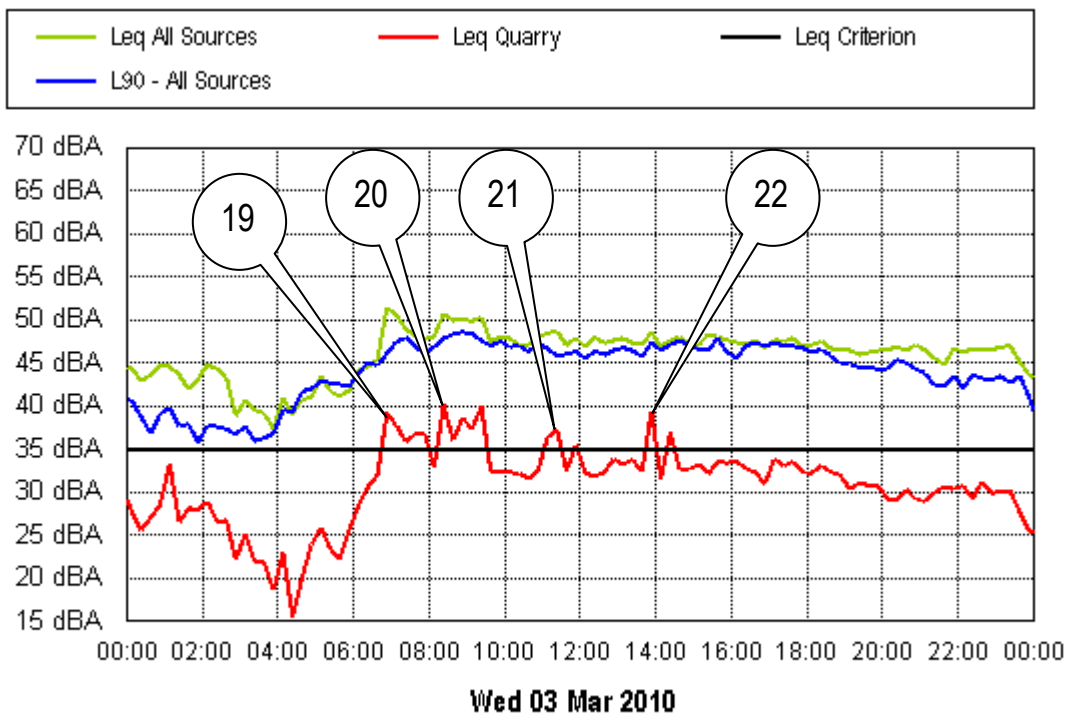
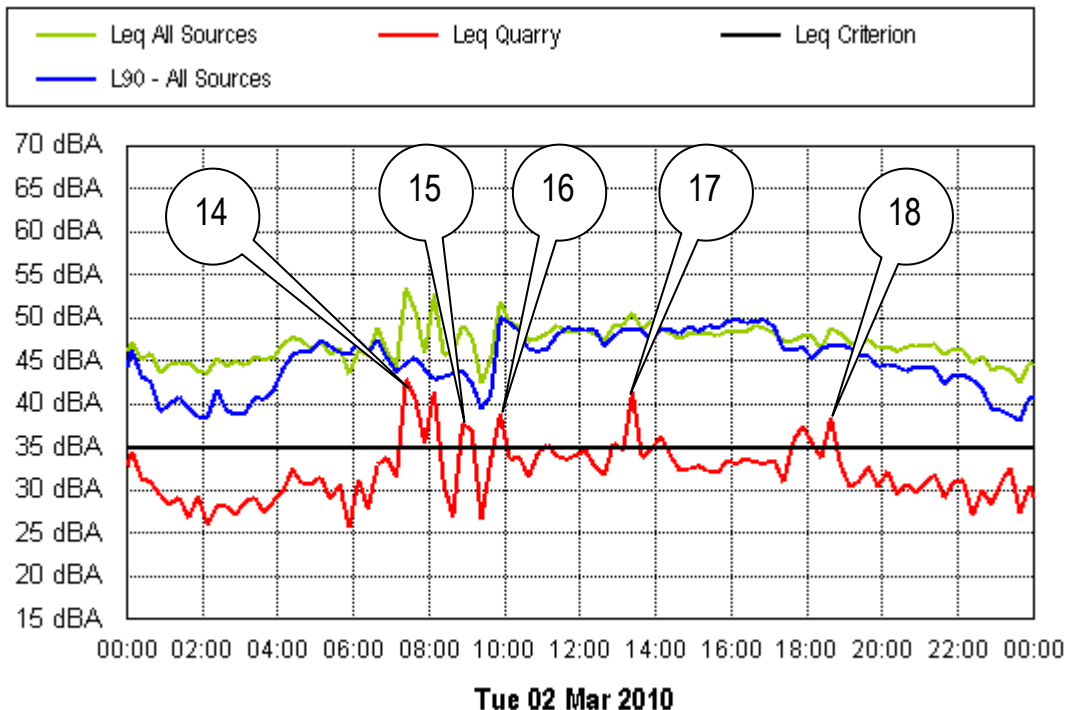
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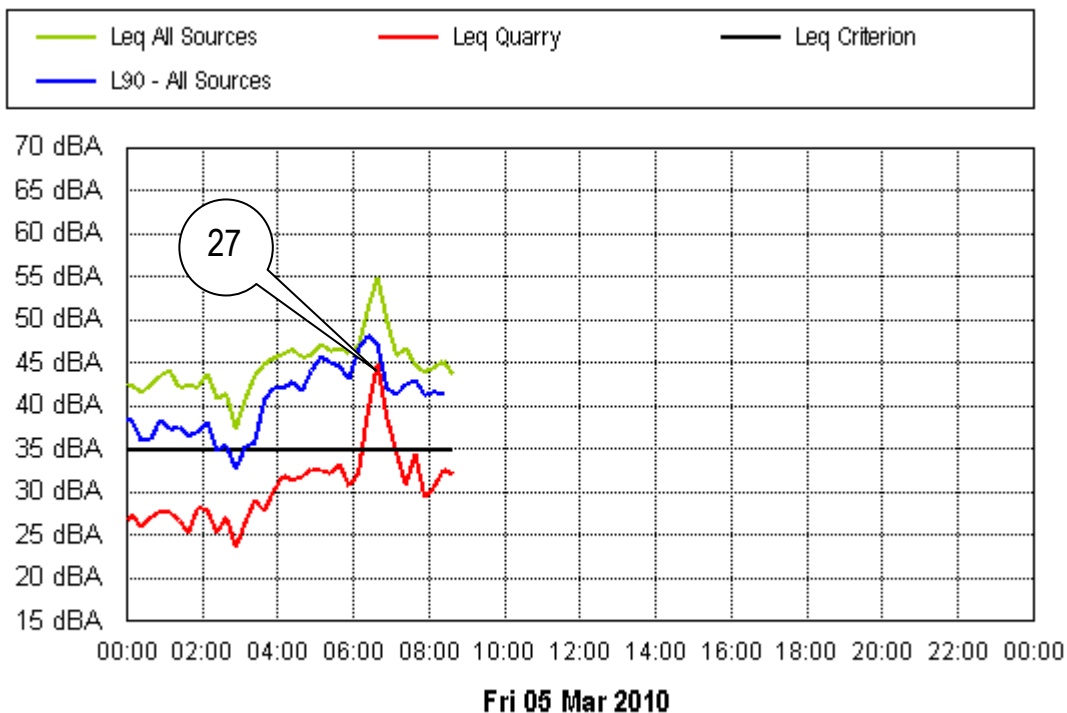
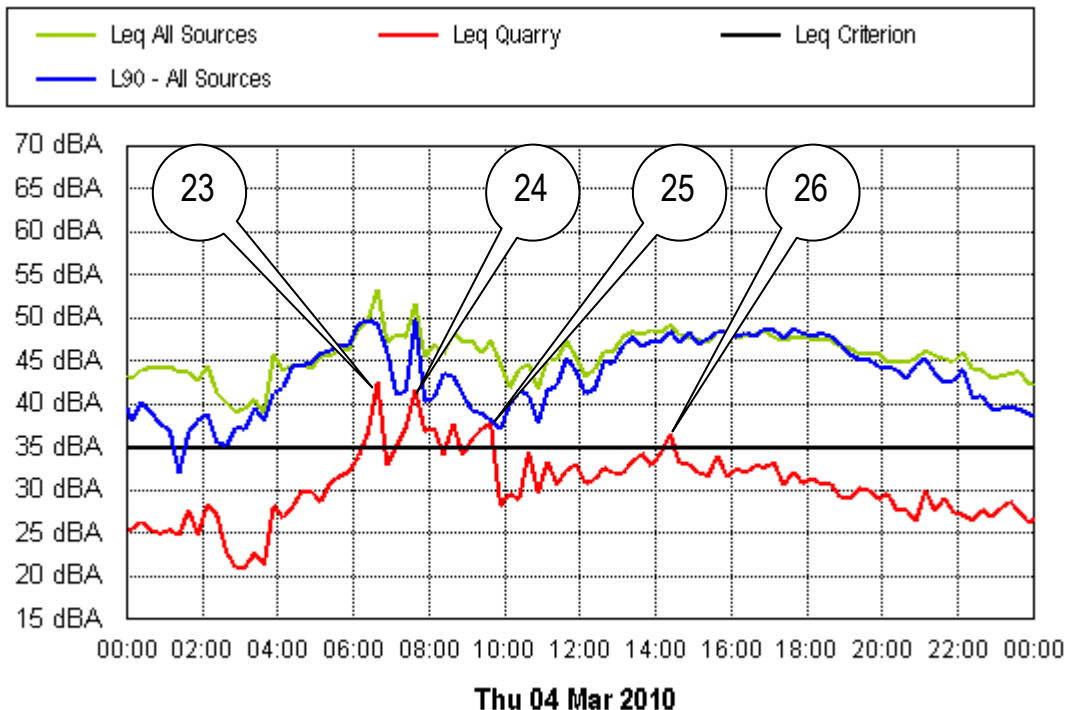
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Project: Calga
Location: Wildlife Park (Barnard Residence)
Filter: A:Raw
Criterion: 35dBAL_{eq} (Day, Eve, Night)



Project: Calga
Location: Wildlife Park
Filter: A:Raw
Criterion: 35dBAL_{eq} (Day, Eve, Night)



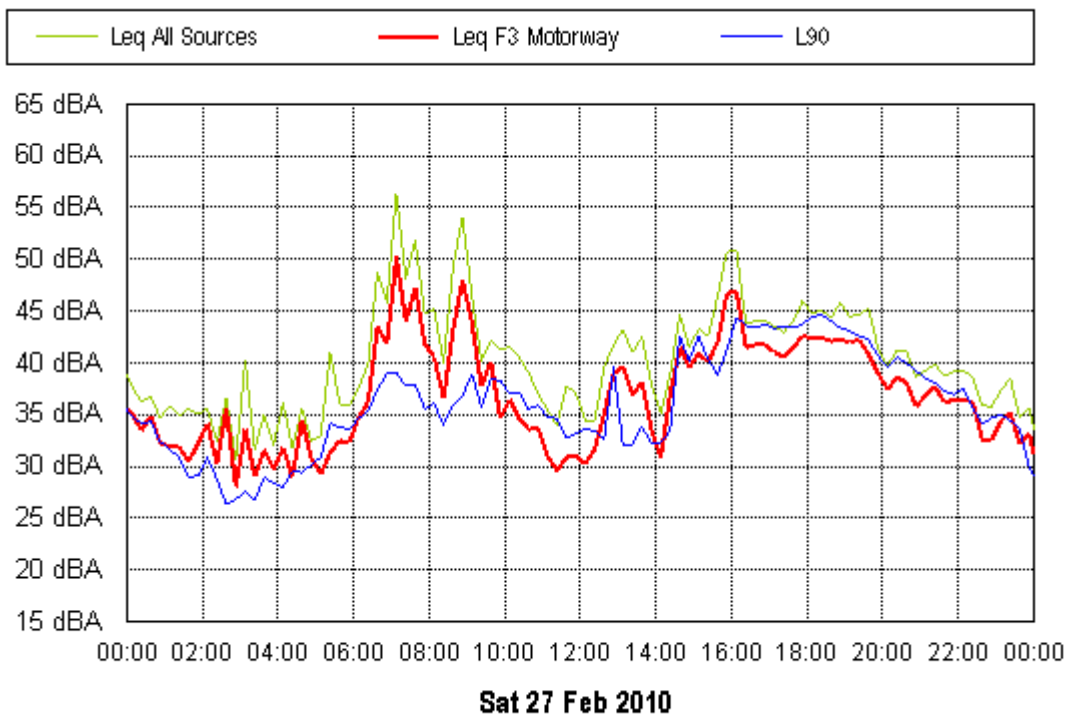
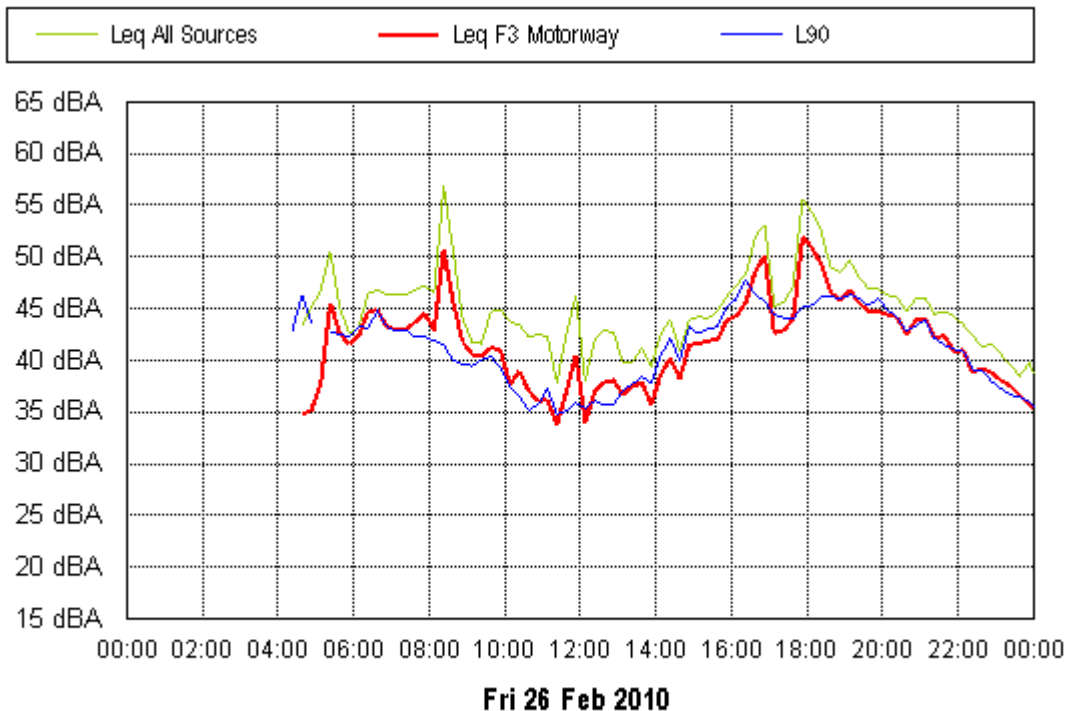
APPENDIX B

BARNOWL DIRECTIONAL NOISE MONITORING RESULTS

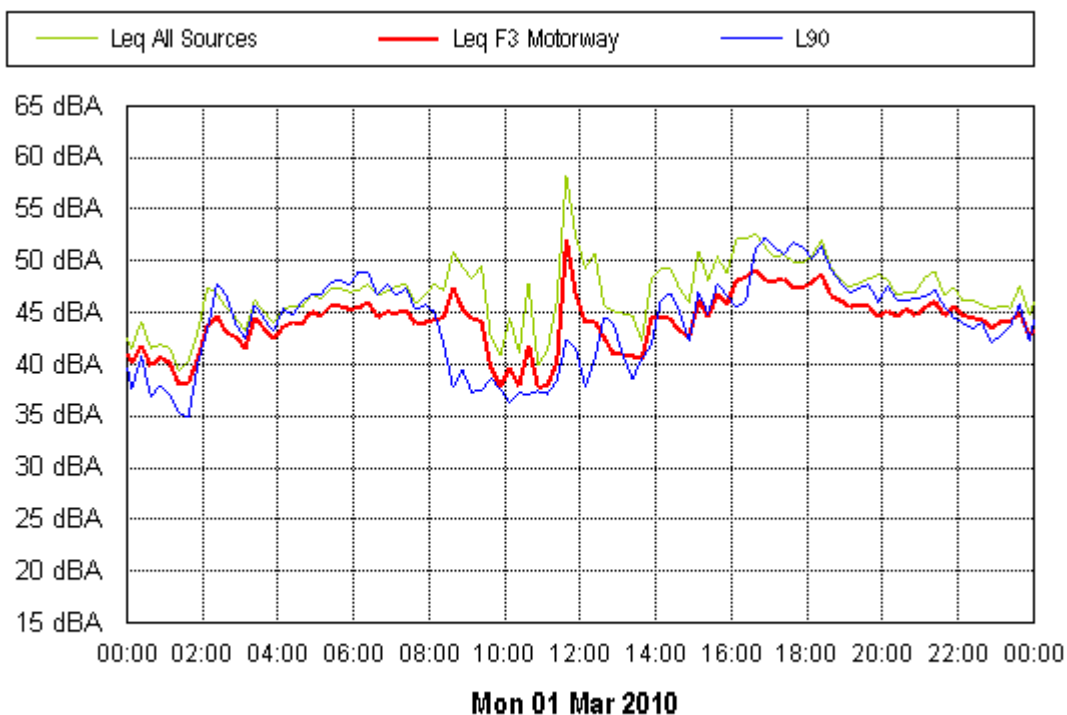
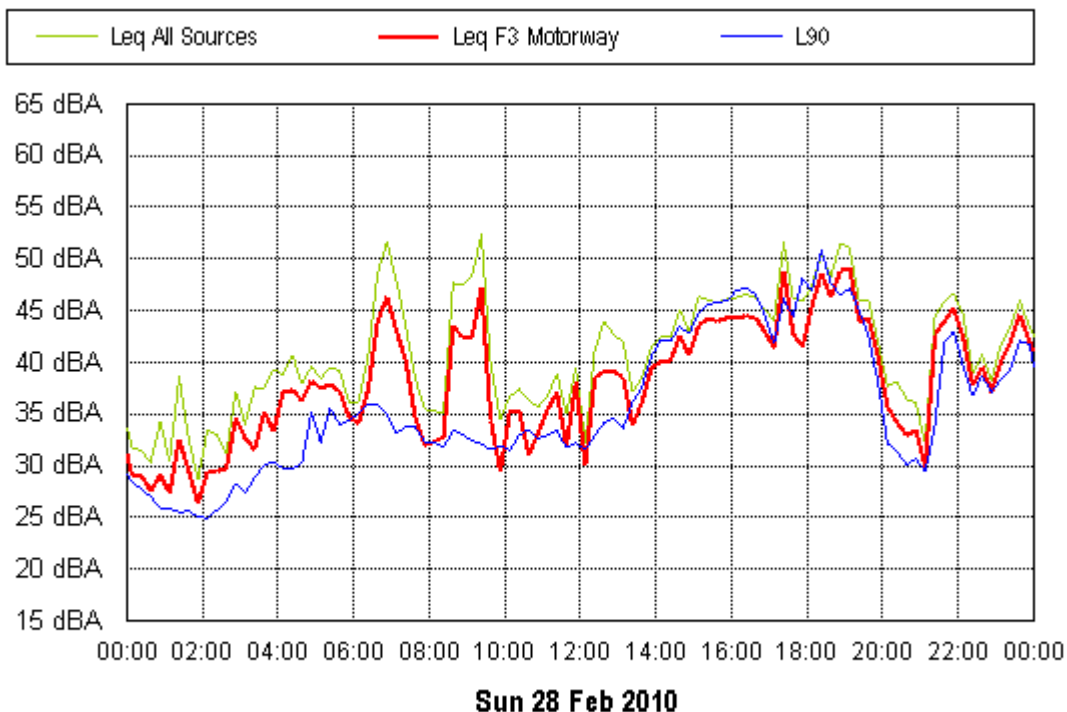
$L_{Aeq,15min}$ Noise Levels from Direction of F3 Motorway



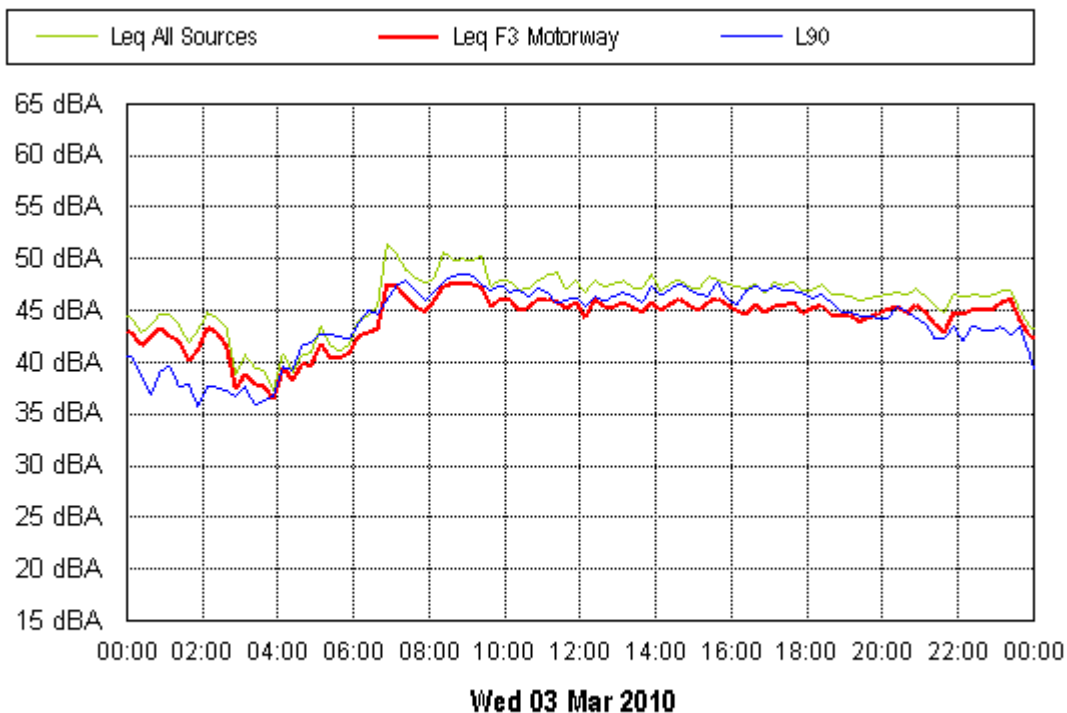
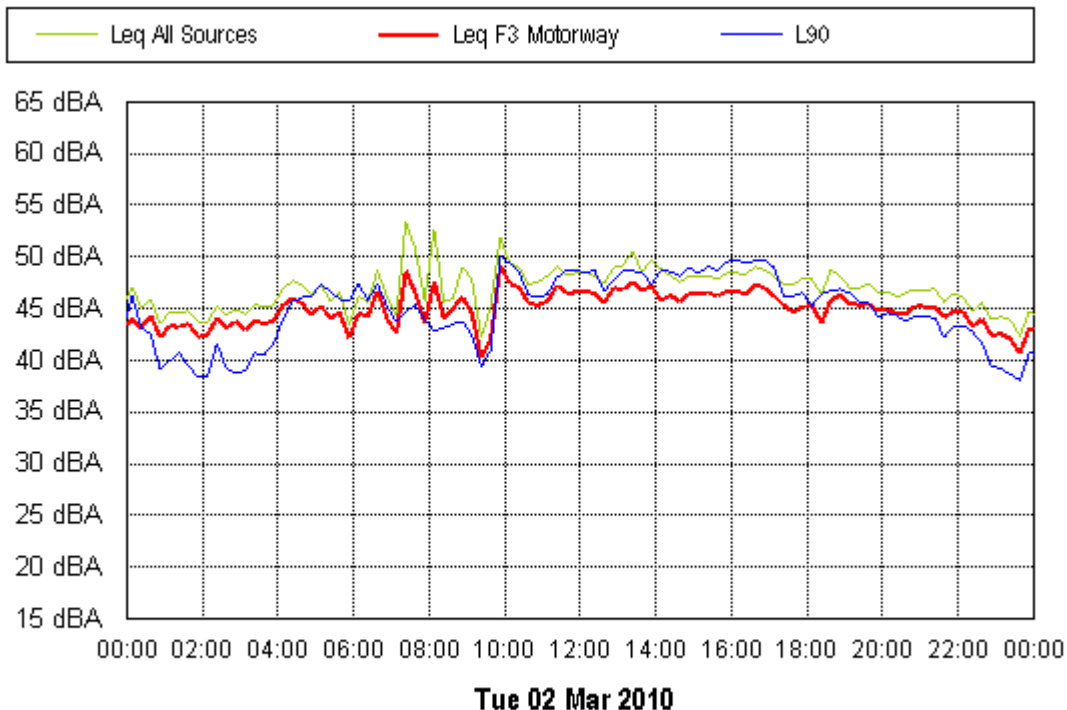
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Filter: A:Raw
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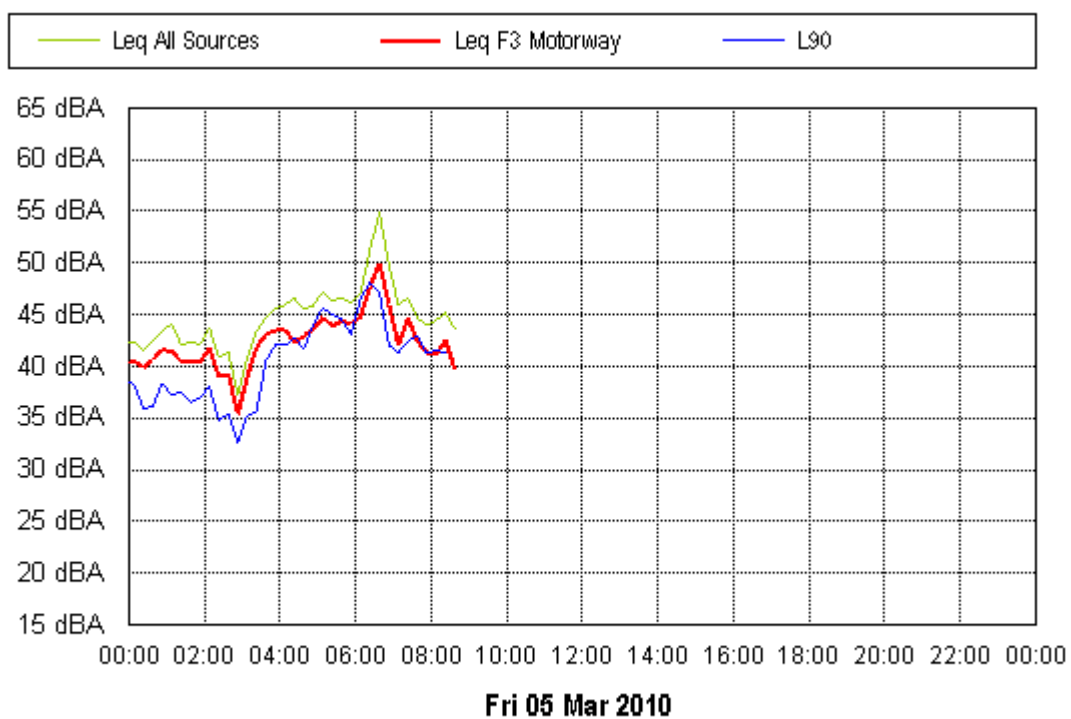
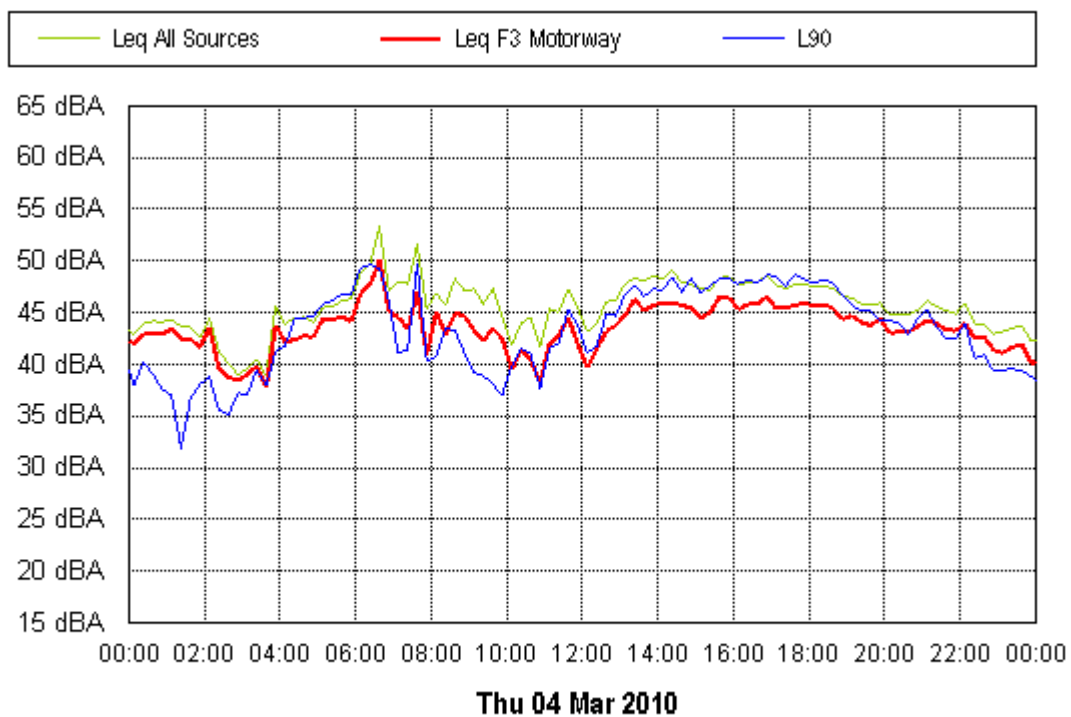
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Filter: A:Raw
Criterion: N/A for F3 Motorway



Project: Calga
Location: Wildlife Park (Barnard Residence)
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Criterion: N/A for F3 Motorway



Project: Calga
Location: Wildlife Park (Barnard Residence)
Filter: A:Raw
Criterion: N/A for F3 Motorway



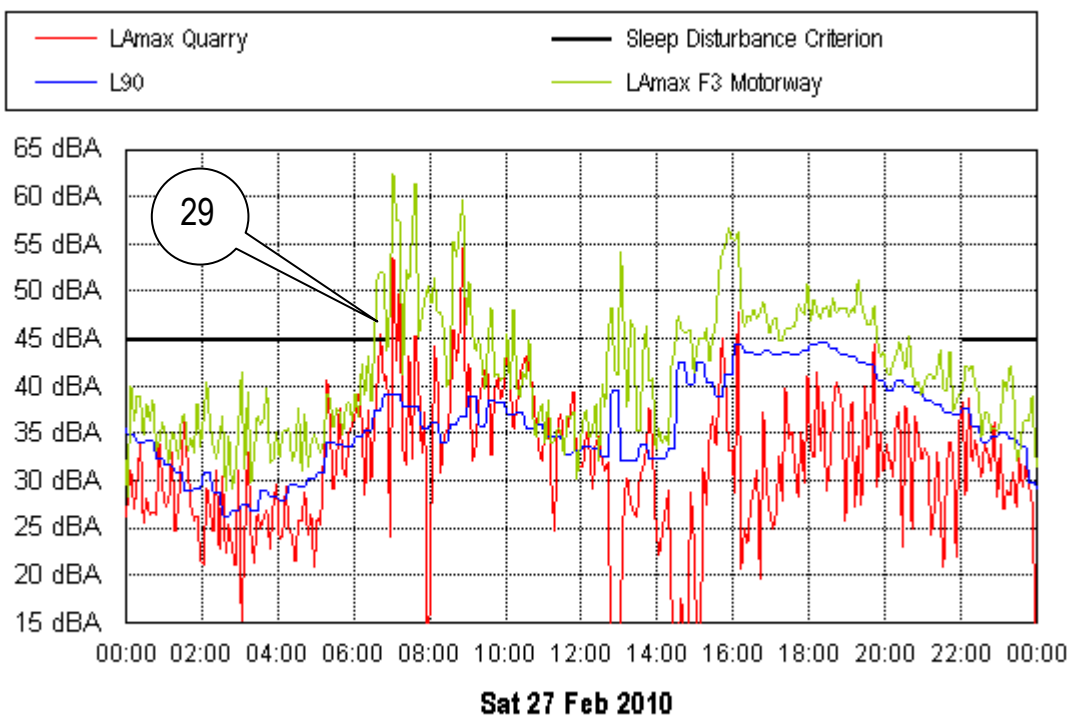
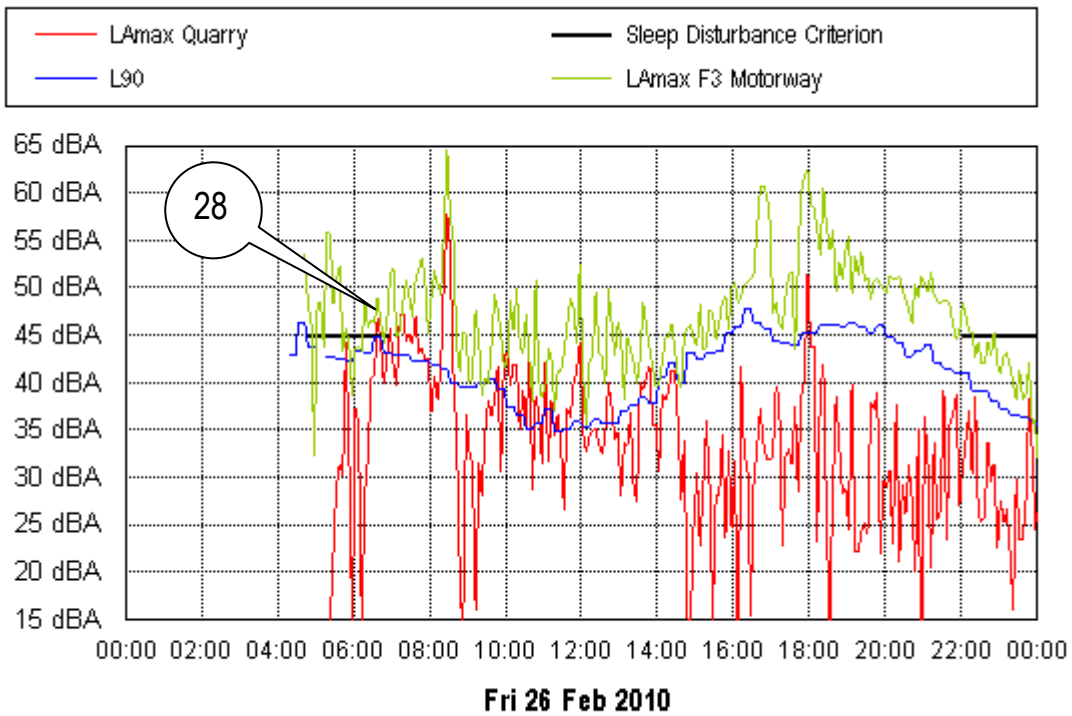
APPENDIX C

BARNOWL DIRECTIONAL NOISE MONITORING RESULTS

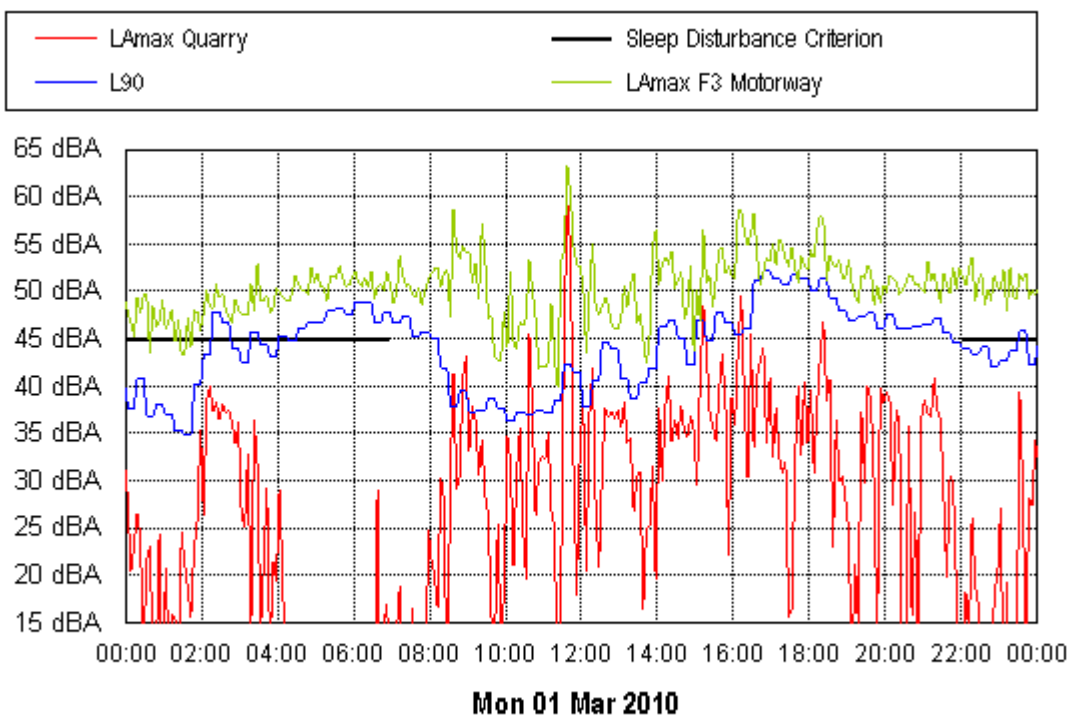
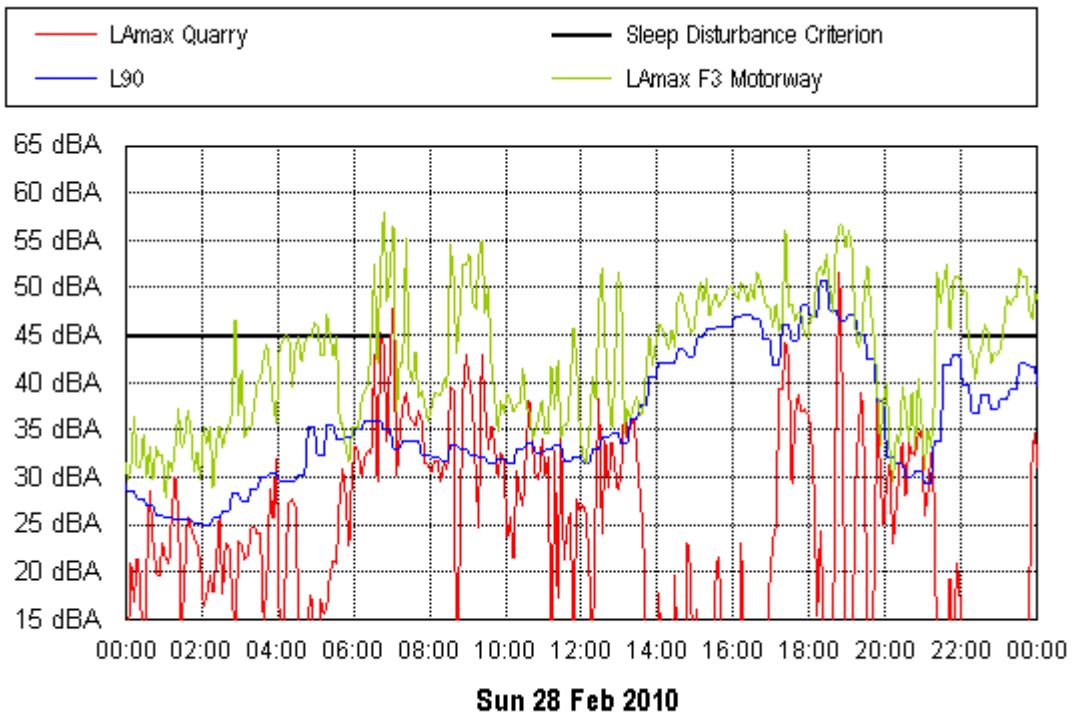
L_{Amax} Noise Levels from All Directions



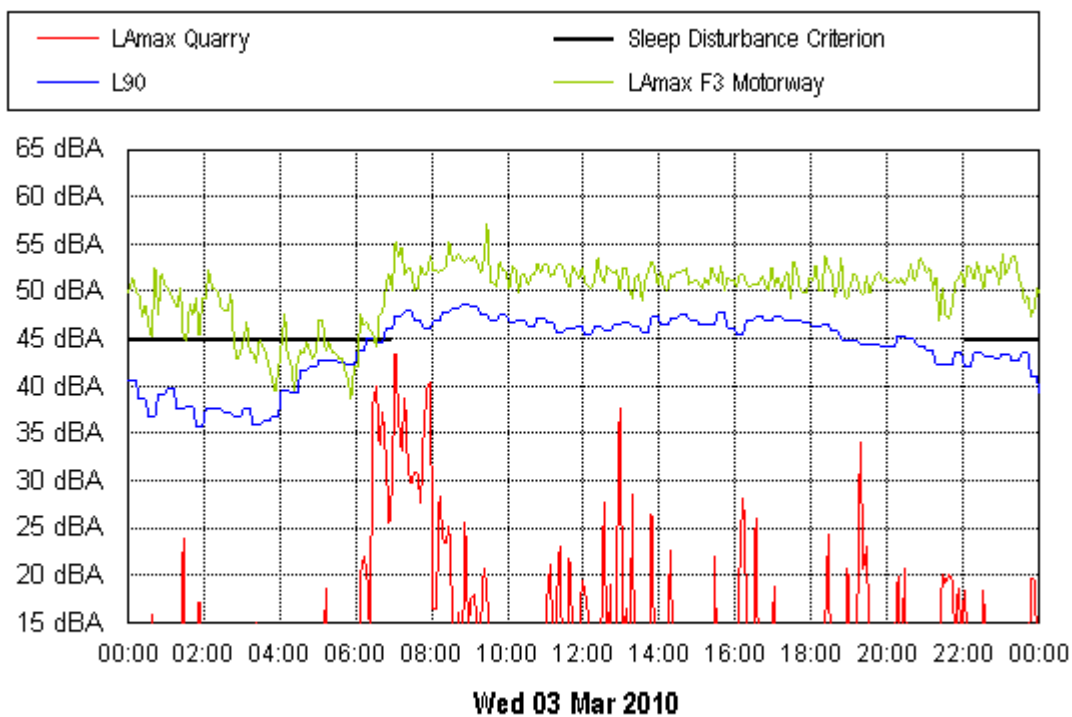
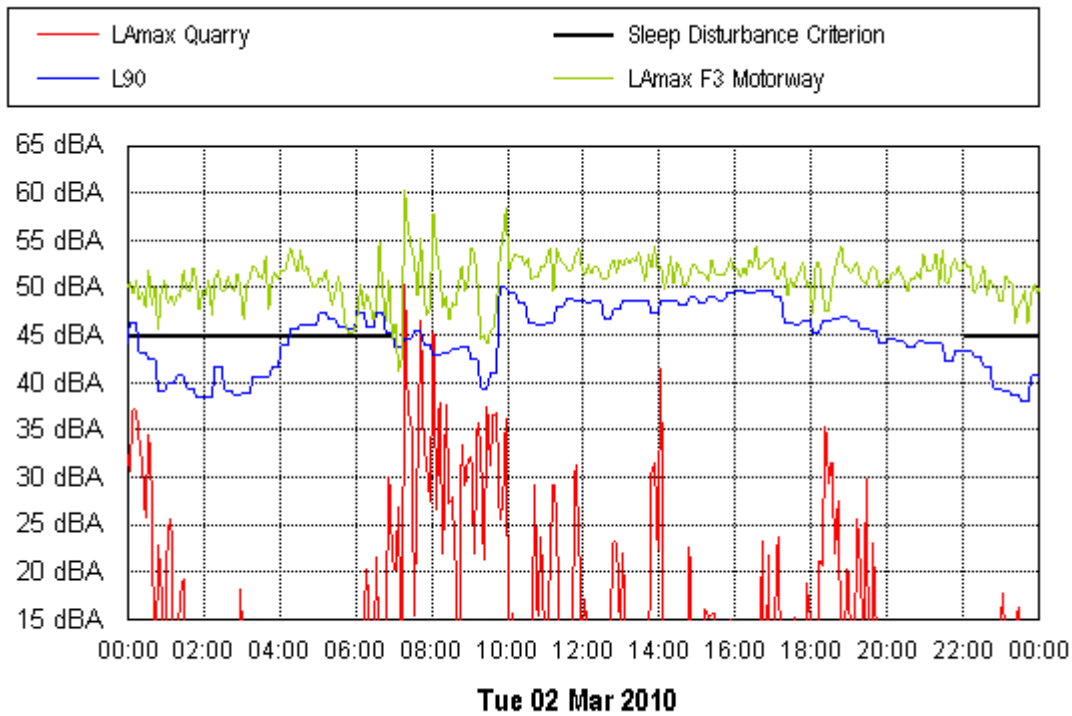
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Source: Quarry
Filter: A:Raw



Project: Calga
Location: Wildlife Park (Barnard Residence)
Source: Quarry
Filter: A:Raw



Project: Calga
Location: Wildlife Park (Barnard Residence)
Source: Quarry
Filter: A:Raw



Project: Calga
Location: Wildlife Park (Barnard Residence)
Source: Quarry
Filter: A:Raw

