

4. Noise and Vibration

4.1 Acoustics, Noise and Vibration Report, SANDY BROWN

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Anfield stadium expansion

Assessment of noise egress from the stadium expansion

Introduction

As part of the ongoing design of the Phase 1 of the Anfield expansion, Sandy Brown Associates (SBA) has assessed the impact of noise egress due to the change expansion of the main stand due to noise sources located within the stadium. The impact of the preliminary massing of Phase 2, which covers the expansion of the Anfield Road stand, is also presented. This memorandum summarises the results of the assessment.

Criteria

The National Planning Policy Framework (NPPF) sets out the government planning requirements, and supersedes previous guidance notes such as PPG24. No specific noise criteria are set out in the NPPF, or in the Noise Policy Statement for England (NPSE) to which it refers.

The NPPF states:

'Planning policies and decisions should aim to:

- *Avoid noise from giving rise to significant adverse impacts on health and quality of life as a result of new development;*
- *Mitigate and reduce to a minimum other adverse impacts on health and quality of life arising from noise from new development, including through the use of conditions;*
- *Recognise that development will often create some noise and existing businesses wanting to develop in continuance of their business should not have unreasonable restrictions put on them because of changes in nearby land uses since they were established; and*
- *Identify and protect areas of tranquillity which have remained relatively undisturbed by noise and are prized for their recreational and amenity value for this reason.'*

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The NPSE states that its aims are as follows:

‘Through the effective management and control of environmental, neighbour and neighbourhood noise within the context of Government policy on sustainable development:

- *Avoid significant adverse impacts on health and quality of life;*
- *Mitigate and minimise adverse impacts on health and quality of life; and*
- *Where possible, contribute to the improvement of health and quality of life.’*

The NPSE adopts established concepts from toxicology that are currently being applied to noise impacts. The concept details noise levels, at which the impacts of an exposure may be classified into a specific category. The classification categories as detailed within NPSE are as follows:

- Avoid noise from giving rise to significant adverse impacts on health and quality of life as a result of new development;
- No Observed Effect Level (NOEL) - the level below which no impact can be detected. Below this level no detectable impact on health and quality of life due to noise can be established;
- Lowest Observable Adverse Effect Level (LOAEL) - the level above which adverse impacts on health and quality of life can be detected; and
- Significant Observed Adverse Effect Level (SOAEL) - the level above which significant adverse impacts on health and quality of life occur.

It is recognised that SOAEL does not have a single objective noise-based level that is applicable to all sources of noise in all situations and therefore the SOAEL is likely to be different for different sources, receptors and at different times of the day.

Neither the NPPF or NPSE sets out specific acoustic criteria for the assessment of noise from sports activities. There is also no regulatory guidance or British Standard’s that sets out assessment criteria for noise from sporting activities.

Noise from Anfield stadium is limited to when football matches or other events occur. As noise from the stadium is an existing source, an assessment of the impact of the main stand extension has been undertaken in terms of the change in crowd noise level.

For the purpose of this assessment, the following criteria have been adopted to demonstrate an impact in accordance with the NPSE. These criteria are based on the human perception of the change in noise level.

NOEL <3 dB - An increase in noise level of 3dB is considered to be just noticeable.

LOAEL >3 dB - An increase in noise level of 3dB is considered to be just noticeable. An increase in noise level of 5dB is considered to be noticeable. However, it should be noted that a perceivable difference in noise level does not indicate that there will be adverse impacts on health and quality of life.

SOAEL >10 dB - An increase of 10dB is considered a doubling of the perceived noise level. However, it should be noted that a doubling of noise level does not indicate that there will be significant adverse impacts on health and quality of life.

Noise surveys

An environmental noise survey was carried out by SBA on Saturday 8 February 2014 when a match between Liverpool and Arsenal was played at Anfield. The details of the noise survey are given in the SBA report '12431-R03-A Match day environmental noise survey report' respectively.

Noise levels were measured at six locations outside of the stadium and at one position inside the stadium. The locations of the external noise monitoring positions are shown in Figure 1.



Figure 1 Measurement locations

The results of the noise monitoring undertaken during the match on Saturday 8 February 2014 are given in Table 1.

The dominant noise sources observed at measurement locations outside the stadium during the match consisted of road traffic noise and passing pedestrians. Less significant noise sources included crowd noise (ie fans cheering) and, music and announcements via the stadium PA system.

The dominant noise sources observed at measurement locations inside the stadium during the match consisted of crowd noise (ie fans cheering), music and announcements via the stadium's PA system. As the dominant noise source of crowd was fairly continuous, there were no less significant noise sources noted.

Table 1 Results of the match day noise survey

Start time	External noise monitoring position	Sound pressure levels (dB)			
		External $L_{Aeq,5min}$	Internal $L_{Aeq,5min}$	External $L_{Amax,5min}$	Internal $L_{Amax,5min}$
12:20	6	63	82	74	93
12:25	-	-	86	-	96
12:30	-	-	85	-	96
12:35	1	59	90	74	102
12:40	1	61	93	76	104
12:45	1	67	99	91	115
12:50	-	-	93	-	107
12:55	2	67	99	81	115
13:00	2	70	98	88	116
13:05	2	74	98	96	116
13:10	-	-	92	-	106
13:15	3	64	89	75	105
13:20	3	64	89	80	105
13:25	3	66	89	80	105
13:30	-	-	91	-	106
13:35	4	70	85	78	97
13:40	4	72	86	80	94
13:45	4	73	87	78	95
13:50	-	-	88	-	101
13:55	5	67	98	78	114
14:00	-	-	90	-	107
14:05	-	-	89	-	108
14:10	5	66	93	80	104
14:15	5	68	88	87	105
14:20	-	-	88	-	101
14:25	6	60	87	72	101
14:30	6	66	92	84	106
14:35	-	-	91	-	106
14:40	-	-	82	-	90
14:45	-	-	78	-	81

The average noise level at the measurement position inside the stadium during the match was L_{Aeq} 92 dB.

Computer modelling

Computer models have been produced of stadium with the existing and proposed expansion of the main stand and the Anfield Road stand. The models for the Phase 1 extension of the main stand have been based on the Stage C design drawings.

The models for the Phase 2 extension of the main stand have been based on the KSS planning drawings. Noise egress from the implementation of Phase 2 is dependent on how the new Anfield Road stand integrates with the adjacent stands. The drawings do not indicate any significant gaps around the side of the stand that allow direct line of sight between the crowd and the residences outside of the stand.

The acoustics within the stadium has been carried out using the room acoustic software Odeon. Modelling of the noise breakout from the stadium has been carried out using the environmental noise software CadnaA. Images from the environmental noise model of the existing and the Phase 1 extension of the main stand are shown in Figure 2.

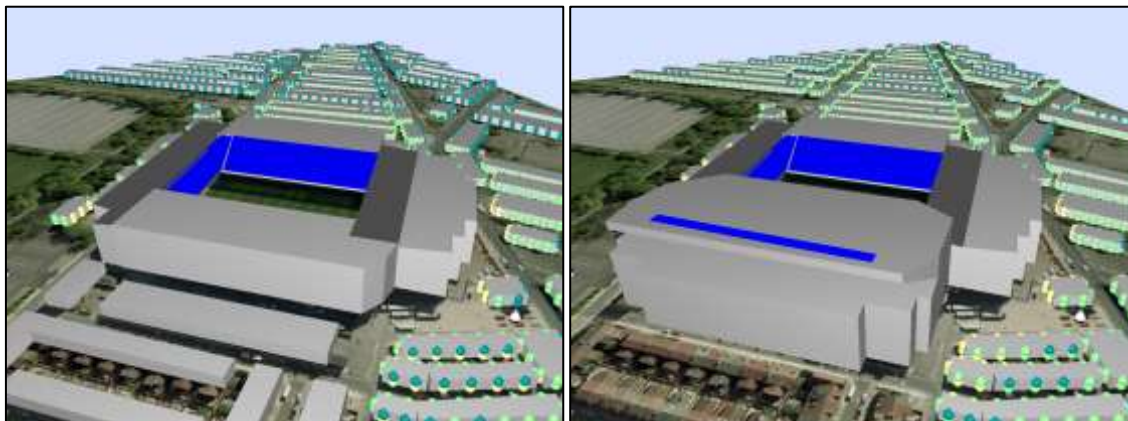


Figure 2 3D Images from CadnaA model of the existing and proposed stands

The models have been used to predict the noise level in the areas surrounding the stadium.

The losses due to screening have been set to limits of 20 dB and 25 dB for single and double barriers in accordance with ISO 9613-2 *Attenuation of sound during outdoor propagation*. The ground absorption of the model has been set as 0 except for the pitch and the park to the north of the site which have been given a ground absorption value of 1.

Noise breakout through the ventilation grills in the roof of the new stand has been taken into account as part of the environmental noise modelling. The sound power levels for these areas have been estimated using the results of room acoustic modelling using Odeon.

The acoustic model of the existing stadium layout was calibrated using the L_{Aeq} data from the match day noise survey. The acoustic model of the proposed stadium layout with the changes to the main stand was interpolated from the model of the existing stadium layout. For the purpose of the computer model, it has been assumed that each stand has the same sound power per unit area.

Results of computer modelling

The calculated noise level, in terms of the L_{Aeq} descriptor, of noise sources within the stadium based on the existing layout are shown in Figure 3. The calculated noise level, in terms of the L_{Aeq} descriptor, of noise sources within the stadium based on the Phase 1 extension of the main stand are shown in Figure 4. The calculated noise level, in terms of the L_{Aeq} descriptor, of noise sources within the stadium based on the Phase 1&2 extensions of the main stand and the Anfield Road stand are shown in Figure 5. The contours show the calculated noise level at a height of 1.5 m, the noise levels shown for the buildings are the highest level over a specific length of building facade.

The models have been used to calculate the difference in L_{Aeq} expected from the change in the stand massing and shape based on noise sources within the stadium. The L_{Aeq} level differences between the existing layout and the Phase 1 extension of the main stand are shown in Figure 6. The L_{Aeq} level differences between the existing layout and the Phase 1&2 extensions of the main stand and Anfield Road Stand are shown in Figure 7. The noise contours show the level difference at a height of 1.5 m, the levels shown for the buildings are the level difference over a specific length of the building facade. Positive value indicates that noise levels from the proposed development will increase.

The existing roof of the stadium forms an effective noise barrier between the stands and the surrounding area. The upper tiers of the new stand are above this existing roof line. There is a direct line of sight from the top tiers to the residents to the east of the stadium. The south stand provides greater screening for the properties to the south east of the stadium than the north stand provides for residences directly to the east of the stadium.

Impact of Phase 1

The calculated change in the A-weighted noise level at properties less than 100 m from the stadium is typically 3 dB or less. A 3 dB change in noise level is considered to be just perceptible and as such is unlikely to have a detectable impact on health and quality of life.

The calculated change in the A-weighted noise level at properties further than 100 m from the stadium is typically 5 dB or less, with the majority of properties experiencing a change in the A-weighted noise level of less than 3 dB.

The properties on Arkles Lane and Watford Road experience a change in the A-weighted noise level of between 5-8 dB. A change in the A-weighted noise level of 5-8 dB is likely to be perceptible. At these locations, noise egress from the sources inside the stadium is calculated to be between L_{Aeq} 56-63 dB.

Impact of Phase 1 and Phase 2

The majority of the properties will experience a change in noise level of at least 1 dB. This is due primarily to the increase in the stadium capacity.

The calculated change in the A-weighted noise level at properties less than 100 m from the stadium is typically 3 dB or less. A 3 dB change in noise level is considered to be just perceptible and as such is unlikely to have a detectable impact on health and quality of life.

The calculated change in the A-weighted noise level at properties further than 100 m from the stadium is typically 6 dB or less, with the majority of properties experiencing a change in the A-weighted noise level of less than 4 dB.

With Phase 2 the properties on Arkles Lane and Watford Road experience a change in the A-weighted noise level of between 2-4 dB, which is lower than the impact of Phase 1 alone.

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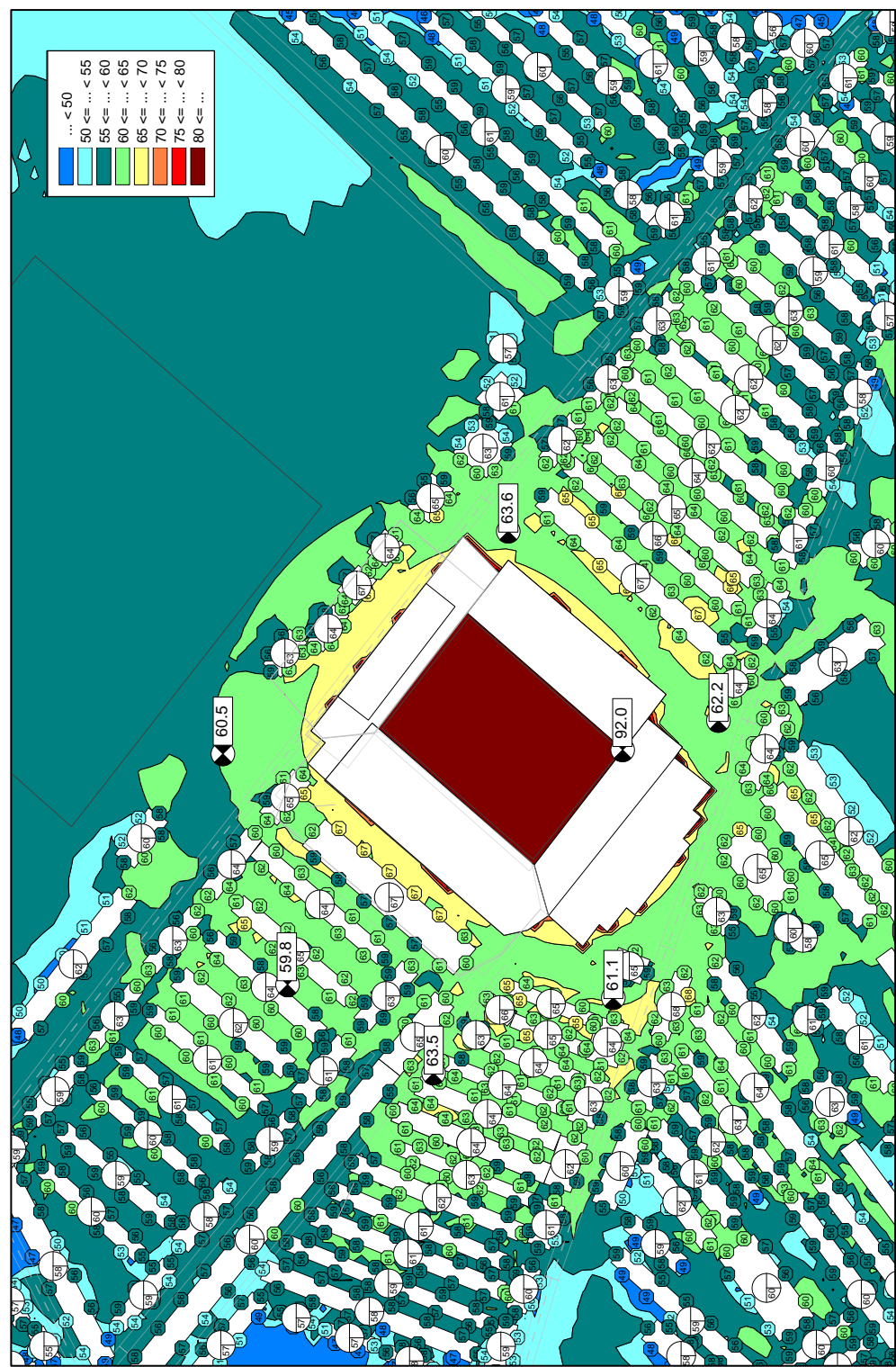


Figure 3 Calculated match day noise levels based on the existing layout

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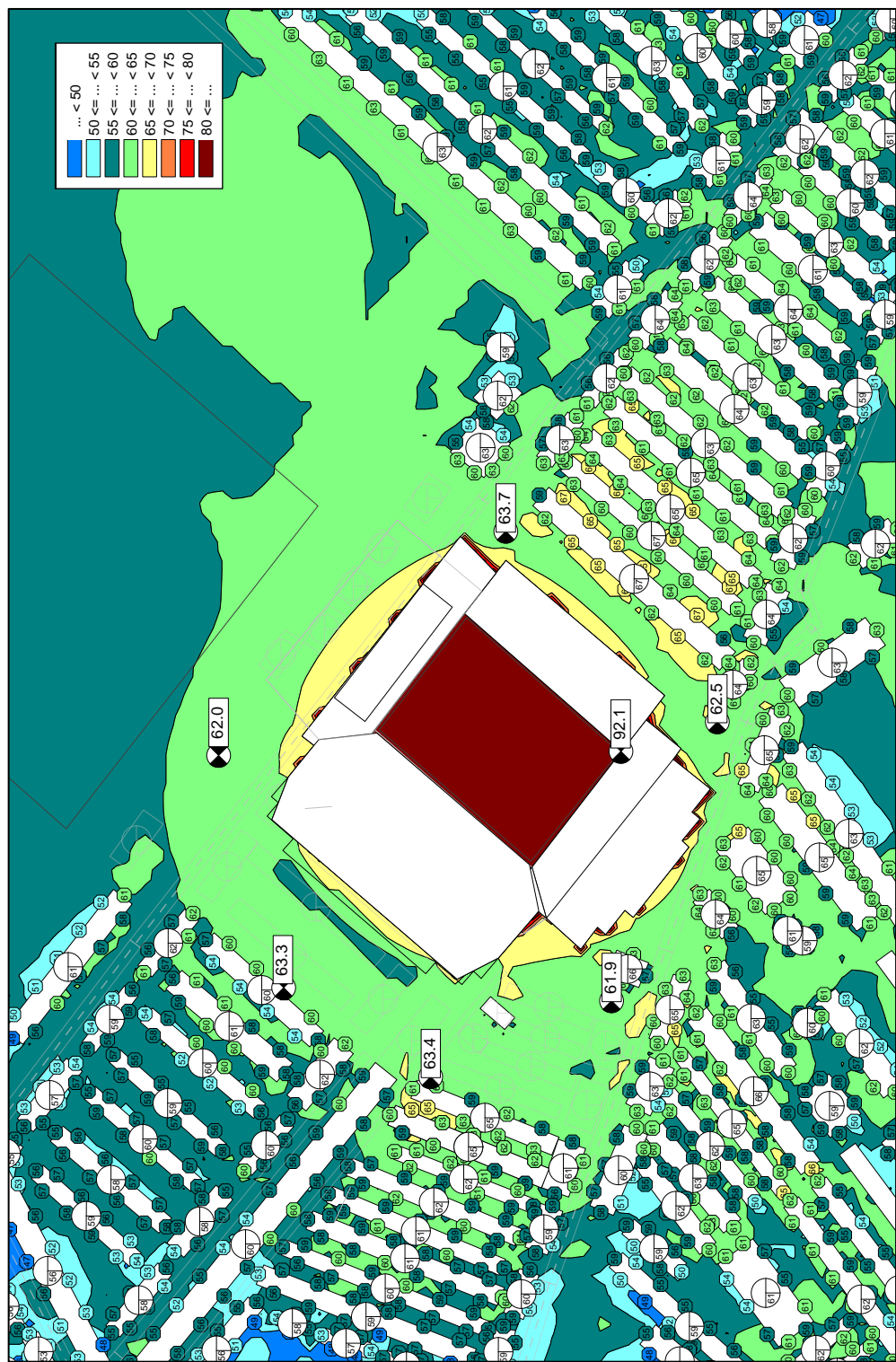


Figure 4 Calculated match day noise levels based on the the Phase 1 scheme

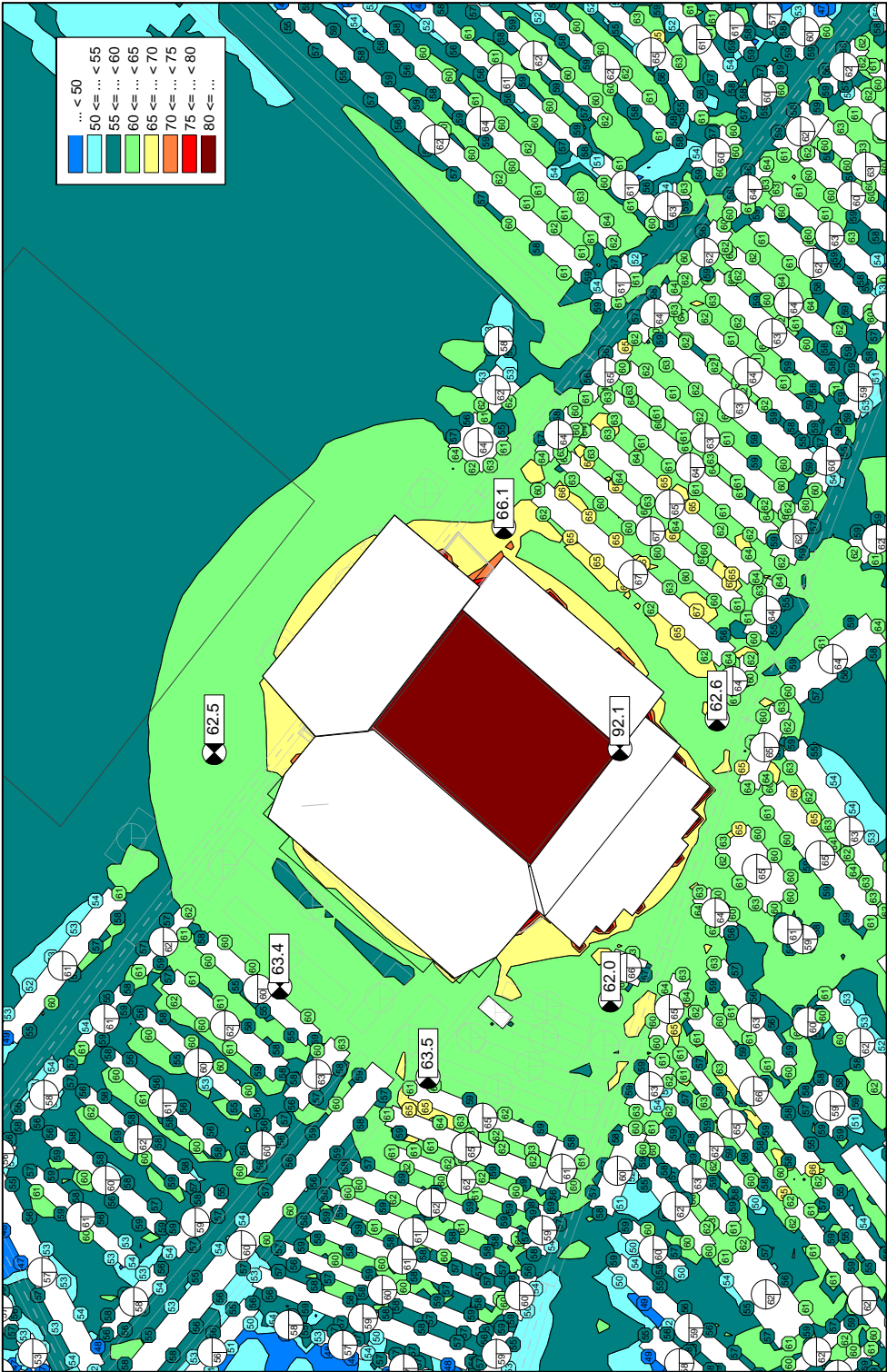


Figure 5 Calculated match day noise levels based on the the Phase 1 and Phase 2 schemes

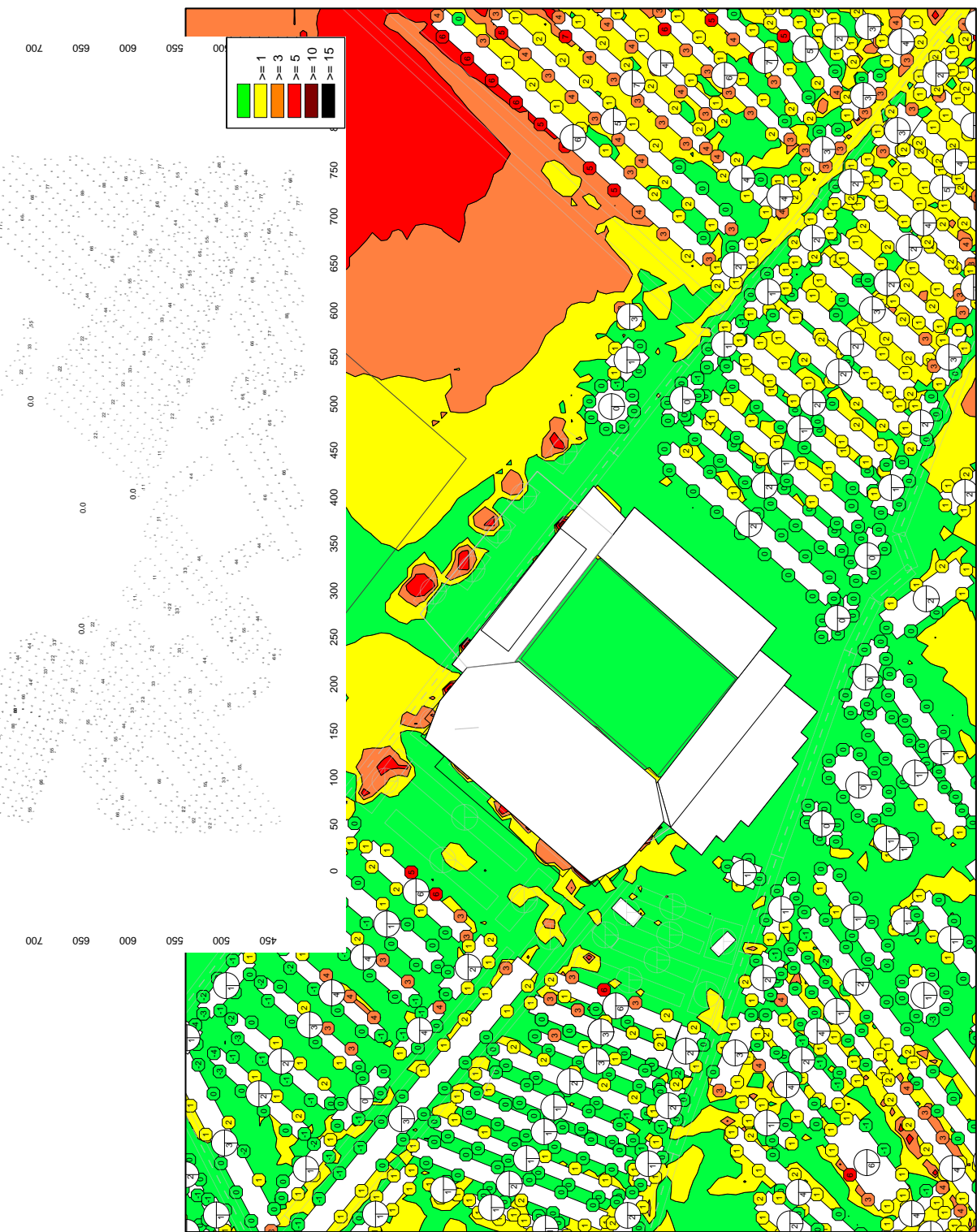


Figure 6 Calculated level difference of the match day noise levels between the existing and the Phase 1 scheme

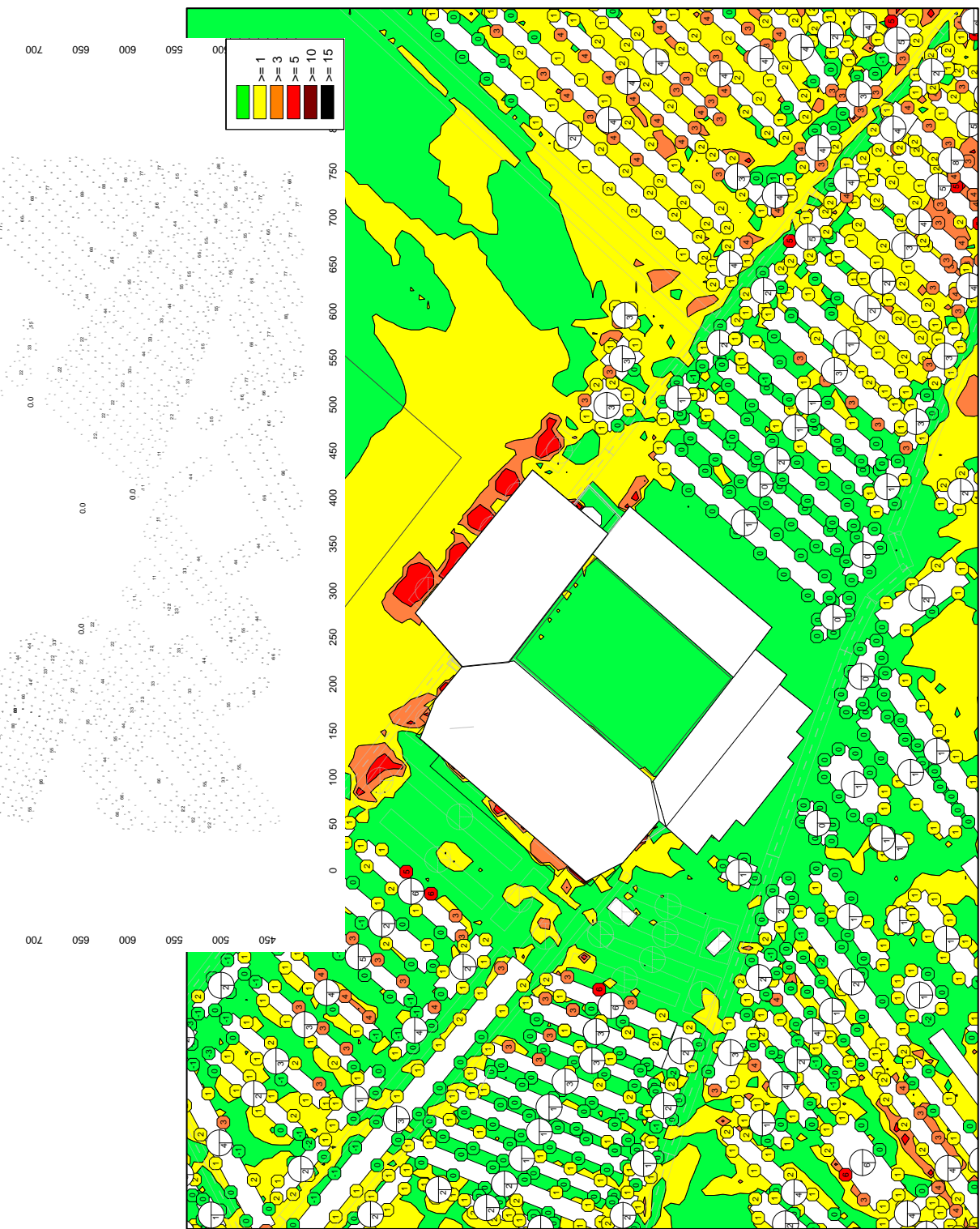


Figure 7 Calculated level difference of the match day noise levels between the existing and the Phase 1 & 2 scheme

4.2 Noise Surveys, ARUP

Appendix 4/3/1 Noise Surveys

Overview

- 4.3.1. A number of noise surveys have been carried out at various times and locations in order to establish:
- noise levels inside the stadium during a football match;
 - noise levels at residential premises during a football match; and
 - ambient noise levels around the site during the day, evening and night.
- 4.3.2. The measurement locations for these surveys are shown in Figure B1.

STADIUM INTERNAL NOISE SURVEY

- 4.3.3. Noise measurements were undertaken inside the existing Anfield Stadium during two Premiership football matches in order to establish average and maximum crowd noise levels inside the stadium.

Dates, Times and Personnel

- 4.3.4. Measurements were taken during the Liverpool v Everton match on Sunday 22 December 2002 (kick-off 16:05 hrs) and the Liverpool v Aston Villa game on Saturday 11 January 2003 (kick-off 15:00 hrs).
- 4.3.5. Fixed position continuous noise monitoring equipment was set up on the control box walkway and the television gantry (further details in Section B2.2) within the stadium approximately 3-4 hours before the kick-off time of each match and monitored noise until approximately 1 hour after each match.
- 4.3.6. Further attended noise monitoring equipment was located at pitchside approximately 30 minutes before the kick-off of each match and monitored noise until approximately 15 minutes after each match.
- 4.3.7. Throughout the surveys, the weather was dry and windspeeds did not exceed 1 m/s.
- 4.3.8. The fixed position noise monitoring equipment was set up by Nick Antonio and Paul Adams of Arup Acoustics. The attended pitchside noise measurements were carried out by Paul Adams.

Measurement Locations

- 4.3.9. The noise measurement locations (see Figure B1) within the stadium are prefixed by 'S'. The matchday noise survey locations outside the stadium are prefixed by 'M' and the ambient noise survey locations are prefixed by 'A'.

- 4.3.10. Location S1 is a façade measurement with the microphone being located below the main television gantry located in the Main Stand.
- 4.3.11. Location S2 is a façade measurement located on the walkway around the control box in the corner of the Centenary and Kop stands. The microphone was located approximately 1 metre from the face of the clock at the corner of the control box.
- 4.3.12. Location S3 is a free field measurement being located in the photographers' pen in front of the Kop Stand. The microphone was positioned just above the level of the hoardings approximately halfway between the goal and the Centenary Stand.

Procedure and Equipment

- 4.3.13. For each of the three measurement locations, statistical noise levels and octave-band frequency spectra were recorded over 30 second periods, storing L_{Aeq} , L_{A10} , L_{A90} and L_{Amax} indices.
- 4.3.14. Measurements were carried out using the equipment detailed in Table B1. The sound level meters and microphones are Type 1 conforming to BS EN 60804. The sound level meters and microphones were calibrated before and after use, to confirm that there was no significant drift in meter response at the calibrator frequency and level. This verification indicated that there was no more than a 0.1 dB variation between checks. The meters are calibrated annually and this calibration is traceable to international standards. All measurements were made with A-weighting and fast (0.125 s) time constant.

TABLE B1: Measurement equipment

Position	Equipment	Manufacturer	Type
S1, S2 and S3	Precision Sound Level Meter	Brüel and Kjær	2260
	Microphone	Brüel and Kjær	4189
	Calibrator	Brüel and Kjær	4231

Results

- 4.3.15. Graphs showing the time history results of the crowd noise measurements at the Liverpool v Everton and the Liverpool v Aston Villa matches are shown in Figures B2 and B3.
- 4.3.16. The Liverpool v Everton Match finished with a 0-0 result and was attended by 44,025 people. The final score in the Liverpool v Aston Villa match was 1-1 and 43,210 people attended.

4.3.17. A summary of the results is given in Table B2.

TABLE B2: Summary of crowd noise measurement results

Date	Location	A-weighted Sound Pressure Level, dB			
		Match L_{Aeq}	Highest $L_{Aeq,30secs}$	Lowest $L_{Aeq,30secs}$	L_{Amax}
22/12/03 (Everton)	S1	92	102	82	112
	S2	93	105	78	113
	S3	102	112	82	114
11/01/03 (Aston Villa)	S1	90	103	80	115
	S2	91	104	79	116
	S3	90	102	77	114

STADIUM EXTERNAL NOISE SURVEY

4.3.18. Noise measurements were taken outside the stadium during the Liverpool v Everton match on Sunday 22 December 2002 and the Liverpool v Aston Villa match on Saturday 11 January 2003 in order to establish crowd noise breakout from the stadium to residential properties. This is so that any adverse affects/improvements in the noise climate at residential properties caused by the relocation of the stadium can be assessed.

Dates, Times and Personnel

4.3.19. Measurements were taken during the Liverpool v Everton match on Sunday 22 December 2002 (kick-off 16:05 hrs) and the Liverpool v Aston Villa game on Saturday 11 January 2003 (kick-off 15:00 hrs).

4.3.20. Fixed position continuous noise monitoring equipment was installed at two separate locations (1 for each match) approximately 2 hours before kick-off in order to obtain measurements of crowd and road traffic noise before and after the matches. Measurements were made until approximately 1 hour after the end of the matches.

4.3.21. Attended spot measurements were also made at seven positions around the existing stadium and the site of the new stadium throughout the duration of the matches.

4.3.22. Throughout the surveys, the weather was dry and wind speeds did not exceed 1 m/s.

4.3.23. The fixed position noise monitoring equipment was set up by Nick Antonio and Paul Adams of Arup Acoustics. The attended spot measurements were carried out by Nick Antonio.

Measurement Locations

4.3.24. The noise measurement locations (Figure B1) outside the stadium are prefixed by 'M' and the ambient noise survey locations are prefixed by 'A'.

4.3.25. For all measurements, the microphone was located approximately 1.2 - 1.5 metres above the ground with the exception of measurement locations M1 and M2.

4.3.26. Location M1 (Everton match only) is a fixed position continuous monitoring free field measurement located on the roof of the petrol filling station on Priory Road. The dominant noise source at this position was traffic on Priory Road and in the Stanley Park car park.

4.3.27. Location M2 (Aston Villa match only) is a fixed position continuous monitoring measurement located outside the first floor window of 20 Arkles Lane. The microphone was positioned approximately 1 metre from the façade and the dominant noise source before and after the match was crowd movement to and from the stadium. During the match the main noise source was idling coaches parked on Arkles Lane with occasional crowd noise from inside the stadium audible.

4.3.28. Location M3 is a free field measurement, the microphone being located at the top end of Stanley Park car park, approx 25 m from the southern edge of the car park. The main noise sources were the crowd and occasional PA announcements, and also occasional traffic on Arkles Lane.

4.3.29. Location M4 is a façade measurement with the microphone located outside 86 Arkles Lane, approximately 2 m from the façade. The main noise source was road traffic. Crowd noise from the stadium was just audible.

4.3.30. Location M5 is a façade measurement located outside 52 Arkles Lane, approximately 2 m from the façade. Crowd noise from the stadium was audible, but noise was dominated by moving road traffic, and stationary coaches in Arkles Lane.

4.3.31. Location M6 (Everton match only) is a façade measurement with the microphone located outside 10 Arkles Lane, approximately 2 m from the façade. Noise sources were the same as those at Location M5.

4.3.32. Location M7 is a façade measurement with the microphone located outside 20 Skerries Lane approximately 2 m from the facade. The noise sources include peripheral match day activities (a hot dog stand and a street sweeper) and occasional road traffic passbys, occasional peaks from the crowd within the stadium were audible.

4.3.33. Location M8 (Aston Villa match only) is a free field measurement. The microphone was located in the car park of “The Park” pub on Walton Breck Road. Road traffic and fans banging wall panels on the Kop dominated the noise climate.

4.3.34. Location M9 is a façade measurement located outside 10 Lothair Road, approximately 2 m from the façade. The noise climate was dominated by crowd noise from the stadium.

Procedure and Equipment

4.3.35. For measurement locations M1 and M2, statistical noise levels were recorded over 30 second periods, storing L_{Aeq} , L_{A10} and L_{A90} indices.

4.3.36. For measurement locations M3 to M9, statistical noise levels were recorded over 5 minute periods, storing L_{Aeq} , L_{A10} , L_{A90} and L_{Amax} indices.

4.3.37. Measurements were carried out using the equipment detailed in Table B3. The sound level meters and microphones are Type 1 conforming to BS EN 60804. The sound level meters and microphones were calibrated before and after use, to confirm that there was no significant drift in meter response at the calibrator frequency and level. This verification indicated that there was no more than a 0.1 dB variation between checks. The meters are annually calibrated and this calibration is traceable to international standards. All measurements were made with A-weighting and fast (0.125 s) time constant. Each measurement was made over a 5 minute period.

TABLE B3: Measurement equipment

Position	Equipment	Manufacturer	Type
M1 & M2	Precision Sound Level Meter	Brüel and Kjær	2236
	Microphone	Brüel and Kjær	4188
	Calibrator	Brüel and Kjær	4231
M3 - M9	Precision Sound Level Meter	Brüel and Kjær	2231
	Microphone	Brüel and Kjær	4165
	Calibrator	Brüel and Kjær	4230

Results

4.3.38. Graphs showing the time history results of the fixed position continuous measurements at Locations M1 and M2 are shown in Figure B4

4.3.39. The results of the spot measurements at Locations M3 to M9 are presented in Table B4 (Liverpool v Everton match) and Table B5 (Liverpool v Aston Villa match). Values are given to the nearest dB, 0.5 being rounded up.

TABLE B4: Measurement results outside stadium during Liverpool v Everton match

Location	Start time (hrs)	L _{A90} (dB)	L _{A10} (dB)	L _{Amax} (dB)	L _{Aeq} (dB)
M3	15:50	48	55	66	53
M3	15:57	50	62	74	58
M3	16:55	43	49	59	47
M3	17:50	46	55	62	52
M4	16:10	59	71	79	66
M4	17:05	54	69	78	64
M5	16:17	53	70	80	66
M5	17:11	52	66	75	62
M6	16:25	54	65	75	61
M6	17:20	50	65	72	61
M7	16:34	51	56	73	56
M7	17:27	52	61	74	58
M9	16:44	42	51	60	48
M9	17:40	45	53	67	51

TABLE B5: Measurement results outside stadium during Liverpool v Aston Villa match

Location	Start time (hrs)	L _{A90} (dB)	L _{A10} (dB)	L _{Amax} (dB)	L _{Aeq} (dB)
M3	14:30	46	58	64	53
M3	14:38	45	55	70	52
M3	14:45	46	56	69	52
M3	14:52	44	53	66	50
M3	14:58	43	57	63	53
M3	15:57	43	49	61	47
M4	15:07	59	71	80	67
M4	16:07	60	71	85	68
M5	15:15	58	69	76	64
M5	16:14	60	70	75	66
M7	15:25	49	57	74	56
M7	16:23	50	59	75	58
M8	15:35	64	75	86	72
M8	16:32	64	73	79	70
M9	15:44	48	64	73	60
M9	16:41	49	59	73	56

AMBIENT NOISE SURVEY

4.3.40. Fixed position and attended ambient noise surveys have been carried out at existing noise sensitive receivers around the site of the proposed stadium. The purpose of these measurements is to assess the ambient noise levels around the site in order to set limiting noise criteria for activities associated with the new stadium i.e. noise from fixed plant.

Date, Times and Personnel

4.3.41. Fixed position ambient noise surveys were taken at two locations (A1 and A2 - see Figure B1) on the roof of the existing Anfield Stadium over the periods Friday 14 February 2003 – Sunday 16 February 2003 and Tuesday 18 February 2003 – Thursday 20 February 2003.

4.3.42. Throughout the survey the weather was dry but the wind speeds picked up to over 5 m/s towards the end of week. The equipment was set up by Paul Adams and David Hiller of Arup Acoustics.

- 4.3.43. Attended spot measurements have also been undertaken over the quietest periods (established from the fixed position monitoring results) of the day, evening and night on Wednesday/Thursday 12/13 March 2003 and Sunday/Monday 16/17 March 2003. These were undertaken at locations A3 to A8 between 14:00 - 15:30 hrs, 21:00 – 23:00 hrs and 02:00 and 04:00 hrs as these are taken to be the quietest times through the day, evening and night.
- 4.3.44. The measurements on the Wednesday were undertaken by Paul Adams and Ben Cox of Arup Acoustics. The weather throughout the survey was dry and wind speeds were approximately 2 m/s, although these dropped later in the survey.
- 4.3.45. The measurements carried out on the Sunday were undertaken by Paul Adams and David Hiller. The weather was fine and dry and wind speeds did not exceed 1 m/s.

Measurement Locations

- 4.3.46. For all measurements, the microphone was located approximately 1.2 - 1.5 metres above the ground with the exception of measurement locations A1 and A2, which were located on the roof of the existing Anfield Stadium.
- 4.3.47. Location A1 is a fixed position continuous monitoring free field measurement located on the flat roofed area at the corner of the existing Anfield Stadium between the Anfield Road and Centenary Stands. Due to the elevated position of the microphone, the dominant noise source was distant road traffic along the main roads in and out of Liverpool. Road traffic on Arkles Lane and Priory Road was also clearly audible. During the night, when road traffic noise levels fell, noise from plant on top of the centenary stand was audible.
- 4.3.48. Location A2 is a fixed position continuous monitoring free field measurement located on the end of the walkway at the corner of the existing Anfield Stadium between the Main Stand and Kop Stand. Due to the elevated location of the microphone, distant road traffic along the main roads in and out of Liverpool was the dominant noise source. Road traffic on Walton Breck Road was also clearly audible. During the night, when road traffic noise levels fell, noise from plant in the Kop Grandstand was audible.
- 4.3.49. Location A3 is a free field measurement located in the crematorium on Priory Road, close to the entrance. The main noise source was road traffic on Priory Road with occasional noise from lawnmowers and other maintenance equipment in the grounds of the cemetery.
- 4.3.50. Location A4 is a façade measurement with the microphone being located approximately 2 metres from the façade of the house on the eastern corner of the Priory Road/Utting

Avenue road junction. During the day, noise from road traffic using the junction was dominant with distant road traffic dominating at night when local road traffic flows decreased significantly.

- 4.3.51. Location A5 is a façade measurement being located outside 78 Arkles lane, approximately 2 metres from the façade. Daytime ambient noise levels were dominated by road traffic on Arkles Lane and Priory Road. Distant road traffic dominated the night time ambient noise levels when road traffic on Arkles Lane and Priory Road decreased.
- 4.3.52. Location A6 is a façade measurement being located outside 40 Arkles lane, approximately 2 metres from the façade. The main daytime noise source was road traffic on Arkles Lane and Priory Road with some road traffic noise on Anfield Road also audible. Distant road traffic dominated the night time ambient noise levels when road traffic on Arkles Lane and Priory Road decreased. During quiet periods at night light plant from 'The Arkles' public house was audible.
- 4.3.53. Location A7 is also a façade measurement. The microphone was positioned approximately 2 metres from the façade of the property at 250 Anfield Road. During the day, ambient noise levels were dominated by road traffic on Anfield Road and Arkles Lane with road traffic on Priory Road also audible during quiet periods. At night, noise levels were dominated by plant noise from equipment on the Centenary Stand.
- 4.3.54. Location A8 is located outside 160 Anfield Road, approximately 2 metres from the façade. This is a façade measurement. The main noise source during the day was road traffic on Anfield Road and Lothair Road with traffic noise from Arkles Lane and Priory Road also audible during quiet periods. At night noise levels were dominated by distant road traffic with occasional plant noise from small condenser units on the wall of the football club building on the opposite side of the main stand car park.

Procedure and Equipment

- 4.3.55. For all measurement locations, statistical noise levels were recorded over 5 minute periods, storing L_{Aeq} , L_{A10} , L_{A90} and L_{Amax} indices. At measurement locations A3 to A8, octave band frequency spectra were also recorded.
- 4.3.56. Measurements were carried out using the equipment detailed in Table B7. The sound level meters and microphones are Type 1 conforming to BS EN 60804. The sound level meters and microphones were calibrated before and after use, to confirm that there was no significant drift in meter response at the calibrator frequency and level. This verification indicated that there was no more than a 0.1 dB variation between checks. The meters are annually calibrated and this calibration is traceable to international standards. All measurements were made with A-weighting and fast

(0.125 s) time constant. Each measurement was made over a 5 minute period.

TABLE B7: Measurement equipment

Position	Equipment	Manufacturer	Type
A1 & A2	Precision Sound Level Meter	Brüel and Kjær	2231
	Microphone	Brüel and Kjær	4165
	Calibrator	Brüel and Kjær	4230
A3 - A8	Precision Sound Level Meter	Brüel and Kjær	2260
	Microphone	Brüel and Kjær	4189
	Calibrator	Brüel and Kjær	4231

Results

4.3.57. Graphs showing the time history results of the fixed position continuous measurements at Locations A1 and A2 are shown in Figures B5 and B6. The results of the spot measurements at Locations A3 to A8 are presented in Tables B8 to B13.

TABLE B8: Results of measurements at Location A3

Date	Start time (hrs)	L _{A90} (dB)	L _{A10} (dB)	L _{Amax} (dB)	L _{Aeq} (dB)
12/03/03	14:06	45	55	65	52
	14:11	46	54	65	52
	15:22	47	55	70	53
	15:27	49	58	71	56

TABLE B9: Results of measurements at Location A4

Date	Start time (hrs)	L_{A90} (dB)	L_{A10} (dB)	L_{Amax} (dB)	L_{Aeq} (dB)
12/03/03	14:26	62	74	83	70
	14:31	62	75	86	71
	20:55	57	70	79	67
	21:00	59	71	87	68
	22:05	59	71	80	67
	22:10	57	69	76	65
	01:57	31	60	77	59
	02:02	31	60	67	55
	03:11	31	60	76	57
	03:16	32	54	77	56
16/03/03	20:58	56	69	81	66
	21:04	55	70	77	66
	21:57	53	68	78	64
	01:52	39	61	84	61
	02:54	40	63	73	59
	02:59	41	59	74	57

TABLE B10: Results of measurements at Location A5

Date	Start time (hrs)	L_{A90} (dB)	L_{A10} (dB)	L_{Amax} (dB)	L_{Aeq} (dB)
12/03/03	14:44	58	73	81	68
	14:49	57	75	81	70
	21:53	45	67	80	63
	21:58	48	64	74	61
	02:09	28	50	73	52
	02:14	30	52	72	51
	03:23	27	49	67	48
	03:28	28	53	70	51
16/03/03	21:11	47	69	76	63
	21:16	50	68	83	65
	22:11	45	63	77	60
	22:16	47	64	75	60
	01:57	34	53	74	53
	02:02	34	54	80	60
	03:08	43	48	58	47
	03:13	43	47	74	52

TABLE B11: Results of measurements at Location A6

Date	Start time (hrs)	L_{A90}(dB)	L_{A10} (dB)	L_{Amax} (dB)	L_{Aeq} (dB)
12/03/03	14:40	55	73	78	68
	14:45	55	73	81	68
	21:41	44	67	79	63
	21:46	45	68	81	65
	22:52	39	61	78	61
	22:57	37	57	76	58
	02:21	28	46	68	49
	02:26	28	45	72	51
	03:35	27	31	48	30
	03:40	29	49	83	59
16/03/03	22:23	39	59	76	57
	22:28	39	60	76	58
	02:10	34	51	75	54
	02:15	33	44	75	51
	03:20	39	45	56	43
	03:25	39	51	77	56

TABLE B12: Results of measurements at Location A7

Date	Start time (hrs)	L_{A90} (dB)	L_{A10} (dB)	L_{Amax} (dB)	L_{Aeq} (dB)
12/03/03	14:58	55	67	79	64
	15:03	53	67	82	64
	21:28	44	62	79	60
	21:33	45	59	76	58
	22:39	43	58	72	56
	22:44	44	62	78	60
	2:34	38	47	66	48
	2:39	38	41	52	40
	3:48	38	40	44	39
	3:53	38	40	47	40
16/03/03	21:25	46	60	84	61
	21:31	46	59	77	59
	22:36	45	55	74	55
	22:41	44	58	69	55
	2:23	43	51	67	49
	2:28	42	44	56	44
	3:34	42	45	58	44
	3:39	43	49	60	47

TABLE B13: Results of measurements at Location A8

Date	Start time (hrs)	L _{A90} (dB)	L _{A10} (dB)	L _{Amax} (dB)	L _{Aeq} (dB)
12/03/03	15:00	47	64	90	63
	15:05	48	64	84	61
	21:14	44	60	67	56
	21:19	42	57	65	53
	22:26	40	56	74	56
	22:31	40	55	75	52
	2:52	32	42	68	46
	2:57	29	36	47	34
	4:02	31	44	59	42
	4:07	30	37	46	34
16/03/03	21:39	40	61	74	57
	21:44	40	55	75	54
	22:50	37	44	68	48
	22:55	38	55	85	58
	2:36	34	38	54	39
	2:41	34	39	50	37
	3:49	39	46	53	42
	3:54	39	45	53	42

FIGURE B1: Noise survey measurement locations - Anfield

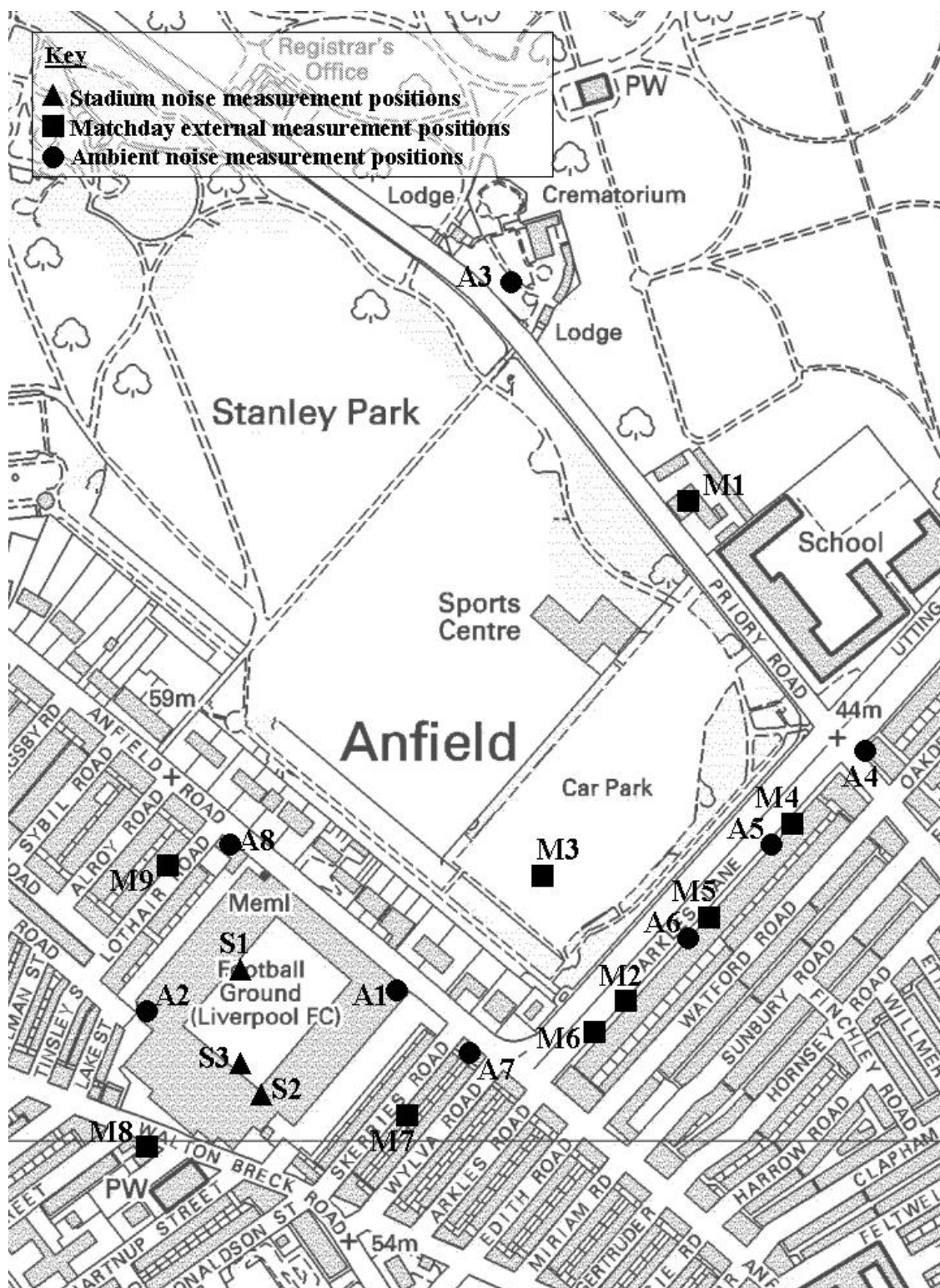


FIGURE B2: Data from within stadium during Everton game

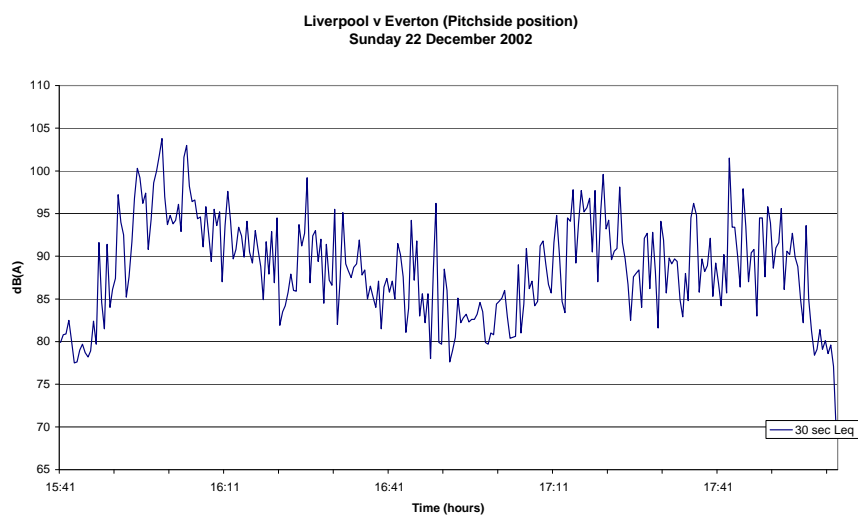
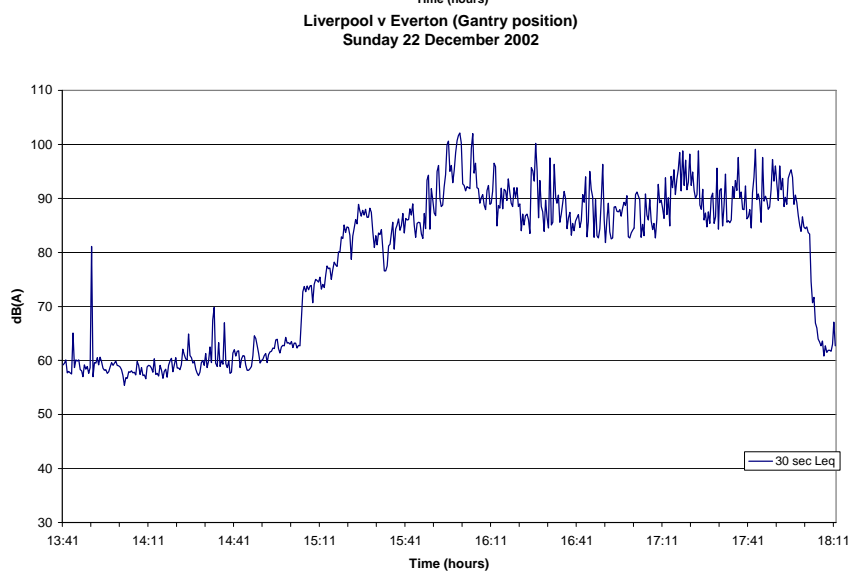
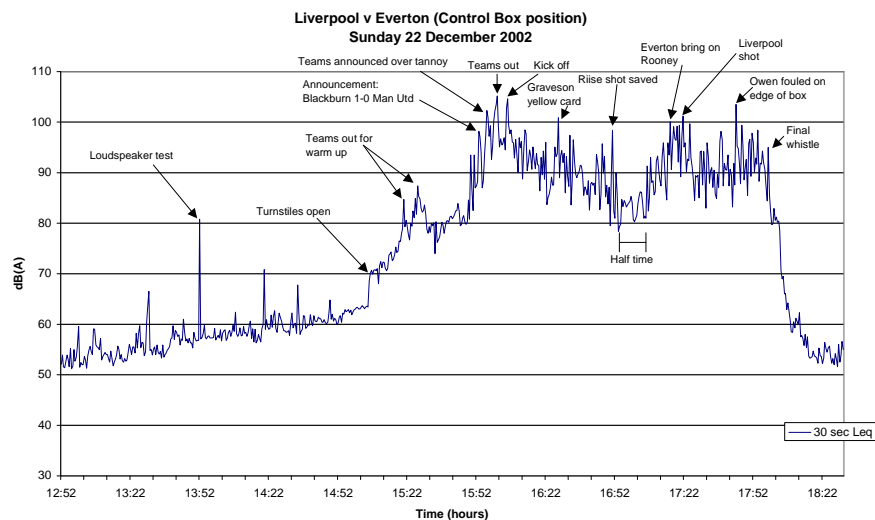


FIGURE B3: Data from within stadium during Aston Villa game

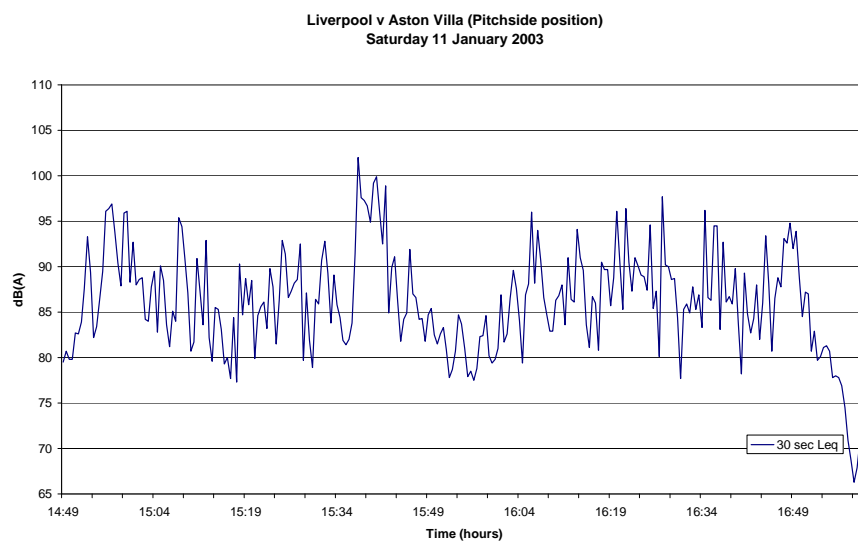
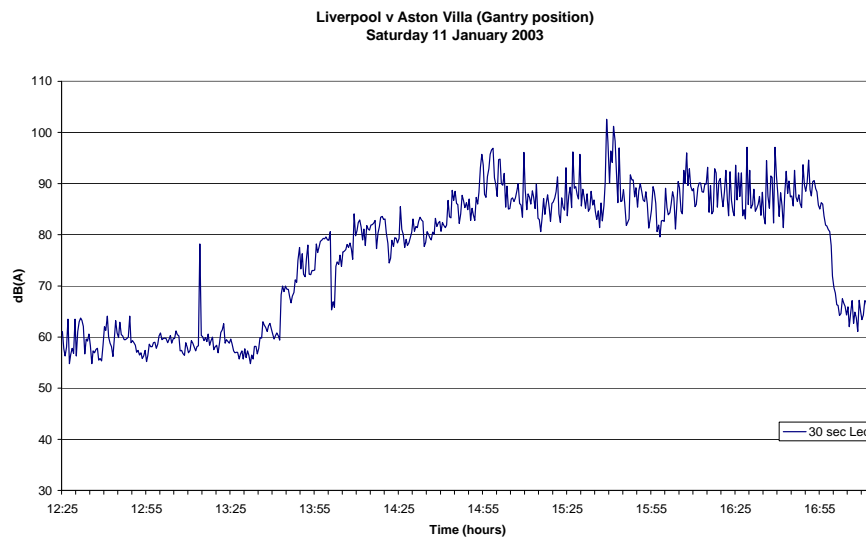
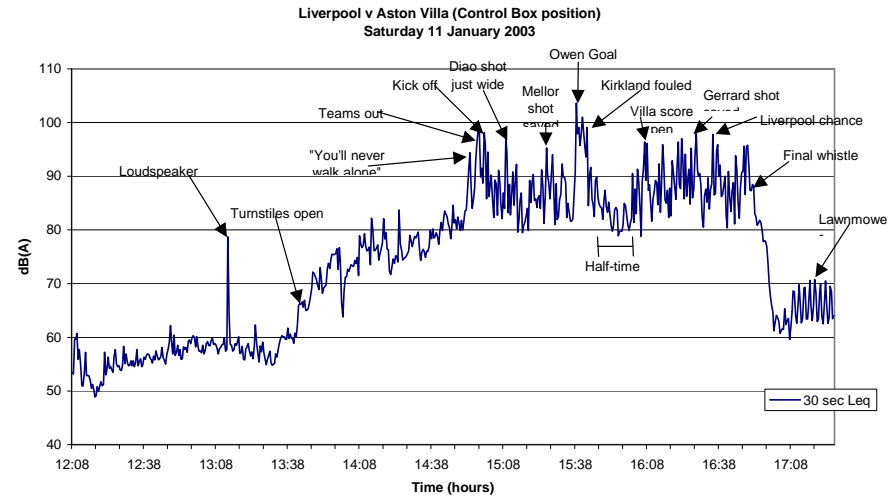
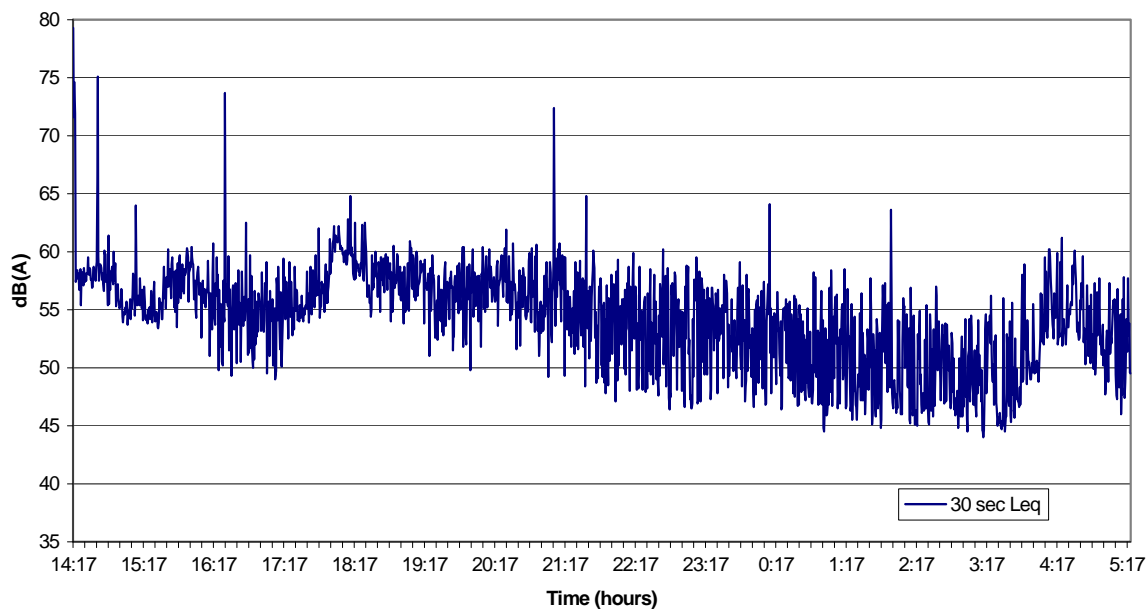


FIGURE B4: Data from outside stadium during Everton and Aston Villa games

Liverpool v Everton (Fixed position on Priory Road)
Sunday 22 December 2002 - Monday 23 December 2002



Liverpool v Aston Villa (Fixed Position at 20 Arkles Lane)
Sunday 11 January 2003

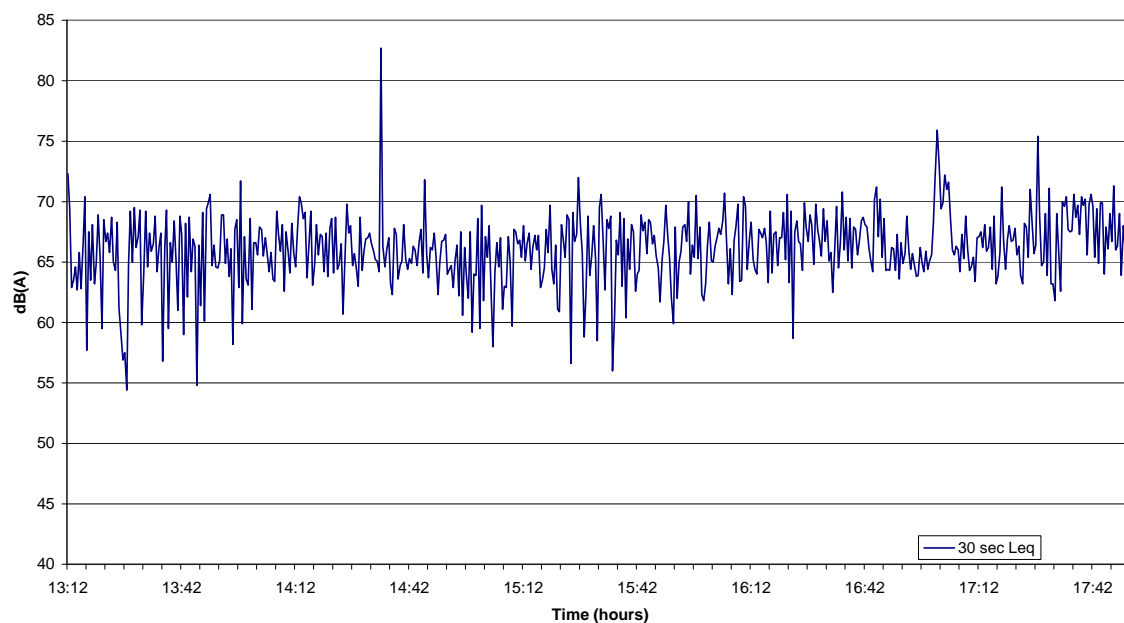


FIGURE B5: Ambient noise data from Anfield Road / Centenary Stand

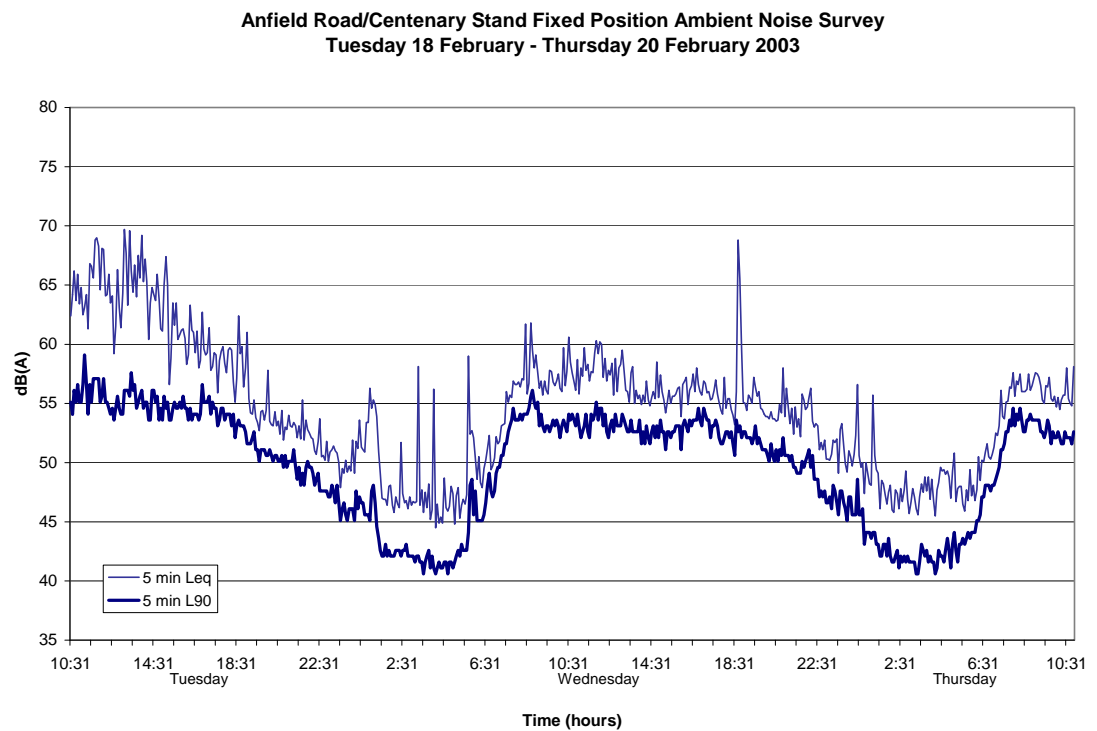
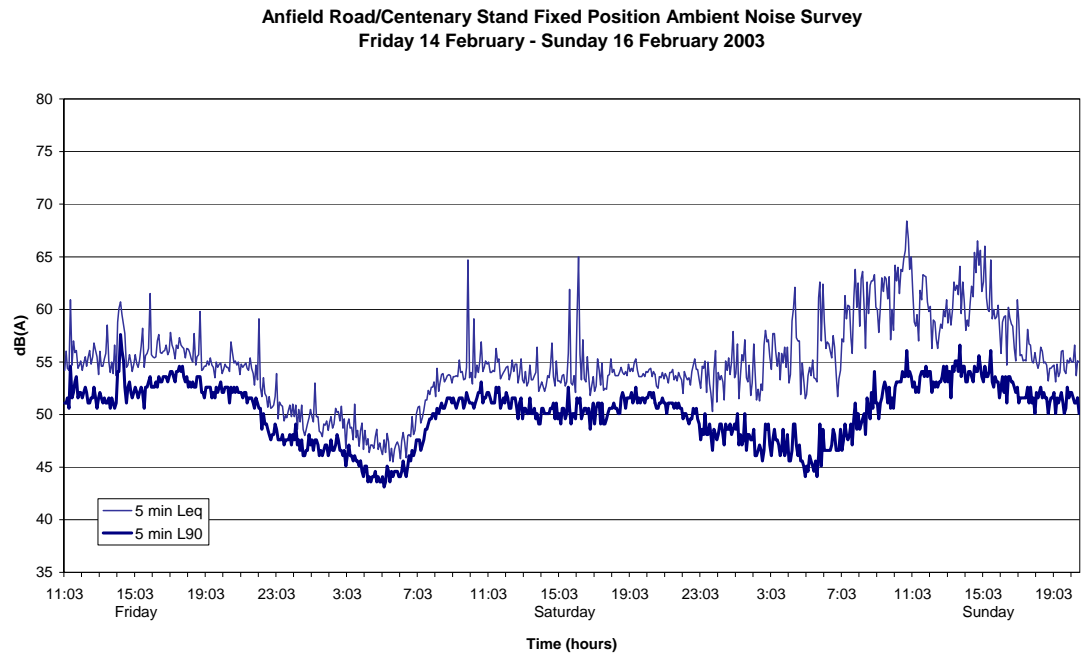


FIGURE B6: Ambient noise data from Kop / Main Stand

