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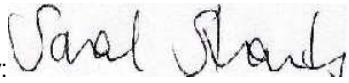
Environmental Noise Assessment
Rail Noise Assessment – Stirling-Alloa-Kincardine Rail Link

Clackmannanshire Council
26th May 2009

Prepared by:  . Approved by: 

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Rail Noise Assessment: Stirling-Alloa-Kincardine Rail Link.

Rev No	Comments	Date
1		30/04/09
2	Amendment to transposed table headings in Appendix 3_ss	26/05/09

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Job No: 60051518 Reference: M001.001 Date Created: 26th May 2009

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Rail Noise Assessment

1 Introduction

1.1 Faber Maunsell was instructed by Clackmannanshire Council to undertake noise measurements to determine whether any of the eligible[1] existing residential properties along the length of the newly constructed section of railway track between Causeywayhead, Stirling and Kincardine would qualify in terms of the provisions set out within the Stirling-Alloa Kincardine (S-A-K) Environmental Statement, 2003[2], in respect of noise insulation. The measurements also served to indicate whether or not any of the properties should have been provided with mitigation against railway noise; the criteria for mitigation was clearly set within the Environmental Statement.

1.2 A brief description of the S-A-K works relevant to this assessment is offered in Section 2. The requirements for assessment of both insulation and mitigation in respect of railway noise identified within the Environmental Statement are reproduced in Section 3. The rail noise assessment methodology is presented in Section 4, and the assessment for rail noise is presented in Section 5. Finally a summary and conclusions can be found in Section 6.

1.3 Rail noise measurements were undertaken between Monday 26th January and Thursday 29th January 2009, for a minimum period of 24 hours continuous monitoring. The rail noise measurement procedures were undertaken at 11 residential properties along the rail track.

1.4 A glossary of acoustical terminology is included as Appendix 1.

1.5 A list of the instrumentation used during the measurement period is included as Appendix 2.

1.6 The detailed site notes taken throughout the measurement period are presented as Appendix 3.

[1] Eligible – (meaning were constructed prior to the passing of the S_A_K Parliamentary Bill

[2] Stirling - Alloa - Kincardine Railway (Route Re-opening) and Linked Improvements (Scotland) Bill - Environmental Statement Volumes 1, 2 & 3. –February 2003.

2 A Brief Description of the Site

2.1. The (S-A-K) rail line comprises of approximately 21km of track between Stirling Station and Longannet Power Station in Kincardine. It provides passenger services from Alloa to Stirling and freight services to Longannet Power Station

2.2. The re-opening of the rail line involved reconstructing the line between Stirling and Kincardine along its former route and upgrading the existing railway route between Kincardine and Longannet Power Station. The section of the route from Stirling to Alloa has been re-opened to passenger and freight trains, with a new railway station located at Alloa and a freight only connection through to Kincardine and on to Longannet Power Station.

2.3. The rail line passes within the Stirling Council, Clackmannanshire Council and Fife Council areas.

3 Criteria for Assessment

3.1. The criteria for assessment are two fold, i.e. in respect of mitigation and insulation. The criterion for mitigation is described in sections 3.2 – 3.3 and the criteria for insulation in section 3.4.

Mitigation Criteria for Assessment as Identified in the Environmental Statement

3.2. *"… all properties subject to a façade noise level (due to railway noise) equal to or greater than 55 dB $L_{Aeq,18h}$ (approximately 52 dB $L_{Aeq,18h}$ free-field) and subject to an increase in free-field noise level equal to or greater than 5 dB(A) were considered in need of mitigation"*[3].

3.3. *"Additionally, the occurrence of $L_{Amax,fast}$ values above 60 dB at the facades of residential properties during night-time (23:00-07:00) is appropriate for assessing the impact of the railway movements specific to sleep disturbance"*[4].

Insulation Criteria for Assessment as Identified in the Environmental Statement

3.4. *"Under certain circumstances, occupiers of dwellings affected by rail traffic noise from a new or additional railway may be entitled to noise insulation treatment (acoustic glazing and acoustic ventilation to habitable rooms) under the Railway Noise Insulation Regulations (Reference 8). These regulations apply in England and Wales but have no equivalent in Scotland. However, legal advice is that the criteria and standards embodied in the regulations can be applied in cases such as this, where no equivalent or alternative is available. The circumstances for entitlement are defined by three conditions which have to be met*

- *the combined expected maximum rail traffic noise level (i.e. the relevant noise level from the new or altered railway) must not be less than the specified noise levels (68 dB $L_{Aeq,18h}$ daytime (06:00-24:00) and 63 dB $L_{Aeq,6h}$ night-time (24:00- 06:00).*
- *the relevant noise level is at least 1.0 dB(A) more than the prevailing noise level.*
- *the contribution to the increase in the relevant noise level from the new or altered railway must be at least 1.0 dB(A).*

Noise from the railway shall be assessed at a reception point located 1 metre outward of the external side of a qualifying window. The railway flows to be used in the calculation shall be the noisiest expected traffic flows occurring during the specified day and night periods within a period of 15 years after opening the system"[5].

[3] Stirling - Alloa - Kincardine Railway (Route Re-opening) and Linked Improvements (Scotland) Bill - Environmental Statement Volume 2 – Topic Specific Report, February 2003. p195
[4] Stirling - Alloa - Kincardine Railway (Route Re-opening) and Linked Improvements (Scotland) Bill - Environmental Statement Volume 2 – Topic Specific Report, February 2003. p189
[5] Stirling - Alloa - Kincardine Railway (Route Re-opening) and Linked Improvements (Scotland) Bill - Environmental Statement Volume 3 – Supporting Information, February 2003. p138

4 Rail Noise Assessment Methodology

4.1 The railway noise was predicted in accordance with the requirements of the Department of Transport *Calculation of Rail Noise (CRN)*[6] publication. This prediction method is used to predict the $L_{Aeq,18hr}$ dB rail noise level for the daytime period (06:00 – 00:00 hours) and the night-time period (00:00 – 06:00 hours).

4.2 The predicted daytime and night-time $L_{Aeq,T}$ noise levels were assessed in accordance with the criteria for assessment identified within the Environmental Statement, as detailed within Section 3.

4.3 The properties selected as monitoring locations were taken to be representative of other properties along the length of the reopened section of the track with a similar relationship to the track in terms of both horizontal and vertical displacement.

[6] The Department of Transport (1995) *Calculation of Railway Noise (CRN).* HMSO

5 Rail Noise Assessment

5.1 A prediction of the rail noise level, at the selected eleven existing residential properties, identified along the route, has been undertaken in accordance with the methodology detailed in Calculation of Railway Noise, (CRN)[7] using on-site noise level measurement data. During the measurement period, the daily numbers of trains passing along the S-A-K line are presented in Table 1.

Table 1: Train Numbers Passing Existing Properties along S-A-K Line

Train Company	Direction	Day 1	Day 2	Night 1	Night 2
Stirling – Alloa (Passenger)	Eastbound	18	18	1	1
	Westbound	18	18	0	0
Stirling – Kincardine (Freight)	Eastbound	7	9	1	2
	Westbound	6	10	1	3

5.2 Attended on-site train noise level measurements were undertaken between Monday 26th January and Thursday 29th January 2009 at eleven selected existing residential properties along the route. Noise level measurements were undertaken of D.B. Schenker (formerly E.W.S) freight train movements and SPT passenger train movements, were applicable, using sound level meters left in situ at the identified properties. The measurement period was for a minimum of 48 hours, with the exception of Dumyat Road and The Gables. The results of the individual measurement periods are contained within the detailed site notes, presented as Appendix 3. Details of the instrumentation used during the measurement are provided in Appendix 2.

5.3 Furthermore, supplementary on-site noise level measurements were undertaken at each of the 11 properties, at varying times throughout the overall measurement period, with a sound level meter equipped with an audio recording facility, to obtain additional data. The purpose of this was to ascertain the specific environmental conditions with 'on the spot' measurements throughout the measurement period, and obtain additional noise level measurement data that could be directly compared with the unattended measurement data results. The results of the additional measurement periods are contained within the detailed site notes, presented as Appendix 3.

5.4 The microphones were positioned at a height of either 1.5m from the ground (ground floor window height), or 4.5m from the ground (at 1st floor window height) at each location. The sound level meters were placed within 'all weather kit[8]' casings and secured within the rear garden areas of each of the properties being assessed. All measurements were taken with the

[7] The Department of Transport (1995) *Calculation of Railway Noise (CRN).* HMSO

[8] 'All weather kit' encompasses a sound level meter with pre-amp secured within an weather-tight plastic case with the microphone on an extension cable attached to a pole (either 1.5m of 4.5m in height) and fitted with a windshield.

microphone positioned at 1m from the façade. Table 2 presents information regarding the type and model of each sound level meter and the height of the microphone at each measurement location.

Table 2: Type and Model of Sound Level Meter and Height of Microphone at Each Monitoring Location

Measurement Location	Sound Level Meter Type and Model	Height of Microphone from Ground (m)	Measurement Location	Sound Level Meter Type and Model	Height of Microphone from Ground (m)
Station House, Kincardine	Rion: NL-32	1.5	75 Grange Road, Alloa	Rion: NL-31	1.5
23 Brucefield Crescent, Clackmannan	Rion: NL-31	4.5	The Gables, near Cambus	Rion: NL-31	1.5
Hamewith, Clackmannan	Rion: NL-31	1.5	East Neuk Cottage, Causewayheed	Rion: NL-32	1.5
101 Devonway, Clackmannan	Rion: NL-31	4.5	138 Ladysneuk Road, Causeywayhead	Rion: NL-31	4.5
22 Park Place, Alloa	Rion: NL-32	4.5	2 Dumyat Road, Causeywayhead.	Rion: NL-31	1.5
24 Kingswell Park, Alloa	Rion: NL-31	1.5	-	-	-

* NL-31 Class 1 integrated sound level meter, NL-32 Class 1 integrated sound level meter with audio recording facility

5.5 At each location the microphone was positioned outside the window of interest, ground floor living room areas/bedroom area windows and first floor bedroom windows, where practicable. At each location the measurement position was in a direct line of site of the rail tack, with the exception of Dumyat Road. The rear garden area of 2 Dumyat Road is positioned such that there is no direct line of sight to the rail track due to the shielding effect of the properties on Causewayhead Road, directly between the rear garden of Dumyat Road and the rail line.

5.6 The noise monitoring equipment was calibrated both before and after the measurement period using an acoustic calibrator, which has itself been calibrated against a reference set traceable to National and International Standards, at each measurement location. There was no shift in the observed calibration level on any of the sound level meters.

5.7 The weather conditions, throughout the measurement period were generally dry with no wind. However, during the daytime measurement period on Tuesday 27th January there was a period of very light drizzle lasting approximately 2 hours. This precipitation was considered to be light enough so as not to adversely affect the measurement procedure and therefore, the weather conditions were deemed to be conducive to rail traffic noise level measurements, throughout. A breakdown of the environmental conditions recorded at intervals throughout the measurement period, are presented within the detailed site notes within Appendix 3.

5.8 Whilst on site up to 113 train pass-bys were measured at each measurement location, over a 48 hour period, dependent upon the location of the measurement site along the track, Tables 3 and 4 detail the measured noise level associated with the trains using the S-A-K line, at each monitoring location, during the 18 hour daytime period (06:00 – 00:00 hours) and six hour night-time period (00:00 – 06:00 hours), respectively.

5.9 The overall $L_{Aeq(T)}$ train noise level during each of the relevant time periods were calculated using the measured train data, using individual measured SELs To assess the noise level associated with the total train pass-bys at each location, the individual measured SELs were summed using Equation (1), as detailed below in CRN:

$$L_{Aeq(T)} = 10 \log \left[\frac{10^{\left(SEL_1/10\right)} + 10^{\left(SEL_2/10\right)} + \ldots 10^{\left(SEL_n/10\right)}}{T_t} \right] \qquad (1)$$

(Where: the SEL_n is the n^{th} measured single event level for a given train type and T_t is the total time in seconds of the $L_{Aeq(T)}$ to be determined)

5.10 Furthermore, the remaining measured noise level during the measurement period, with the train pass-bys extracted, is deemed to be representative of the background noise level ($L_{Aeq,T}$) within the area, as defined within CRN. The predicted ambient noise level is the total measured train noise level combined with the measured background noise level, with the train line in operation, see Tables 3 and 4.

Table 3: Measured Daytime Noise Levels at Existing Residential Properties Along the S-A-K Route, with Rail Line in Operation

Measurement Period on 27/01/09 between 06:00 – 00:00 hours (18 hour Daytime Period)					
Property	**Total Measured Train Noise Level $L_{Aeq,18hr}$ (dB)**	**Measured Freight Train Noise Level $L_{Aeq,18hr}$ (dB)**	**Measured Passenger Train Noise Level $L_{Aeq,18hr}$ (dB)**	**Measured Background Noise Level $L_{Aeq,18hr}$ (dB)**	**Predicted Ambient Noise Level $L_{Aeq,18hr}$ (dB)**
Station House, Kincardine	55.3	55.3	-	51.0	**56.7**
23 Brucefield Crescent, Clackmannan	51.8	51.8	-	58.4	**59.3**
Hamewith, Clackmannan	44.2	44.2	-	48.1	**49.6**
101 Devonway, Clackmannan	53.3	53.3	-	52.5	**55.9**
22 Park Place, Alloa	51.3	51.3	-	48.7	**53.7**
24 Kingswell Park, Alloa	50.9	50.9	-	52.6	**54.8**
75 Grange Road,+ Alloa	58.5	55.3	55.9	54.7	**60.0**
The Gables, nr Cambus	N/A*	N/A*	N/A*	N/A*	**N/A***
East Neuk Cottage, Causewayhead	61.3	59.0	57.4	63.1	**65.3**
138 Ladysneuk Rd, Causewayhead	56.4	54.6	51.8	55.1	**58.8**
2 Dumyat Road, Causewayhead	40.4	38.1	36.6	51.6	**51.9**

*No measurements undertaken on 27/01/09 due to monitoring equipment fault

+At Grange Road the noise level meter was not operation for approximately 1 hours and 45minutes. Therefore, an approximation to the noise level has been made using equivalent measured train data, at this and adjacent locations

Measurement Period on 28/01/09 between 06:00 – 00:00 hours (18 hour Daytime Period)					
Property	**Total Measured Train Noise Level $L_{Aeq,18hr}$ (dB)**	**Measured Freight Train Noise Level $L_{Aeq,18hr}$ (dB)**	**Measured Passenger Train Noise Level $L_{Aeq,18hr}$ (dB)**	**Measured Background Noise Level $L_{Aeq,18hr}$ (dB)**	**Predicted Ambient Noise Level $L_{Aeq,18hr}$ (dB)**
Station House, Kincardine	55.6	55.6	-	50.3	**56.7**
23 Brucefield Crescent, Clackmannan	52.2	52.2	-	59.1	**59.9**
Hamewith, Clackmannan	45.1	45.1	-	48.2	**49.9**
101 Devonway, Clackmannan	53.5	53.5	-	53.4	**56.4**
22 Park Place, Alloa	52.4	52.4	-	50.1	**54.4**
24 Kingswell Park,* Alloa**	53.1	53.1	-	51.8	**55.5**
75 Grange Road, Alloa	59.9	57.3	56.5	55.5	**60.8**
The Gables, nr Cambus	56.7	54.3	52.9	52.8	**58.1**
East Neuk Cottage, Causewayhead	61.9	59.7	58.0	63.2	**65.6**
138 Ladysneuk Rd, Causewayhead	56.9	55.0	52.3	55.4	**59.2**
2 Dumyat Road, Causewayhead	N/A**	N/A**	N/A**	N/A**	**N/A****

**Measurements at Dumyat Road excluded as results corrupted by local construction related noise events

*** At Kingswell Park, the noise level meter was not operation for approximately 6 hours. Therefore, an approximation to the noise level has been made using equivalent measured train data, at this and adjacent locations

Table 4: Measured Night-Time Noise Levels at Existing Residential Properties Along the S-A-K Route, with Rail Line in Operation

Measurement Period on 27/01/09 between 00:00 – 06:00 hours (6 hour Night-Time Period)					
Property	**Total Measured Train Noise Level $L_{Aeq,6hr}$ (dB)**	**Measured Freight Train Noise Level $L_{Aeq,6hr}$ (dB)**	**Measured Passenger Train Noise Level $L_{Aeq,6hr}$ (dB)**	**Measured Background Noise Level $L_{Aeq,6hr}$ (dB)**	**Predicted Ambient Noise Level $L_{Aeq,6hr}$ (dB)**
Station House, Kincardine	51.2	51.2	-	43.4	**51.9**
23 Brucefield Crescent, Clackmannan	47.3	47.3	-	49.4	**51.5**
Hamewith, Clackmannan	40.6	40.6	-	38.8	**42.8**
101 Devonway, Clackmannan	47.9	47.9	-	43.6	**49.3**
22 Park Place, Alloa	47.8	47.8	-	40.2	**48.5**
24 Kingswell Park, Alloa	49.4	49.4	-	43.5	**50.4**
75 Grange Road, Alloa	51.0	50.4	42.5	46.0	**52.2**
The Gables, nr Cambus	N/A	N/A	N/A	N/A	**N/A**
East Neuk Cottage, Causewayhead	55.3	54.8	45.2	53.1	**57.3**
138 Ladysneuk Rd, Causewayhead	51.1	39.6	50.8	46.6	**52.4**
2 Dumyat Road, Causewayhead	N/A*	N/A*	N/A*	N/A*	**N/A***

***** Measurements at Dumyat Road excluded as results influenced by constant road traffic noise, trains indistinguishable

Measurement Period on 28/01/09 between 00:00 – 06:00 hours (6 hour Night-Time Period)					
Property	**Total Measured Train Noise Level $L_{Aeq,6hr}$ (dB)**	**Measured Freight Train Noise Level $L_{Aeq,6hr}$ (dB)**	**Measured Passenger Train Noise Level $L_{Aeq,6hr}$ (dB)**	**Measured Background Noise Level $L_{Aeq,6hr}$ (dB)**	**Predicted Ambient Noise Level $L_{Aeq,6hr}$ (dB)**
Station House, Kincardine	53.7	53.7	-	43.3	**54.1**
23 Brucefield Crescent, Clackmannan	51.2	51.2	-	51.9	**54.6**
Hamewith, Clackmannan	42.1	42.1	-	41.6	**44.9**
101 Devonway, Clackmannan	52.6	52.6	-	46.0	**53.5**
22 Park Place, Alloa	51.3	51.3	-	42.1	**51.8**
24 Kingswell Park, Alloa	50.7	50.7	-	44.1	**51.6**
75 Grange Road, Alloa	55.5	55.4	39.5	45.9	**56.0**
The Gables, nr Cambus	54.5	54.5	35.7	42.6	**54.8**
East Neuk Cottage, Causewayhead	59.5	59.3	45.2	53.4	**60.5**
138 Ladysneuk Rd, Causewayhead	54.8	54.7	39.2	47.2	**55.5**
2 Dumyat Road, Causewayhead	N/A**	N/A**	N/A**	N/A**	**N/A****

**Measurements at Dumyat Road excluded as results influenced by constant road traffic noise, trains indistinguishable

5.11 The threshold for mitigation as outlined within the ES[3] states "*These results were used to assess the need for mitigation in the form of lineside barriers. Applying the methodology discussed previously, all properties subject to a façade noise level (due to railway noise) equal to or greater than 55 dB $L_{Aeq,18h}$ (approximately 52 dB $L_{Aeq,18h}$ free-field) and subject to an increase in free-field noise level equal to or greater than 5 dB(A) were considered in need of mitigation*." It is therefore assumed that the threshold for mitigation is simply a predicted railway façade level of 55dB or more and an increase of 5dB or more in the ambient noise level. It should be noted that this criteria is for daytime noise levels only, as at the time of the publication of the ES it was stated *"Indication is that there would be no timetabled railway movements at all in the period 24.00-06.00"* [9].

5.12 Therefore, from the measured results within Table 3 it clearly can be seen that the only properties that fall within this criteria are Station House, Kincardine and 75 Grange Road, Alloa. At both of these existing residences the predicted free-field ambient noise levels, at a distance of 1m from the façade of the properties are greater than $L_{Aeq,18hr}$ 55.0dB and are also subject to an increase in free-field noise level of 5dB or more.

5.13 At Station House, Kincardine the predicted daytime ambient noise levels, with the S-A-K line in operation were $L_{Aeq,18hr}$ 56.7 dB, on both the 27th and 28th January, respectively. Consequently these ambient noise levels are 5.7dB(A) and 6.4dB(A) above the measured background noise levels of $L_{Aeq,18hr}$ 51.0dB and $L_{Aeq,18hr}$ 50.3 dB on the 27th and 28th January, respectively. Therefore Station House falls within the criteria for rail noise mitigation, as defined within the ES.

5.14 At 75 Grange Road, Alloa the predicted daytime ambient noise levels, with the S-A-K line in operation were $L_{Aeq,18hr}$ 60.0 dB and $L_{Aeq,18hr}$ 60.8 dB, on the 27th and 28th January, respectively. Consequently these ambient noise levels are both 5.3dB(A) above the measured background noise levels of $L_{Aeq,18hr}$ 54.7dB and $L_{Aeq,18hr}$ 55.5 dB on the 27th and 28th January, respectively. Therefore 75 Grange Road falls within the criteria for rail noise mitigation, as defined within the ES.

5.15 The criterion for eligibility in terms of noise insulation is set out in section 3.4 of this report.

5.16 From Tables 3 and 4 it is evident that none of the existing properties qualify for sound insulation treatment in accordance with the adopted criteria.

5.17 Although, throughout the ES, it is stated that there is to be no timetabled night-time railway movements, i.e., between the hours of 24:00 and 06:00 hours, it is also stated in Volume 2, p.189. *"Additionally, the occurrence of $L_{Amax,fast}$ values above 60 dB at the facades of residential properties during night-time (23:00-07:00) is appropriate for assessing the impact of the railway movements specific to sleep disturbance"*[4]. However, no information in relation to the qualifying number of occurrences of this maximum level was provided within the ES. To assess the significance of impact for the night time period it is essential that the number of events which exceed the suggested trigger level of 60dB $L_{Amax,fast}$ is also included within the criteria. The level of 60dB $L_{Amax,fast}$ is derived from World Health Organisation (WHO) Guidelines for

[9] Stirling - Alloa - Kincardine Railway (Route Re-opening) and Linked Improvements (Scotland) Bill - Environmental Statement Volume 3 – Supporting Information, February 2003 p167.

Community Noise precautionary guideline value of 45dB $L_{Amax,fast}$ inside a bedroom with the windows open. In respect of this precautionary guideline value the WHO advise that indoor sound pressure levels in bedrooms should not exceed approximately 45 dB $L_{Amax,fast}$ more than 10–15 times per night. To avoid the situation whereby all 10-15 events occur within the same hour and being deemed acceptable because they do not occur throughout the night-time period, it is advisable to assume not more than 2 events in any one hour period throughout the night time duration to avoid sleep disturbance.

5.18 The basis of the assessment of potential night time noise disturbance referred to in the ES is the absolute maximum levels referred to within the World Health Organisation (WHO) document entitled Guidelines for Community Noise. However, it has been explained that the WHO guidelines can be interpreted as providing a conservative and precautionary approach to noise impact assessment. This is because they represent noise levels at which it is possible to start detecting effects and below which effects can be assumed to be negligible, and values exceeding the recommended noise levels are not necessarily indicative of significant adverse impacts. Furthermore, there is no evidence that anything other than a small minority of the population exposed to noise at the WHO guideline noise levels find them to be particularly onerous in the context of their daily lives.

5.19 The internal level of 45 dB $L_{Amax,fast}$ is based on an external level of 60dB $L_{Amax,fast}$ and a reduction of 15dB(A) for a partially open window. Whether the assessment should be made with the window open or closed is also an issue for consideration.

5.20 However, laudable this precautionary approach may be the appropriate night time maximum noise levels and the provision of mitigation has previously been addressed by the Scottish Parliament in respect of the following schemes: Edinburgh Tram Lines Glasgow Airport Rail Link (GARL) and Edinburgh Airport Rail Link (EARL). Both the Edinburgh Tram Line and EARL noise and vibration policies clearly state that the maximum level which should not be exceed more than twice in any one hour is in fact 82dB $L_{AMax,fast}$.

5.21 The justification for the use of 82dB $L_{Amax,fast}$ previously adopted by the Scottish Parliament in relation to maximum level of noise from train pass bys is based on the fact that sleep disturbance from noise is a complex subject and one over which there is some debate. The subject has been reviewed by various authorities. The most relevant review was carried out at the request of the UK government by a Committee led by Dr CGB Mitchell in 1990-1991. The Committee's remit was to provide the then Secretary of State for Transport with recommendations for national noise standards for noise insulation for new railways which equitably relate to the standard set by regulations for new highways. The Committee comprised 8 leading experts in transportation noise. Over the course of a year the Committee reviewed the scientific evidence on transportation noise from the UK and abroad, considering contributions from 52 local authorities and 30 consultants, operators and professional bodies, and produced its report 'Railway Noise and the Insulation of Dwellings', ("Mitchell Report"). The Mitchell Reports concludes that 'Noise from railways causes less disturbance to sleep than does noise from roads. The noise differential in favour of rail for equal sleep disturbance is at least 5dBA.

Studies have tentatively suggested to avoid sleep disturbance the façade noise level from railways should be no more than 60 dBA $L_{Aeq,T}$ and the maximum noise level should be no more than 85 dBA L_{Amax}, with the additional proviso that there should be no more than 20 'noise events' per night (Section 3.7 and 4.2)'.

5.22 The Department for Transport did not include an L_{Amax} limit in the 1996 Insulation Regulations, but the L_{Amax} limit recommended in the Mitchell Report to avoid sleep disturbance remains (i.e. 85dB at façade level, which is 82dB away from the façade in the free-field – at least 3.5m away from hard reflecting surfaces apart for the ground).

5.23 However, the criterion adopted by GARL was different in that it was 70dB L_{Amax} (Paisley to Airport). The lower level was adopted on the basis that the trains were moving at slow speed as a consequence of track alignment.

5.24 In view of the above it would appear appropriate to adopt a level of 82dB $L_{Amax,fast\ (free\ field)}$ not being exceeded more than twice in any one hour period during night-time hours as a threshold for consideration of mitigation measures. It should also be noted that in considering the appropriateness of mitigation measures cognisance must be taken of acceptable standards in terms of traffic, safety, environmental and economic issues.

5.25 Taking the measured $L_{Amax,slow}$ dB values of each individual train pass-by, measured at 1m from the façade at each location, and calculating the percentage of train pass-bys resulting in a noise level greater than $L_{Amax,slow}$ 60dB it can be seen in Table 5 that 100% of the measured train pass-bys exceed this value at all sample receptors, with the exception of Dumyat Road. Accordingly the associated $L_{Amax,fast}$ noise level of each train pass-by will also exceed the $L_{Amax,fast}$ 60dB criterion quoted within the ES at all measured properties except 2 Dumyat Road. It is important to note that the ES did not qualify the L_{Amax} criteria in terms of the number of occurrences that may occur in a given time period and even if an absolute level of 60dB $L_{Amax.fast}$ was considered an appropriate threshold it is also vital to take account of the number of occurrences when considering possible sleep disturbance (see section 2 5.17-5.24).

5.26 Taking in the calculated $L_{Amax,fast}$ values calculated from the data recorded shows that the 82dB $L_{Amax,fast}$ threshold is likely to be exceeded at the properties where then average values are shown as highlighted in grey in Table 5, i.e. at East Neuk Cottage and the Gables.

Table 5: Adjusted* Night-time $L_{Amax,}$ Noise Levels.

Train Passes	2 Dumyat Road	22 Park Place	23 Brucefield Crescent	24 Kingswell Park	101 Devonway	Hamewith
1	-	84.2 (F)	75.2 (F)	86.2 (F)	79.0 (F)	73.3 (F)
2	-	73.1 (F)	78.3 (F)	79.3 (F)	79.6 (F)	71.6 (F)
3	-	85.9 (F)	76.3 (F)	84.4 (F)	87.3 (F)	67.5 (F)
4	-	77.1 (F)	79.0 (F)	79.3 (F)	81.7 (F)	75.7 (F)
5	-	81.1 (F)	76.5 (F)	81.8 (F)	83.0 (F)	66.3 (F)
6	-	76.4 (F)	77.9 (F)	74.4 (F)	75.2 (F)	67.2 (F)
Average (Measured) $L_{Amax,slow}$ (dB)	-	**76.6**	**74.2**	**77.9**	**78.0**	**67.3**
Calculated $L_{Amax,fast}$ (dB)	-	**79.4**	**77.0**	**80.7**	**80.8**	**70.1**

*Measurements at Dumyat Road excluded as results influenced by constant road traffic noise, trains indistinguishable

Train Passes	75 Grange Road	138 Ladysneuk Rd	East Neuk Cottage	Kincardine	The Gables
1	79.3 (F)	84.6 (F)	89.5 (F)	74.1(F)	87.4 (F)
2	79.8 (F)	77.3 (F)	83.8 (F)	77.9 (F)	88.4 (F)
3	79.7 (P)	77.5 (P)	83.7 (P)	73.6 (F)	78.3 (F)
4	79.6 (F)	82.9 (F)	85.2 (F)	81.0 (F)	86.3 (F)
5	88.0 (F)	81.3 (F)	87.4 (F)	77.7 (F)	74.7 (P)
6	79.1 (F)	84.8 (F)	87.4 (F)	81.3 (F)	-
7	89.4 (F)	79.6 (F)	90.0 (F)	81.3 (F)	-
8	75.8 (P)	75.2 (F)	84.0 (F)	76.8 (F)	-
9	-	77.9 (P)	85.0 (P)	74.0 (F)	
Average (Measured) $L_{Amax,slow}$ (dB)	**78.3**	**77.4**	**83.4**	**75.0**	**80.0**
Calculated $L_{Amax,fast}$ (dB)	**81.1**	**80.2**	**86.2**	**77.8**	**82.8**

(F) – Freight Train (P) – Passenger Train

*The measured $L_{Amax,slow}$ (dB) noise levels quoted have had 3dB subtracted from the results to approximate free-field levels). The calculated $L_{Amax,fast}$ (dB) noise levels quoted are free-field levels)

5.27 In the ES forty-eight properties are identified as requiring possible mitigation in respect of daytime operations, with the S-A-K line operational. Of the 11 properties for which measurements have been undertaken, as stated within Section 5.12 – 5.14 of this report, only 2 properties have been identified as requiring possible mitigation in respect of daytime operations, with the S-A-K line operational. Details of the 48 properties stated in the ES as requiring possible mitigation are not given in the ES, so it is not possible to correlate the ES properties with the 2 properties identified in this report as meeting the mitigation criteria.

5.28 However, Tables 6.6-1 – 6.6-4, Volume 3 (Supporting Information) of the ES[10] present the predicted ($L_{Aeq,18hr}$ dB) façade noise levels, for operation of the railway with no mitigation. Four

[10] Stirling - Alloa - Kincardine Railway (Route Re-opening) and Linked Improvements (Scotland) Bill - Environmental Statement Volume 3 – Supporting Information, February 2003. pp172-174

of the representative properties within these tables were locations where on-site measurements were undertaken as part of the current noise assessment. For comparison purposes only, Table 6 presents the difference between the predicted daytime noise levels (Scott Wilson) and the measured daytime noise levels (Faber Maunsell) at existing properties.

Table 6: The Difference Between the Predicted Daytime Noise Levels (Scott Wilson) and the Measured Daytime Noise Levels (Faber Maunsell)

Location	Predicted Daytime $L_{Aeq,18hr}$ dB (façade) 06:00 – 24:00		Measured Ambient Daytime $L_{Aeq,18hr}$ dB (façade) 06:00 – 24:00		Difference between Predicted and Measured Ambient Noise levels (dB)	
	Floor Level		Floor Level		Floor Level	
	Ground	First	Ground	First	First	Ground
The Gables, near Cambus	68.6	68.5	58.1	-	10.5	-
75 Grange Road, Alloa	71.1	71.0	60.8	-	10.3	-
22 Park Place, Alloa	69.5	69.3	-	54.4	-	14.9
101 Devonway, Clackmannan	68.6	68.6	-	56.4	-	12.2

5.29 From Table 6 it can be seen that there is a large difference between the predicted daytime noise levels and measured daytime noise levels at the existing properties. The ES predicted that forty-eight of the existing properties may qualify for mitigation in the form of barriers, and four properties may qualify for insulation in terms of the criteria adopted within the ES.

5.30 From the initial results of the measured noise levels, with the S-A-K line in operation, it would appear that the predicted results of the ES erred on the side of caution in respect of the noise levels at existing properties and therefore an overestimation of the number of properties that may qualify for mitigation in relation to the re-opening of the S-A-K rail line is likely to have occurred.

6 Conclusions

6.1 Faber Maunsell was instructed by Clackmannanshire Council to undertake noise measurements to determine whether any of the eligible[1] existing residential properties along the length of the newly construction section of railway track between Causeywayhead, Stirling and Kincardine would qualify in terms of the provisions set out within the S-A-K Environmental Statement, 2003[2], in respect of noise insulation.

6.2 The criteria for assessment are two fold, i.e. in respect of mitigation and insulation. The criterion for mitigation is described in Sections 3.2 – 3.3 and the criteria for insulation in Section 3.4.

6.3 Attended on-site train noise level measurements were undertaken between Monday 26th January and Thursday 29th January 2009 at eleven selected existing residential properties along the route. At each location the microphone was positioned outside the window of interest, ground floor living room areas/bedroom area windows and first floor bedroom windows, where practicable.

6.4 From the measured results presented within Table 3 it can clearly be seen that the only properties that fall within the ES criterion for possible rail noise mitigation are Station House, Kincardine and 75 Grange Road, Alloa. At both of these existing residences the predicted free-field ambient noise levels, at a distance of 1m from the façade of the properties are greater than $L_{Aeq,18hr}$ 55.0dB and are also subject to an increase in free-field noise level of 5dB or more.

6.5 From Tables 3 and 4 it is evident that none of the existing properties qualify for sound insulation treatment in accordance with the adopted criteria[5].

6.6 From Table 6 it can be seen that there is a large difference between the predicted daytime noise levels in the ES and actual measured daytime noise levels at the existing properties. The ES predicted that forty-eight of the existing properties may qualify for mitigation in the form of barriers, and that four properties may qualify for insulation the criteria set out within the ES.

6.7 From the results of the measured noise levels, with the S-A-K line in operation, it would appear that the predicted results of the ES erred on the side of caution in respect of the noise levels at existing properties and therefore an overestimation of the number of properties that may qualify for mitigation and/or insulation in relation to the re-opening of the S-A-K rail line is likely to have occurred.

6.8 The appropriate criteria for the assessment of night-time noise is considered in Section 5. The measured night-time noise levels in terms of $L_{Amax,slow}$ dB of each individual train pass-by, was measured at 1m from the façade at each location. The percentage of train pass-bys resulting in a noise level greater than $L_{Amax,slow}$ 60dB was then calculated and it can be seen in Table 5 that 100% of the measured train pass-bys exceed this value at all sample receptors, with the exception of Dumyat Road. Accordingly the associated $L_{Amax,fast}$ noise level of each train pass-

by will also exceed the $L_{Amax,fast}$ 60dB criterion quoted within the ES at all properties except 2 Dumyat. It is important to note that the ES did not qualify the L_{Amax} criteria in terms of the number of occurrences. It is vital to take account of the number of occurrences when considering possible sleep disturbance.

6.9 If the assessment of night-time noise and the provision of mitigation is considered on the same basis as has previously been addressed by the Scottish Parliament in respect the: Edinburgh Tram Lines Glasgow Airport Rail Link (GARL) and Edinburgh Airport Rail Link (EARL) i.e. both that the maximum level which should not be exceeded more than twice in any one hour is in fact 82dB $L_{AMax,fast}$. On this basis the threshold value is likely to be exceeded at East Neuk Cottage and The Gables and at present we are advised that there is no evidence to suggest that the number of occurrences are being exceeded.

Appendix 1 – Glossary of Acoustical Terminology

Ambient Noise	Totally encompassing sound in a given situation at a given time usually composed of sound from many source near and far.
"A" Weighting (dB(A))	The human ear does not respond uniformly to different frequencies. "A" weighting is commonly used to simulate the frequency response of the ear. It is used in the assessment of risk of damage of hearing due to noise.
Decibel (dB)	The range of audible sound pressures is approximately 2×10^{-5} Pa to 200 Pa. Using decibel notation presents this range in a more manageable form, 0dB to 140 dB. Mathematically: Sound Pressure Level (dB) = $20 \log \{p(t)/ P_o\}$ Where $P_o = 2 \times 10^{-5}$ Pa
Frequency (Hz)	The number of cycles per second, for sound this is subjectively perceived as pitch.
Frequency Spectrum	Analysis of the relative contributions of different frequencies that make up a noise.
$L_{A10,T}$	The A-weighted sound pressure level of the residual noise in decibels exceeded for 10% of a given time interval. This is the parameter defined by the government to describe road traffic noise.
$L_{Aeq,T}$	Equivalent Continuous A-weighted Sound Pressure Level. The value of the A-weighted sound pressure level in decibels of continuous steady sound that within a specified time interval, T, has the same mean-square sound pressure as a sound that varies with time. It is quoted to the nearest whole number of decibels.
Noise	Unwanted sound.
Sound Exposure Level	(SEL) This is the noise level at a reception point which, if maintained for 1 second, would cause the same A-weighted sound energy to be received as is actually received from a given noise event.
$L_{Amax,fast}$	The maximum RMS A-weighted sound pressure level occurring within a specified time period. Fast time weighting indicates sound pressure level measurements undertaken using a 125-millisecond moving average time weighting period.
$L_{Amax,slow}$	The maximum RMS A-weighted sound pressure level occurring within a specified time period. Slow time weighting indicates sound pressure level measurements undertaken using a 1.0 second moving average time weighting period.

Appendix 2 – Instrumentation Used

Brüel & Kjær Hand Held Analyser Type 2250
Serial Number 2507254

Brüel & Kjær Microphone Type 4189
Serial Number 2542984

Brüel & Kjær Sound Analysis Software BZ 5503

Brüel & Kjær Sound Level Calibrator Type 4231
Serial Number 2545421

Rion NL-31 Class 1 Sound Level Meter

Sound Level Meter: Serial No:	00583286
Microphone Model UC-53A:	314293
Pre-Amp NH-21:	27516
Sound Level Meter: Serial No:	01062702
Microphone Model UC-53A:	310415
Pre Amp NH-21:	20340
Sound Level Meter: Serial No:	00583274
Microphone Nodel UC-53A:	207770
Pre Amp NH-21:	13603
Sound Level Meter: Serial No:	00583265
Microphone Model UC-53A:	312260
Pre-Amp NH-21:	27495
Sound Level Meter: Serial No:	00952329
Microphone Model UC-53A:	309170
Pre-Amp NH-21:	17185
Sound Level Meter: Serial No:	01141948
Microphone Model UC-53A:	307736
Pre-Amp NH-21:	13593
Sound Level Meter: Serial No:	00583267
Microphone Model UC-53A:	312273
Pre-Amp NH-21:	279497
Sound Level Meter: Serial No:	00952275
Microphone Model UC-53A:	309103
Pre-Amp NH-21:	17127
Sound Level Meter: Serial No:	00583273
Microphone Model UC-53A:	312281
Pre-Amp NL-21:	27503

Rion NL-32 Class 1 Sound Level Meter

Sound Level Meter: Serial No:	00482654
Microphone Model UC-53A:	314029
Pre-Amp NH-21:	27758
Sound Level Meter: Serial No:	00240642
Microphone Model UC-53A:	305546
Pre-Amp NH-21:	10683
Sound Level Meter: Serial No:	00751323
Microphone Model UC-53A:	308645
Pre-Amp NH-21:	23663

Rion NC-74 Class 1 Acoustic Calibrator

NC-74 Calibrator:	34251552

Appendix 3 – Detailed Site Notes

Location 1: 2 Dumyat Road, Causewayhead

Measurement position 1 was located 1m from the north eastern facing façade, within the rear garden area of the property. This position in turn was approximately 50m west of the rail link as shown in Figure 1.2. The Rion NL-31 sound level meter was secured within a weatherproof box with the microphone positioned 1.5m above the ground. The monitoring equipment was calibrated both before and after the measurement period using an acoustic calibrator, which has itself been calibrated against a reference set traceable to National and International Standards. There was no shift in the observed calibration level. This sound level meter was secured at the property and left continuously logging throughout the measurement period.

The dominant noise of this location, at the time of measurement, was continuous road traffic noise associated with the A9. Also present was noise associated with local construction projects and occasional birdsong, throughout the measurement procedure.

Measurement position 2 was located 1m from the south western facing façade, at the front of the property. This measurement position was also approximately 50m west of the rail link, as shown in Figure 1.2. The Brüel & Kjær 2250 sound level meter was secured to a tripod with the microphone 1.5m above the ground. The monitoring equipment was calibrated both before and after the measurement period using an acoustic calibrator, which has itself been calibrated against a reference set traceable to National and International Standards. There was no shift in the observed calibration level. Fifteen minute snapshot noise level measurements were undertaken with the B&K 2250 at 2 Dumyat Road, throughout the measurement procedure.

Measured Results: 2 Dumyat Road, Causewayhead

Period	Date	Start Time (hh:mm)	Duration (hh:mm)	Noise Level (dB)			Weather		Comments
				$L_{Aeq,T}$	L_{A10}	L_{A90}	Wind Speed (m/s) & Direction	Conditions	
Rion NL-31 Sound Level Meter									
Weekday 18hr (position 1)	27/01/09	06:00	18:00	**51.9**	-	-	Calm	Dry, Overcast, 7℃	Nearby construction noise, road traffic noise, occasional birdsong
Weekday 18hr (position 1)	28/01/09	06:00	18:00	-	-	-	Calm	Dry, bright, 6℃	Street sweeper intermittently passing site throughout the day
Brüel & Kjær 2250 Sound Level Meter									
Weekday DAY (position 1)	27/01/08	09:51	00:15	**52.9**	**55.9**	**45.9**	Calm	Dry, Overcast, 7℃	09:54 – EWS loaded 23 carriage freight (eastbound)
Weekday EVE (position 2)	28/01/09	20:42	00:15	**54.1**	**57.9**	**44.6**	Calm	Dry, clear skies, 2℃	20:48 – 3 carriage passenger train (eastbound) 20:51 – EWS loaded 22 carriage freight (eastbound)

* - Not measured

Further Breakdown of Rion Measurements

Period	Date	Train Noise		Background Noise	Number of Trains	
		Passenger	Freight		Passenger	Freight
Weekday 18hr	**27/01/09**	**36.6**	**38.1**	**51.6**	**36**	**13**
Weekday 18hr	**28/01/09**	**-**	**-**	**-**	**-**	**-**

* Some data missing – battery stopped

Figure 1.1: Rion NL-31 Sound Level Meter and B&K 2250 Sound Level Meter at Measurement Position 1, 2 Dumyat Road, Causewayhead.

Figure 1.2: Site Location and Approximate Measurement Positions, 2 Dumyat Road, Causewayhead

Location 2: 138 Ladysneuk Road, Causewayhead

Measurement position 1 was located 1m from the eastern facing façade, within the rear garden area of the property. This position in turn was approximately 20m north of the rail link as shown in Figure 2.2. The Rion NL-31 sound level meter was secured within a weatherproof box with the microphone positioned 4.5m above the ground at first floor window height, see Figure 2.1. The monitoring equipment was calibrated both before and after the measurement period using an acoustic calibrator, which has itself been calibrated against a reference set traceable to National and International Standards. There was no shift in the observed calibration level. This sound level meter was secured at the property and left continuously logging throughout the measurement period.

The dominant noise of this location, at the time of measurement, was distant road traffic noise associated with the A907. Also present was occasional birdsong.

Measurement position 2 was located 1m from the southern facing façade of the conservatory. The Brüel & Kjær 2250 sound level meter was secured to a tripod with the microphone 1.5m above the ground. The monitoring equipment was calibrated both before and after the measurement period using an acoustic calibrator, which has itself been calibrated against a reference set traceable to National and International Standards. There was no shift in the observed calibration level. Fifteen minute snapshot noise level measurements were undertaken with the B&K 2250 at 138 Ladysneuk Road, throughout the measurement procedure.

Measured Results: 138 Ladysneuk Road, Causewayhead

Period	Date	Start Time (hh:mm)	Duration (hh:mm)	Noise Level (dB)			Weather		Comments
				$L_{Aeq,T}$	L_{A10}	L_{A90}	Wind Speed (m/s) & Direction	Conditions	
Rion NL-31 Sound Level Meter									
Weekday 18hr (position 1)	27/01/09	06:00	18:00	**58.8**	-	-	Calm	Dry, Overcast, 7℃	Distant road traffic, occasional noise emissions from Remploy premises to east at 5pm
Weekday 18hr (position 1)	28/01/09	06:00	18:00	**59.2**	-	-	Calm	Dry, bright, 6℃	Distant road traffic, occasional noise emissions from Remploy premises to east at 5pm, birsdong
Brüel & Kjær 2250 Sound Level Meter									
Weekday DAY (position 2)	27/01/09	10:18	00:15	**50.7**	**52.2**	**47.0**	N ^2.0m/s ave. 1.5m/s	Dry, overcast, 7℃	Dominant Noise: distant road traffic A907, also present birdsong
Weekday EVE (position 2)	28/01/09	20:16	00:15	**48.4**	**50.7**	**44.7**	Calm	Dry, clear skies 2℃	Distant road traffic noise A907

* - Not measured

Further Breakdown of Rion Measurements

Period	Date	Train Noise		Background Noise	Number of Trains	
		Passenger	Freight		Passenger	Freight
Weekday 18hr	**27/01/09**	**51.8**	**54.6**	**55.1**	**36**	**13**
Weekday 18hr	**28/01/09**	**52.3**	**55.0**	**55.5**	**37**	**18**

Figure 2.1: Rion NL-31 Sound Level Meter at Measurement Position 1, 138 Ladysneuk Road, Causewayhead.

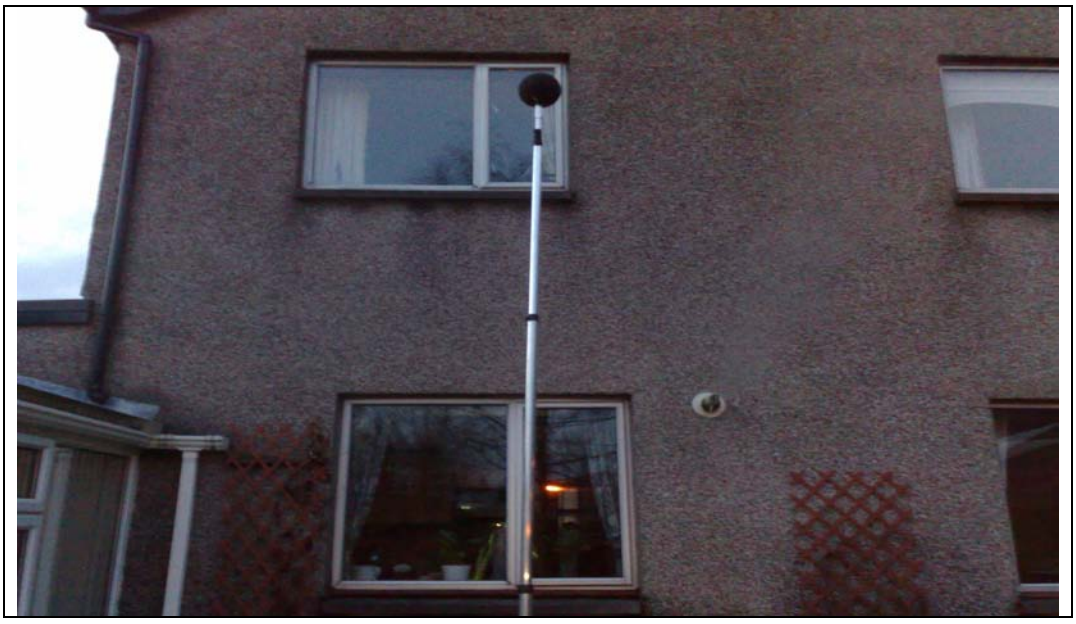


Figure 2.2: Site Location and Approximate Measurement Positions, 138 Ladysneuk Road, Causewayhead

Location 3: East Neuk, Ladysneuk Road, Causewayhead

The measurement position was located 1m from the northern facing façade, within the rear garden area of the property. This position in turn was approximately 7m south of the nearside edge of the rail link as shown in Figure 3.2. The Rion NL-32 sound level meter was secured within a weatherproof box with the microphone positioned 1.5m above the ground at ground floor window height, see Figure 3.1. The monitoring equipment was calibrated both before and after the measurement period using an acoustic calibrator, which has itself been calibrated against a reference set traceable to National and International Standards. There was no shift in the observed calibration level. This sound level meter was secured at the property and left continuously logging, with an audio recording event trigger set, throughout the measurement period.

The dominant noise of this location, at the time of measurement, was continuous road traffic noise associated with the A907. Also present was occasional birdsong and intermittent dog barking.

The Brüel & Kjær 2250 sound level meter was secured to a tripod with the microphone 1.5m above the ground, adjacent to the Rion NL-32 sound level meter. The monitoring equipment was calibrated both before and after the measurement period using an acoustic calibrator, which has itself been calibrated against a reference set traceable to National and International Standards. There was no shift in the observed calibration level. Fifteen minute snapshot noise level measurements were undertaken with the B&K 2250 at East Neuk, Ladysneuk Road, throughout the measurement procedure.

Measured Results: East Neuk, Ladysneuk Road, Causewayhead

Period	Date	Start Time (hh:mm)	Duration (hh:mm)	Noise Level (dB)			Weather		Comments
				$L_{Aeq,T}$	L_{A10}	L_{A90}	Wind Speed (m/s) & Direction	Conditions	
Rion NL-32 Sound Level Meter									
Weekday 18hr (position 1)	27/01/09	06:00	18:00	**65.3**	-	-	Calm	Dry, Overcast, 7℃	Constant road traffic noise from A907
Weekday 18hr (position 1)	28/01/09	06:00	18:00	**65.5**	-	-	Calm	Dry, bright, 6℃	Constant road traffic noise from A907
Brüel & Kjær 2250 Sound Level Meter									
Weekday DAY (position 2)	27/01/09	10:40	00:15	**62.0**	**65.5**	**53.5**	Calm	Dry, overcast, 7℃	Dominant Noise: continuous road traffic A907, also present birdsong, occasional dog barking
Weekday EVE (position 2)	28/01/09	19:46	00:15	**63.7**	**66.8**	**51.5**	Calm	Dry, clear skies 2℃	Continuous road traffic noise, A907

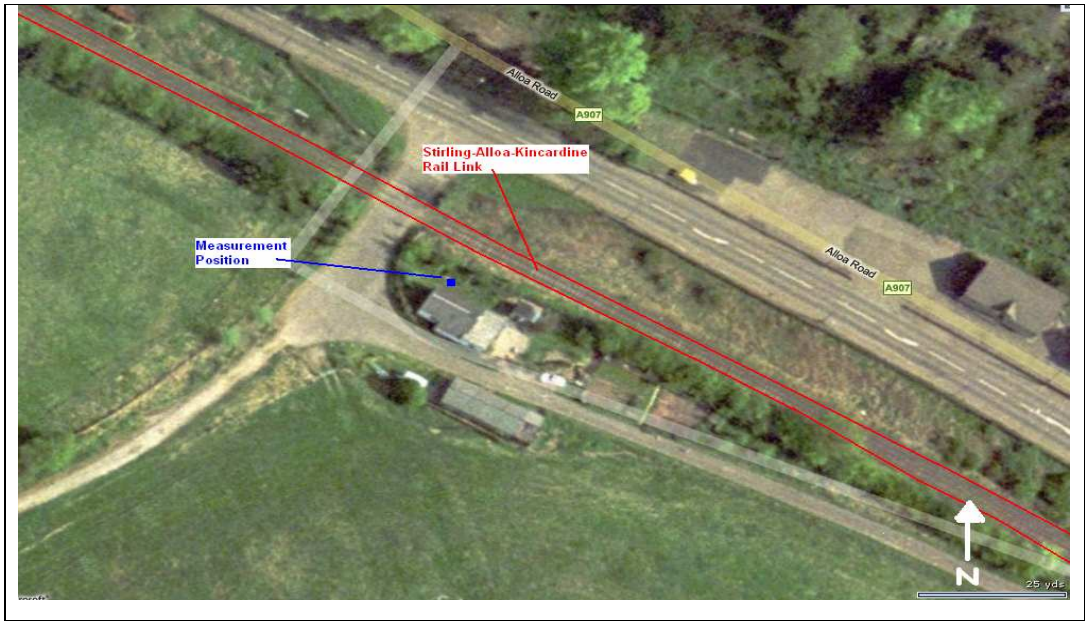
* - Not measured

Further Breakdown of Rion Measurements

Period	Date	Train Noise		Background Noise	Number of Trains	
		Passenger	Freight		Passenger	Freight
Weekday 18hr	**27/01/09**	**57.4**	**59.0**	**63.1**	**36**	**13**
Weekday 18hr	**28/01/09**	**58.0**	**59.7**	**63.2**	**37**	**18**

Figure 3.1: Rion NL-32 Sound Level Meter at Measurement Position, East Neuk, Ladysneuk Road, Causewayhead.

Figure 3.2: Site Location and Approximate Measurement Positions, East Neuk, Ladysneuk Road, Causewayhead



Location 4: 75 Grange Road, Alloa

The measurement position was located 1m from the northern facing façade, within the rear garden area of the property. This position in turn was approximately 7.5m south of the nearside edge of the rail link as shown in Figure 4.2. The Rion NL-31 sound level meter was secured within a weatherproof box with the microphone positioned 1.5m above the ground at ground floor window height, see Figure 4.1. The monitoring equipment was calibrated both before and after the measurement period using an acoustic calibrator, which has itself been calibrated against a reference set traceable to National and International Standards. There was no shift in the observed calibration level. This sound level meter was secured at the property and left continuously logging, throughout the measurement period.

The dominant noise of this location, at the time of measurement, was road traffic noise associated with the A907 to the north of the rail link. Also present was occasional birdsong and intermittent construction noise from the north.

The Brüel & Kjær 2250 sound level meter was secured to a tripod with the microphone 1.5m above the ground, adjacent to the Rion NL-31 sound level meter, see Figure 4.1. The monitoring equipment was calibrated both before and after the measurement period using an acoustic calibrator, which has itself been calibrated against a reference set traceable to National and International Standards. There was no shift in the observed calibration level. Fifteen minute snapshot noise level measurements were undertaken with the B&K 2250 at 75 Grange Road, throughout the measurement procedure.

Measured Results: 75 Grange Road, Alloa

Period	Date	Start Time (hh:mm)	Duration (hh:mm)	Noise Level (dB)			Weather		Comments
				$L_{Aeq,T}$	L_{A10}	L_{A90}	Wind Speed (m/s) & Direction	Conditions	
Rion NL-31 Sound Level Meter									
Weekday 18hr (position 1)	27/01/09	06:00	18:00	**60.1**	-	-	Calm	Dry, Overcast, 7℃	Distant road traffic noise, occasional pedestrians using footbridge, birdsong
Weekday 18hr (position 1)	28/01/09	06:00	18:00	**60.8**	-	-	Calm	Dry, bright, 6℃	Distant road traffic noise, occasional pedestrians using footbridge, birdsong
Brüel & Kjær 2250 Sound Level Meter									
Weekday DAY (position 2)	27/01/09	11:40	00:15	**63.0**	**57.6**	**50.0**	Calm	Dry, overcast, 7℃	11:48: EWS 22 carriage unloaded freight (westbound)
Weekday EVE (position 2)	28/01/09	18:43	00:15	**62.3**	**57.7**	**49.2**	Calm	Dry, clear skies 4℃	18:43: EWS 23 carriage loaded freight (eastbound)

* - Not measured

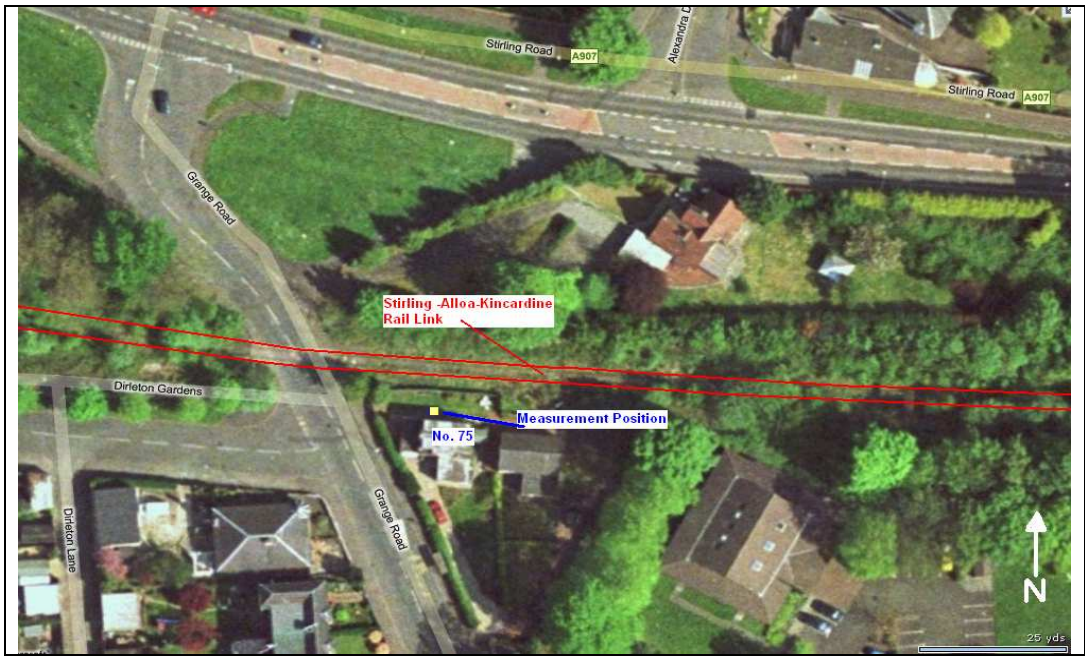
Further Breakdown of Rion Measurements

Period	Date	Train Noise		Background Noise	Number of Trains	
		Passenger	Freight		Passenger	Freight
Weekday 18hr	**27/01/09**	**55.9**	**55.3**	**54.7**	**36**	**13**
Weekday 18hr	**28/01/09**	**56.5**	**57.3**	**55.5**	**37**	**19**

* Some data missing – battery stopped

Figure 4.1: Rion NL-31 Sound Level Meter and B&K 2250 Sound Level Meter at Measurement Position, 75 Grange Road, Alloa.

Figure 4.2: Site Location and Approximate Measurement Positions, 75 Grange Road, Alloa



Location 5: 24 Kingswell Park

The measurement position was located 1m from the eastern facing façade, within the rear garden area of the property. This position in turn was approximately 13m north of the nearside edge of the rail link as shown in Figure 5.2. The Rion NL-31 sound level meter was secured within a weatherproof box with the microphone positioned 1.5m above the ground at ground floor window height, see Figure 5.1. The monitoring equipment was calibrated both before and after the measurement period using an acoustic calibrator, which has itself been calibrated against a reference set traceable to National and International Standards. There was no shift in the observed calibration level. This sound level meter was secured at the property and left continuously logging, throughout the measurement period.

The dominant noise of this location, at the time of measurement, was road traffic noise associated with the A908 to the south east of the rail link. Also present was intermittent noise events emanating from Alloa Railway Station located the south west of the property, and occasional birdsong.

The Brüel & Kjær 2250 sound level meter was secured to a tripod with the microphone 1.5m above the ground, adjacent to the Rion NL-31 sound level meter, see Figure 5.1. The monitoring equipment was calibrated both before and after the measurement period using an acoustic calibrator, which has itself been calibrated against a reference set traceable to National and International Standards. There was no shift in the observed calibration level. Fifteen minute snapshot noise level measurements were undertaken with the B&K 2250 at 24 Kingswell Park, throughout the measurement procedure.

Measured Results: 24 Kingswell Park, Alloa

Period	Date	Start Time (hh:mm)	Duration (hh:mm)	Noise Level (dB)			Weather		Comments
				$L_{Aeq,T}$	L_{A10}	L_{A90}	Wind Speed (m/s) & Direction	Conditions	
Rion NL-31 Sound Level Meter									
Weekday 18hr (position 1)	27/01/09	06:00	18:00	**54.8**	-	-	Calm	Dry, Overcast, 7℃	Dominant Noise: road traffic A907, also present intermittent noise events from Alloa Station, birdsong
Weekday 18hr (position 1)	28/01/09	06:00	18:00	**55.5**	-	-	Calm	Dry, bright, 6℃	Dominant Noise: road traffic A907, also present intermittent noise events from Alloa Station, birdsong
Brüel & Kjær 2250 Sound Level Meter									
Weekday DAY (position 2)	27/01/09	12:11	00:15	**52.2**	**53.9**	**47.8**	Calm	Dry, overcast, 7℃	12:15 - Water running off drainpipe, 12:16 – passenger train with engine running at Alloa Station to west
Weekday EVE (position 2)	28/01/09	17:45	00:15	**53.7**	**53.9**	**48.9**	Calm	Dry, clear skies, 4℃	17:50 – distant police siren

* - Not measured

Further Breakdown of Rion Measurements

Period	Date	Train Noise		Background Noise	Number of Trains	
		Passenger	Freight		Passenger	Freight
Weekday 18hr	**27/01/09**	**-**	**50.9**	**52.6**	**-**	**13**
Weekday 18hr	**28/01/09**	**-**	**53.1**	**51.8**	**-**	**19**

* Some data missing – battery stopped

Figure 5.1: Rion NL-31 Sound Level Meter and B&K Sound Level Meter at Measurement Position, 24 Kingswell Park, Alloa.

Figure 5.2: Site Location and Approximate Measurement Position, 24 Kingwell Park, Alloa

Location 6: 22 Park Place, Alloa

The measurement position was located 1m from the eastern facing façade, within the rear garden area of the property. This position in turn was approximately 6m south of the nearside edge of the rail link as shown in Figure 6.2. The Rion NL-32 sound level meter was secured within a weatherproof box with the microphone positioned 4.5m above the ground at first floor window height, see Figure 6.1. The monitoring equipment was calibrated both before and after the measurement period using an acoustic calibrator, which has itself been calibrated against a reference set traceable to National and International Standards. There was no shift in the observed calibration level. This sound level meter was secured at the property and left continuously logging, with an audio recording event trigger set, throughout the measurement period.

The dominant noise of this location, at the time of measurement, was distant road traffic noise associated with the A907 to the south of the property. Also present was occasional birdsong.

The Brüel & Kjær 2250 sound level meter was secured to a tripod with the microphone 1.5m above the ground, adjacent to the Rion NL-32 sound level meter, see Figure 6.1. The monitoring equipment was calibrated both before and after the measurement period using an acoustic calibrator, which has itself been calibrated against a reference set traceable to National and International Standards. There was no shift in the observed calibration level. Fifteen minute snapshot noise level measurements were undertaken with the B&K 2250 at 22 Park Place, throughout the measurement procedure.

Measured Results: 22 Park Place, Alloa

Period	Date	Start Time (hh:mm)	Duration (hh:mm)	Noise Level (dB)			Weather		Comments
				$L_{Aeq,T}$	L_{A10}	L_{A90}	Wind Speed (m/s) & Direction	Conditions	
Rion NL-32 Sound Level Meter									
Weekday 18hr (position 1)	27/01/09	06:00	18:00	**53.7**	-	-	Calm	Dry, Overcast, 7℃	Distant road traffic noise, occasional birdsong, light rain in afternoon (approx 2 hours) but not considered heavy enough to affect measurement
Weekday 18hr (position 1)	28/01/09	06:00	18:00	**54.4**	-	-	Calm	Dry, bright, 6℃	Distant road traffic, occasional birdsong
Brüel & Kjær 2250 Sound Level Meter									
Weekday DAY (position 2)	27/01/09	12:38	00:15	**47.2**	**48.7**	**44.5**	Calm	Overcast, light drizzle 7℃	No train passes
Weekday EVE (position 2)	28/01/09	18:13	00:15	**55.0**	**55.5**	**45.4**	Calm	Dry, clear skies, 4℃	18:18 – EWS 23 carriage freight westbound unloaded (stopped in from of property for approx 1 min)

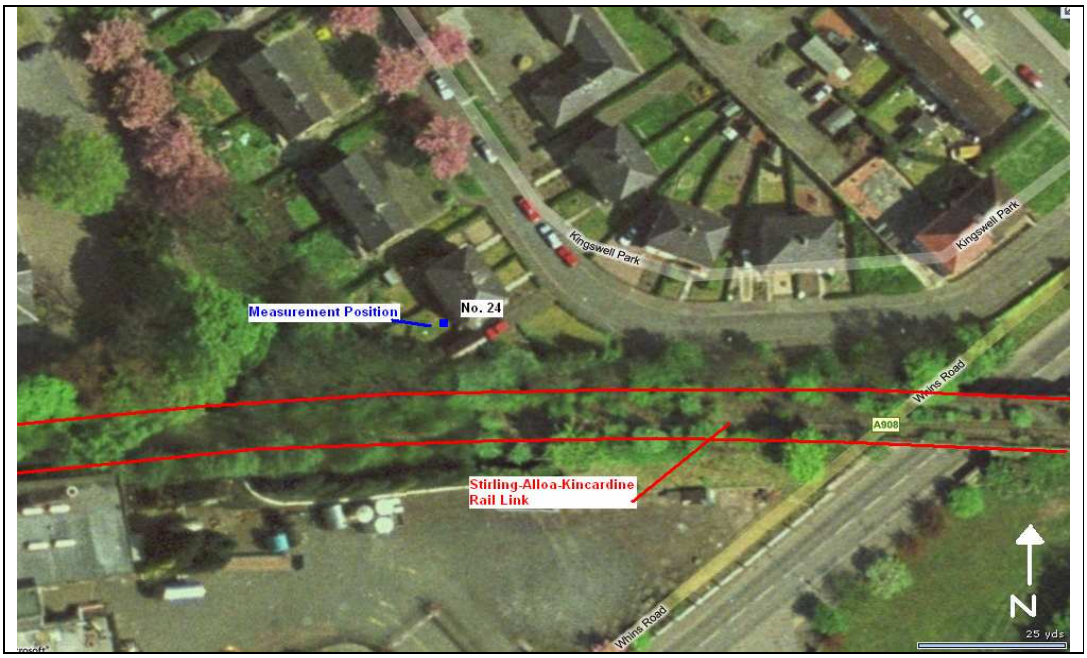
* - Not measured

Further Breakdown of Rion Measurements

Period	Date	Train Noise		Background Noise	Number of Trains	
		Passenger	Freight		Passenger	Freight
Weekday 18hr	**27/01/09**	**-**	**51.3**	**48.7**	**-**	**13**
Weekday 18hr	**28/01/09**	**-**	**52.4**	**50.1**	**-**	**19**

Figure 6.1: Rion NL-32 Sound Level Meter at Measurement Position, 22 Park Place, Alloa.

Figure 6.2: Site Location and Approximate Measurement Position, 22 Park Place, Alloa



Location 7:101 Devonway, Clackmannan

The measurement position was located 1m from the south eastern facing façade, within the rear garden area of the property. This position in turn was approximately 12m southwest of the nearside edge of the rail link as shown in Figure 7.2. The Rion NL-31 sound level meter was secured within a weatherproof box with the microphone positioned 4.5m above the ground at first floor window height, see Figure 7.1. The monitoring equipment was calibrated both before and after the measurement period using an acoustic calibrator, which has itself been calibrated against a reference set traceable to National and International Standards. There was no shift in the observed calibration level. This sound level meter was secured at the property and left continuously logging, throughout the measurement period.

The dominant noise of this location, at the time of measurement, was distant road traffic noise associated with the A907 to the north of the property. Also present was occasional birdsong.

The Brüel & Kjær 2250 sound level meter was secured to a tripod with the microphone 1.5m above the ground, 1m from the south eastern façade of the conservatory, see Figure 7.1. The monitoring equipment was calibrated both before and after the measurement period using an acoustic calibrator, which has itself been calibrated against a reference set traceable to National and International Standards. There was no shift in the observed calibration level. Fifteen minute snapshot noise level measurements were undertaken with the B&K 2250 at 101 Devonway, throughout the measurement procedure.

Measured Results: 101 Devonway, Clackmannan

Period	Date	Start Time (hh:mm)	Duration (hh:mm)	Noise Level (dB)			Weather		Comments
				$L_{Aeq,T}$	L_{A10}	L_{A90}	Wind Speed (m/s) & Direction	Conditions	
Rion NL-31 Sound Level Meter									
Weekday 18hr (position 1)	27/01/09	06:00	18:00	**55.9**	-	-	Calm	Dry, Overcast, 7℃	Distant road traffic noise, occasional birdsong
Weekday 18hr (position 1)	28/01/09	06:00	18:00	**56.4**	-	-	Calm	Dry, bright, 6℃	Distant road traffic noise, occasional birdsong, intermittent lawnmower in afternoon
Brüel & Kjær 2250 Sound Level Meter									
Weekday DAY (position 2)	27/01/09	13:08	00:15	**48.3**	**50.0**	**44.6**	Calm	Overcast, light drizzle 7℃	No train pass-bys
Weekday EVE (position 2)	28/01/09	12:46	00:15	**41.7**	**42.2**	**37.2**	Calm	Dry, clear skies, 4℃	No train pass-bys
	26//01/09	10:52	00:15	**61.2**	**60.6**	**39.1**	Calm	Dry, clear skies, 3℃	10:53 – EWS freight– south 23 carriage unloaded 11:01 – EWS freight north 23 carriage loaded

* - Not measured

Further Breakdown of Rion Measurements

Period	Date	Train Noise		Background Noise	Number of Trains	
		Passenger	Freight		Passenger	Freight
Weekday 18hr	**27/01/09**	**-**	**53.3**	**52.5**	**-**	**13**
Weekday 18hr	**28/01/09**	**-**	**53.5**	**53.4**	**-**	**19**

Figure 7.1: Rion NL-31 Sound Level Meter and B&K 2250 Sound Level Meter at Measurement Position, 101 Devonway, Clackmannan

Figure 7.2: Site Location and Approximate Measurement Position, 101 Devonway, Clackmannan

Location 8: Hamewith, Mill Road, Clackmannan

The measurement position was located 1m from the south western facing façade, within the rear garden area of the property. This position in turn was approximately 10m northeast of the nearside edge of the rail link as shown in Figure 8.2. The Rion NL-31 sound level meter was secured within a weatherproof box with the microphone positioned 1.5m above the ground at ground floor window height, see Figure 8.1. The monitoring equipment was calibrated both before and after the measurement period using an acoustic calibrator, which has itself been calibrated against a reference set traceable to National and International Standards. There was no shift in the observed calibration level. This sound level meter was secured at the property and left continuously logging, throughout the measurement period.

The dominant noise of this location, at the time of measurement, was distant road traffic noise associated with the B910 to the south of the property. Also present was occasional birdsong.

The Brüel & Kjær 2250 sound level meter was secured to a tripod with the microphone 1.5m above the ground, 1m from the south western façade of the property, see Figure 8.1. The monitoring equipment was calibrated both before and after the measurement period using an acoustic calibrator, which has itself been calibrated against a reference set traceable to National and International Standards. There was no shift in the observed calibration level. Fifteen minute snapshot noise level measurements were undertaken with the B&K 2250 at Hamewith, throughout the measurement procedure.

Measured Results: Hamewith, Mill Road, Clackmannan

Period	Date	Start Time (hh:mm)	Duration (hh:mm)	Noise Level (dB)			Weather		Comments
				$L_{Aeq,T}$	L_{A10}	L_{A90}	Wind Speed (m/s) & Direction	Conditions	
Rion NL-31 Sound Level Meter									
Weekday 18hr (position 1)	27/01/09	06:00	18:00	**49.6**	-	-	Calm	Dry, Overcast, 7℃	Distant road traffic , birdsong, light rain (not considered heavy enough to affect measurements)
Weekday 18hr (position 1)	28/01/09	06:00	18:00	**49.9**	-	-	Calm	Dry, bright, 6℃	Distant road traffic, birdsong
Brüel & Kjær 2250 Sound Level Meter									
Weekday DAY (position 2)	27/01/09	13:45	00:15	**52.1**	**50.9**	**40.0**	Calm	Overcast, light drizzle 7℃	13:45: EWS 23 carriage freight unloaded (westbound)
Weekday DAY (position 2)	28/01/09	13:16	00:15	**49.7**	**48.6**	**40.7**	Calm	Dry, clear skies, 4℃	13:21 EWS 25 carriage loaded freight (loaded)

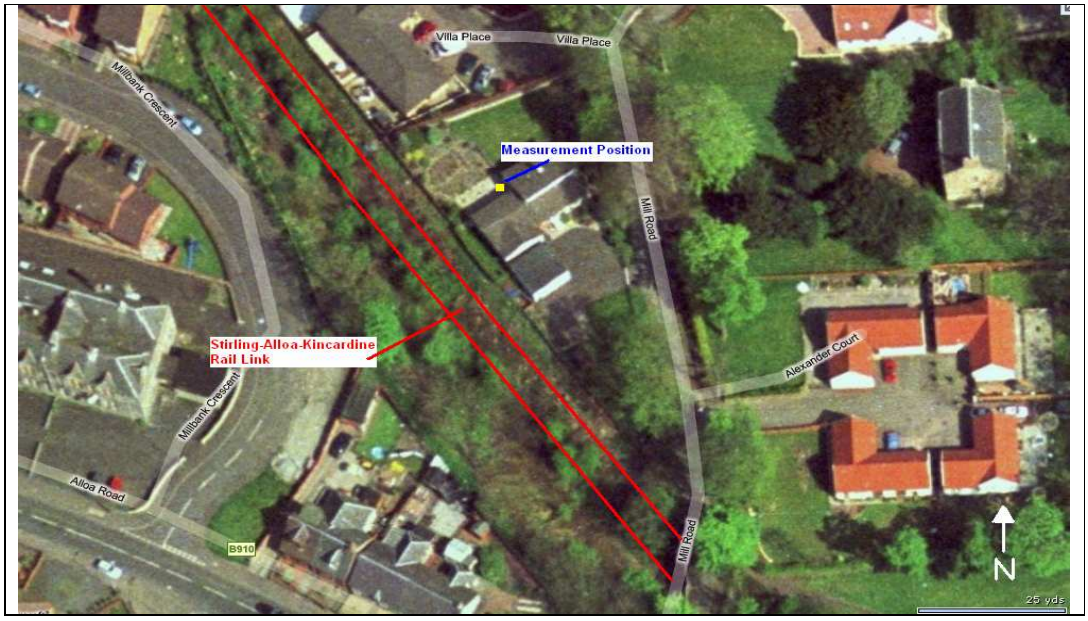
* - Not measured

Further Breakdown of Rion Measurements

Period	Date	Train Noise		Background Noise	Number of Trains	
		Passenger	Freight		Passenger	Freight
Weekday 18hr	**27/01/09**	**-**	**44.2**	**48.1**	**-**	**13**
Weekday 18hr	**28/01/09**	**-**	**45.1**	**48.2**	**-**	**19**

Figure 8.1: Rion NL-31 Sound Level Meter and B&K 2250 Sound Level Meter at Measurement Position, Hamewith, Mill Road, Clackmannan

Figure 8.2: Site Location and Approximate Measurement Position, Hamewith, Mill Road, Clackmannan



Location 9: 23 Brucefield Crescent, Clackmannan

The measurement position was located 1m from the north eastern facing façade, within the rear garden area of the property. This position in turn was approximately 8m southwest of the nearside edge of the rail link as shown in Figure 9.2. The Rion NL-31 sound level meter was secured within a weatherproof box with the microphone positioned 4.5m above the ground at first floor window height, see Figure 9.1. The monitoring equipment was calibrated both before and after the measurement period using an acoustic calibrator, which has itself been calibrated against a reference set traceable to National and International Standards. There was no shift in the observed calibration level. This sound level meter was secured at the property and left continuously logging, throughout the measurement period.

The dominant noise of this location, at the time of measurement, was distant road traffic noise associated with the A907 to the north east of the property. Also present was occasional birdsong.

The Brüel & Kjær 2250 sound level meter was secured to a tripod with the microphone 1.5m above the ground, 1m from the north eastern façade of the property, adjacent to the Rion NL-31. The monitoring equipment was calibrated both before and after the measurement period using an acoustic calibrator, which has itself been calibrated against a reference set traceable to National and International Standards. There was no shift in the observed calibration level. Fifteen minute snapshot noise level measurements were undertaken with the B&K 2250 at Hamewith, throughout the measurement procedure.

Measured Results: 23 Brucefield Crescent, Clackmannan

Period	Date	Start Time (hh:mm)	Duration (hh:mm)	Noise Level (dB)			Weather		Comments
				$L_{Aeq,T}$	L_{A10}	L_{A90}	Wind Speed (m/s) & Direction	Conditions	
Rion NL-31 Sound Level Meter									
Weekday 18hr (position 1)	27/01/09	06:00	18:00	**59.3**	-	-	Calm	Dry, Overcast, 7℃	Road traffic noise, birdsong
Weekday 18hr (position 1)	28/01/09	06:00	18:00	**59.9**	-	-	Calm	Dry, bright, 6℃	Road traffic noise, birdsong, light rain during afternoon period (not heavy enough to affect measurements)
Brüel & Kjær 2250 Sound Level Meter									
Weekday DAY (position 2)	26/01/09	11:32	00:15	**53.1**	**56.3**	**46.1**	Calm	Overcast, light drizzle 7℃	No trains
Weekday AFTERNOON (position 2)	28/01/09	13:48	00:15	**53.6**	**55.4**	**44.0**	Calm	Dry, clear skies, 4℃	13:48 – EWS 23 carriage freight loaded 13:51 plane overhead

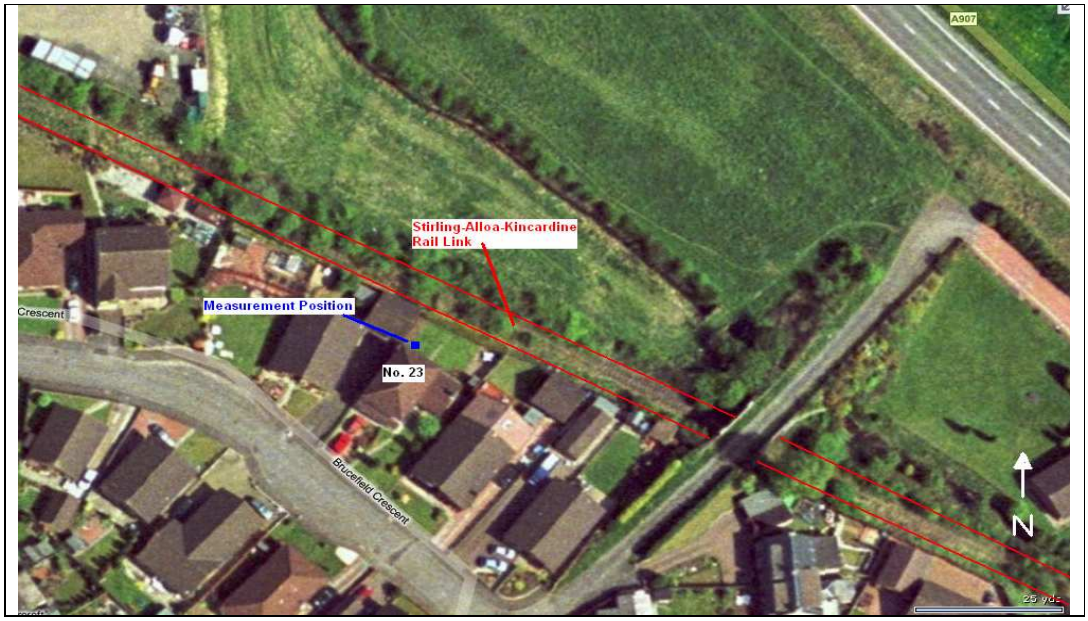
* - Not measured

Further Breakdown of Rion Measurements

Period	Date	Train Noise		Background Noise	Number of Trains	
		Passenger	Freight		Passenger	Freight
Weekday 18hr	**27/01/09**	**-**	**51.8**	**58.4**	**-**	**13**
Weekday 18hr	**28/01/09**	**-**	**52.2**	**59.1**	**-**	**19**

Figure 9.1: Rion NL-31 Sound Level Meter and B&K 2250 Sound Level Meter at Measurement Position, 23 Brucefield Crescent Clackmannan

Figure 9.2: Site Location and Approximate Measurement Position, 23 Brucefield Crescent, Clackmannan



Location 10: Station House, Kincardine

The measurement position was located 1m from the western facing façade, within the rear garden area of the property. This position in turn was approximately 18m east of the nearside edge of the rail link as shown in Figure 10.2. The Rion NL-32 sound level meter was secured within a weatherproof box with the microphone positioned 1.5m above the ground at ground floor window height, see Figure 10.1. The monitoring equipment was calibrated both before and after the measurement period using an acoustic calibrator, which has itself been calibrated against a reference set traceable to National and International Standards. There was no shift in the observed calibration level. This sound level meter was secured at the property and left continuously logging, with an audio recording event trigger set, throughout the measurement period.

The dominant noise of this location, at the time of measurement, was distant road traffic noise associated with the A876 Kincardine Bridge, to the south of the property and the Clackmannan Bridge, passing to the west of the property. Also present was birdsong.

The Brüel & Kjær 2250 sound level meter was secured to a tripod with the microphone 1.5m above the ground, 1m from the south eastern façade of the conservatory, see Figure 10.1. The monitoring equipment was calibrated both before and after the measurement period using an acoustic calibrator, which has itself been calibrated against a reference set traceable to National and International Standards. There was no shift in the observed calibration level. Fifteen minute snapshot noise level measurements were undertaken with the B&K 2250 at Station House, throughout the measurement procedure.

Measured Results: Station House, Kincardine

Period	Date	Start Time (hh:mm)	Duration (hh:mm)	Noise Level (dB)			Weather		Comments
				$L_{Aeq,T}$	L_{A10}	L_{A90}	Wind Speed (m/s) & Direction	Conditions	
Rion NL-31 Sound Level Meter									
Weekday 18hr (position 1)	27/01/09	06:00	18:00	**56.7**	-	-	Calm	Dry, Overcast, 7℃	V. distant road traffic (Kincardine bridge), birdsong
Weekday 18hr (position 1)	28/01/09	06:00	18:00	**56.5**	-	-	Calm	Dry, bright, 6℃	Nearby lawnmower, v. distant road traffic (Kincardine bridge), birdsong
Brüel & Kjær 2250 Sound Level Meter									
Weekday DAY (position 2)	28/01/09	11:26	04:35**	**48.0**	**49.7**	**45.6**	Calm	Overcast, dry 7℃	**memory ran out – SD card changed
Weekday DAY (position 2)	28/01/09	11:58	00:15	**45.5**	**47.9**	**42.0**	Calm	Dry, clear skies, 3℃	No train passes

* - Not measured

** - Memory ran out – had to change SD card

Further Breakdown of Rion Measurements

Period	Date	Train Noise (dB)		Background Noise (dB)	Number of Trains	
		Passenger	Freight		Passenger	Freight
Weekday 18hr	**27/01/09**	**-**	**55.3**	**51.0**	**-**	**13**
Weekday 18hr	**28/01/09**	**-**	**55.3**	**50.3**	**-**	**18**

Figure 10.1: Rion NL-31 Sound Level Meter and B&K 2250 Sound Level Meter at Measurement Position, Station House, Kincardine

Figure 10.2: Site Location and Approximate Measurement Position, Station House, Kincardine

Location 11: The Gables, near Cambus

The measurement position was located 1m from the southern facing façade, within the rear garden area of the property. This position in turn was approximately 9m north of the nearside edge of the rail link as shown in Figure 11.2. The Rion NL-31 sound level meter was secured within a weatherproof box with the microphone positioned 1.5m above the ground at ground floor window height, see Figure 11.1. The monitoring equipment was calibrated both before and after the measurement period using an acoustic calibrator, which has itself been calibrated against a reference set traceable to National and International Standards. There was no shift in the observed calibration level. This sound level meter was secured at the property and left continuously logging, throughout the measurement period.

The dominant noise of this location, at the time of measurement, was distant road traffic noise associated with the A907 to the north of the property. Also present was birdsong.

The Brüel & Kjær 2250 sound level meter was secured to a tripod with the microphone 1.5m above the ground, 1m from the south eastern façade of the conservatory, see Figure 11.1. The monitoring equipment was calibrated both before and after the measurement period using an acoustic calibrator, which has itself been calibrated against a reference set traceable to National and International Standards. There was no shift in the observed calibration level. Fifteen minute snapshot noise level measurements were undertaken with the B&K 2250 at The Gables, throughout the measurement procedure.

Measured Results: The Gables, Near Cambus

Period	Date	Start Time (hh:mm)	Duration (hh:mm)	Noise Level (dB)			Weather		Comments
				$L_{Aeq,T}$	L_{A10}	L_{A90}	Wind Speed (m/s) & Direction	Conditions	
Rion NL-31 Sound Level Meter									
Weekday 18hr (position 1)	27/01/09	06:00	18:00	-	-	-	Calm	Dry, Overcast, 7℃	Road traffic noise, birdsong
Weekday 18hr (position 1)	28/01/09	06:00	18:00	**58.1**	-	-	Calm	Dry, bright, 6℃	Road traffic noise, birdsong
Brüel & Kjær 2250 Sound Level Meter									
Weekday EVE (position 2)	28/01/09	19:14	00:15	**52.0**	**48.8**	**40.7**	Calm	Dry, clear skies, 2℃	No train passes
Weekday DAY (position 2)	28/01/09	10:30	00:15	**53.5**	**55.9**	**49.4**	S.W. ^1.5 m/s Ave. 0	Dry, overcast 7℃	10:40 - 3 carriage passenger train pass (eastbound)
Weekday DAY (position 2)	29/01/09	10:33	00:15	**56.1**	**55.2**	**49.8**	Calm	Dry, bright, 6℃	10:38 - 3 carriage passenger train pass (westbound) 10:40 & 10:47 – Plane pass overhead

* - Not measured

Further Breakdown of Rion Measurements

Period	Date	Train Noise		Background Noise	Number of Trains	
		Passenger	Freight		Passenger	Freight
Weekday 18hr	**27/01/09**	**-**	**-**	**-**	**-**	**-**
Weekday 18hr	**28/01/09**	**52.9**	**54.3**	**52.8**	**37**	**19**

* Some data missing – measurement started 1 day late due to faulty equipment

Figure 11.1: Rion NL-31 Sound Level Meter and B&K 2250 Sound Level Meter at Measurement Position, The Gables, near Cambus

Figure 11.2: Site Location and Approximate Measurement Position, The Gables, near Cambus