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NETWORK RAIL

BORDERS RAILWAY

OPERATIONAL NOISE AND VIBRATION (YEAR 1, ROUND 2)

15375-REP-003

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1. NON-TECHNICAL SUMMARY

IKM Consulting Ltd (IKM) was commissioned by Network Rail to undertake noise and vibration monitoring of the operational Borders Railway to demonstrate compliance with the Waverley Railway Noise and Vibration Policy (ERM 2008) or the Waverley Railway Policy. The purpose of the policy document is to set out Network Rail's commitments for mitigating noise and vibration effects during the operation of the Borders Railway. As laid out in the policy document, Network Rail is required to instruct monitoring of the operational effects of the railway, at six monthly intervals, for the first three years after the railway opened to passengers, and annually thereafter. The policy document is legally enforceable through Section 46 of the Waverley Railway (Scotland) Act 2006.

IKM began the initial round of monitoring in February 2016, the second round was undertaken in August 2016. The full dataset will be collected by 2021.

During the initial monitoring round, readings were carried out in 22 locations as agreed previously with Network Rail and environmental health officers (EHOs) from the relevant Local Authorities (Midlothian Council and Scottish Borders Council) in a consultation meeting in February 2016. Following Round 1, IKM then attended a subsequent consultation meeting with Network Rail in June 2016; ahead of Round 2, during the meeting it was agreed that noise monitoring would be undertaken at 20 locations along the route and two of those locations would also have vibration monitoring undertaken.

Noise and vibration monitoring was undertaken between Monday 1 August and Wednesday 17 August 2016. All monitoring conformed with the technical memorandum *Calculation of Railway Noise (CRN)* (The Department of Transport, 1995) and the British Standard BS 6472 (2008) Evaluation of Human Exposure to Vibration in Buildings (BS 6472:2008).

During the daytime period (06:00-00:00) and the night-time period (00:00 – 06:00) noise levels did not exceed the Unacceptable Impact Levels of 66dB and 61dB, respectively. The night-time maximum noise level L_{Amax} (stipulated as exceeding 82dB) was exceeded at five locations, these locations will be monitored during the next round of noise monitoring.



Vibration monitoring was undertaken at two properties, as agreed with Network Rail. On all occasions the vibration dose values (VDV) levels were found to be lower than the threshold specified in the policy document.

All findings have been relayed to Network Rail.



2. INTRODUCTION

2.1 Brief

IKM Consulting Ltd (IKM) was commissioned by Network Rail to undertake noise and vibration monitoring of the operational Borders Railway to demonstrate compliance with the Waverley Railway Noise and Vibration Policy (ERM, 2008). The purpose of the policy document is to set out Network Rail's commitments for mitigating noise and vibration effects during the operation of the Borders Railway. As laid out in the policy document, Network Rail is required to instruct monitoring of the operational effects of the railway, at six monthly intervals for the first three years after the railway opened to passengers and annually thereafter. The policy document is legally enforceable through Section 46 of the Waverley Railway (Scotland) Act 2006.

Noise Thresholds

As part of the policy document, the requirements for noise mitigation relate to a set of noise thresholds:

Unacceptable Impact Levels:

Day - L_{Aeq} , (06:00 – 00:00 hours) 66dB

Night - L_{Aeq} , (00:00 – 06:00 hours) 61dB

Night - L_{Amax} , greater than 82dB

Vibration Thresholds

Regarding train vibration, the following vibration dose value (VDV) levels are given in the policy document, for the level at which, or below, the probability of adverse comment is considered to be low:

Day (07:00 – 23:00 hours) – $0.4\text{m/s}^{1.75}$

Night (23:00 – 07:00) – $0.13\text{m/s}^{1.75}$

Any measured noise or vibration levels will be compared to the two sets of thresholds.

IKM undertook the first round of monitoring in February 2016, round two was undertaken in August 2016. The full dataset will be collected by 2021.



2.2 Scope of Works

As part of the project, IKM undertook the following scope of work:

- A review of all previous noise related reports for the project (as listed in the reference section of this report)
- Identify locations along the route where noise and vibration monitoring was required, to target the following:
 - Noise sensitive receptors identified in the Environmental Statement;
 - Noise barrier locations;
 - Noise or vibration related complaints received; and
 - Known noise and vibration 'hot spots'.
- Consult with Network Rail and environmental health officers (EHOs) from the Local Authorities –Midlothian Council and Scottish Borders Council – to agree the scope of noise and vibration monitoring and proposed locations.
- Carry out noise and vibration monitoring surveys, where required.
- Produce a written report detailing all results from the noise monitoring, including a non-technical summary for ease of use by Network Rail, in identifying any areas requiring potential mitigation.

Please note that all references to trains in this document relate to passenger train services only. No consideration is given to any other nature of rail traffic.

2.3 Disclaimer

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Any noise and vibration survey provides data as observed during a specified monitoring period only. The acoustic environment for the site is interpreted as a whole on the basis of a limited number of survey results; it was therefore not possible to preclude the existence of on-site conditions that were not encountered during the noise survey. This report has been compiled in accordance with appropriate British Standards.



3. BACKGROUND

3.1 Agreement of Scope

On 15 June 2016, IKM met with Network Rail to agree the scope for the second round of monitoring for Year 1 and to discuss and agree suitable monitoring locations.

During this meeting, it was agreed that noise monitoring would be undertaken at 20 locations along the route, whilst vibration monitoring would be carried out at two of those locations. The monitoring locations took account of the noise barrier locations, sensitive receptors identified in the Environmental Statement, and noise and vibration 'hot spots' where complaints associated with the operation of the railway had been lodged with the local authority and/or Network Rail.

The EHO's requested that IKM capture the following data during their monitoring regime:

- Two train passes travelling in each direction (northwards: from Tweedbank towards Edinburgh and southwards: from Edinburgh towards Tweedbank) during the daytime reference period of 06:00 – 00:00. A total of four train passes were required during the daytime period for each monitoring location i.e. two northbound and two southbound.
- Two train passes travelling in each direction during the night-time reference period of 00:00 – 06:00. It was agreed that at least a single train pass in each direction would be captured during the night-time period for each monitoring location.
- Note the different combination of carriage numbers (i.e. two carriages and four carriages), to allow a comparison to be undertaken in the noise levels produced.
- At monitoring locations close to a station, target different scenarios, i.e. trains pulling into/away from the station and trains idling in the station, to allow a comparison to be undertaken.



3.2 Programme and Notification Letters

Following the meeting with Network Rail, IKM developed a detailed noise and vibration monitoring programme intended to capture all the data sets and scenarios discussed above, with the aid of the Scot Rail passenger timetable for the route. The monitoring programme was sent to Network Rail; IKM then produced notification letters for the 20 residents located at the required monitoring locations. The notification letter was reviewed by Network Rail prior to its issue to each of the residents.

3.3 Monitoring Locations

Table 1 below details the locations that featured on the monitoring programme. The table indicates whether vibration monitoring was required, if the monitoring was required because a noise barrier was present, or if the monitoring was required due to a previous complaint. Monitoring locations one and seventeen, originally monitored during round 1, were found to no longer have occupants through correspondence with the Royal Mail. These monitoring locations were therefore taken out of the monitoring program for Round 2.

Table 1: Monitoring Locations Featured in August 2016 Monitoring Programme (Round 2)

Monitoring Location (ML)*	Address	Monitored in Round 1	Noise Barrier or Complainant	Vibration Monitoring Required?
2	Avenue Road, Dalkeith	✓	Noise barrier	NO
3	Bonnyrigg Rd, Dalkeith	✓	Noise barrier	NO
4	Westfield Bank, Dalkeith	✓	Complaint	YES
4a	Westfield Bank, Dalkeith	✓	Complaint	YES
5	Westfield Drive, Dalkeith	✓	Complaint	NO
6	Hardengreen Lane,		Complaint	NO



Monitoring Location (ML)*	Address	Monitored in Round 1	Noise Barrier or Complainant	Vibration Monitoring Required?
	Dalkeith	✓		
6a	Dalhousie Mains, Dalkeith	✓	Noise barrier	NO
7	Victoria Gardens, Newtongrange	✓	Noise barrier	NO
8	Station Rd, Newtongrange	✓	Noise barrier	NO
9	Dean Park, Newtongrange	✓	Noise barrier	NO
10	Jenks Loan, Newtongrange	✓	Noise barrier	NO
10a	Private Road, Gorebridge	✘	Complaint	NO
11	Granary , Fushie Bridge	✓	Noise barrier	NO
12	Tynehead Farm	✓	Complaint during construction	NO
13	Stagebank View, Heriot	✓	Complaint	NO
14	Still Haugh, Fountainhall	✓	Noise barrier	NO
15	Stow Primary School	✓	Noise barrier	NO
16	Woodlea, Galashiels		Complaint	NO



Monitoring Location (ML)*	Address	Monitored in Round 1	Noise Barrier or Complainant	Vibration Monitoring Required?
		✓		
18	High Buckholmside, Galashiels	✓	Complaint	YES
19	Glenfield Rd East, Galashiels	✓	Complaint	NO

**Note – all monitoring location numbers adopted for Round 1 were retained as far as possible for Round 2.*



4. METHODOLOGY

4.1 General

Noise and vibration monitoring was undertaken between Monday 1 August and Wednesday 17 August 2016.

4.2 Meteorological Conditions

All noise monitoring was undertaken during favourable weather conditions and conformed to the requirements detailed in Section 41 Physical Conditions for Measurement detailed within the Calculation of Railway Noise (1995). Scheduled monitoring was cancelled where meteorological conditions were poor or did not meet the requirements of Section 41. All scientists carried a pocket weather meter, and were able to record temperature and average/maximum wind speeds during the monitoring period.

4.3 Noise Monitoring

A Brüel & Kjaer 2250 analysing digital sound level meter (SLM) was used to record noise levels. The B&K 2250 is a Class 1 sound level meter. The SLM is independently calibrated at a UKAS accredited laboratory at least once every two years. Calibration certificates for the SLM microphone, pre-amplifier and calibrator were kept with the equipment on-site and are attached as Appendix A. The sound meter was calibrated on-site at the start and end of each monitoring shift, to ensure that there was no drift in the sensitivity of the instrument. A fitted omni-directional microphone and windshield was attached to the meter for all noise monitoring. The microphone was orientated towards the railway. The microphone was mounted on a freestanding tripod, which was extendable from 1.2m - 4.5m above ground level, representative of the height of a first floor bedroom.

Noise levels were recorded in one hour sampling periods, which were divided into one minute increments to enable further interrogation of the data for each train pass, wherever possible. Broadband and frequency noise data was recorded concurrently. Noise monitoring was undertaken using a slow weighted time response.

IKM aimed to obtain between 45 minutes and one hour of data at each monitoring location, with the intention of recording the passage of two trains in both directions at each monitoring location during the day and night reference time-periods.



On the majority of occasions, the noise meter was set up to record façade readings, located between the (railway- facing) façade of the sensitive property and the railway. The noise meter was located approximately 1m from this façade. On some occasions a façade reading was not possible (due to access or obstructions) and a free-field reading was undertaken (i.e. located at least 3.5m from all other reflective surfaces, other than the ground.) This was the case at the following locations:

- ML5 – Westfield Drive;
- ML6 – Hardengreen Lane;
- ML9 – Dean Park;
- ML14 – Fountainhall village.

The following noise parameters were recorded at each location:

- L_{Aeq} The equivalent continuous A-weighted sound pressure level.
- L_{AF10} , L_{AF50} and L_{AF90} The noise level exceeded for 10%, 50% or 90% of the sampling period of the measured time, respectively. L_{AF90} is commonly understood to represent the background noise level.
- L_{Amax} and L_{Amin} The maximum/minimum noise level measured during the sampling period.

All readings were given in decibels (dB) based on the A-weighted network, using slow time response weighted (S).

IKM used two sound level meters during the monitoring programme and all measurements complied with the measurement method detailed in Calculation of Railway Noise (1995).



4.4 Vibration Monitoring

A Vibrock V901-2 triaxial vibration seismograph was used to record ground-borne vibration. Two transducers were set up on a firm, horizontal, surface situated as close to the building's foundations as possible, for example on a back door step. The transducers were set up to measure vibration dose value (VDV). The arrows on the transducers were orientated in the direction of the noise source (i.e. the railway). The transducers were firmly coupled to the surface by weighting with sandbags. Calibration certificates for this equipment were kept on-site and are included as Appendix A.

During the monitoring programme, IKM used one vibration seismograph.

The seismograph was set up to measure vibration dose value (VDV) in $\text{mms}^{-1.75}$.

The vibration meter was set up to record continuously for between 45 minutes and one hour periods at each monitoring location.

At both monitoring locations vibration monitoring was carried out within the property. IKM employed the same methodology as detailed above, but instead of setting the seismograph up at a location close to the building's foundation, the meter was set up at a location where the resident reported the highest vibration levels had occurred - this was typically beside a couch in a living room or beside a bed in the bedroom.

All vibration monitoring complied with the British Standard *BS: 6472 (2008)*.

4.5 Limitations in the Noise Data Set

There are a few areas where there were limitations in the dataset:

- Only one southbound, and three northbound daytime trains were captured at ML18 - High Buckholmside. This was due to an operational error. At least two train passes, both north and southbound, were captured at all other monitoring locations.
- On a few occasions, the site staff were required to set up meters in different positions at the same monitoring location due to access restrictions. Where this has occurred, we have highlighted this in the dataset (Appendix B).



- IKM has not undertaken any statistical analysis of the noise levels recorded when different numbers of carriages passed the monitoring locations. IKM did make an attempt to capture different train lengths, and the data collated has been logarithmically averaged to ensure that carriage numbers greater than two have been taken into account.



5. RAIL TRAFFIC CALCULATIONS

5.1 Rail Traffic Calculations

Appendix B shows calculations which allows comparison to the Unacceptable Impact levels given in the policy document. The Unacceptable Impact Levels are defined as the levels at which, if, after consideration of measures at source, any of the relevant unacceptable levels are exceeded, then noise insulation will be offered, provided the corresponding ambient noise level is routinely exceeded by at least 1dB.

The time reference periods for the Unacceptable Impact Level's are slightly different from the time reference period given within Calculation of Railway Noise (1995) (i.e. $L_{Aeq, 18\text{hour}}$ (06:00 – 00:00) and $L_{Aeq, 6\text{ hour}}$ (00:00 – 06:00)). All train passes were collated into the time reference periods associated with the Unacceptable Impact levels and the following calculation process was undertaken:

- Reference to the Borders Railway published rail timetable, to determine the total number of trains passing each monitoring location during an 18 hour day (06:00 – 00:00), and an 6 hour night (00:00 - 06:00);
- Determination of the $L_{Aeq, 18\text{hr}}$ (daytime) and $L_{Aeq, 6\text{hr}}$ (night-time) parameters for both northbound and southbound trains using the formula:

$$L_{Aeq, T} = SEL + 10 \log n - 10 \log T$$

Where,

n = number of trains passing in time period, T

T = reference time period, in seconds.

On calculation, IKM compared the calculated values to the Unacceptable Impact Levels detailed in the Policy document and determined whether the day or night thresholds had been exceeded. IKM also examined the noise data to see if the measured L_{Amax} noise levels exceeded the Night-time L_{Amax} Unacceptable Impact Level.



5.2 Limitations for Unacceptable Noise Impact Levels

By adopting the time reference periods for the Unacceptable Impact Levels for Round 2 and rationalising the number of targeted train passes to one in each direction for night-time, most of the data limitations encountered during Round 1 were overcome. The reduced target for capture of night-time train passes was adopted due to very few scheduled train passes that occur within the 00:00 - 06:00 time period requiring multiple revisits to obtain the required dataset for each monitoring location.

In addition, only one southbound train pass was captured during daytime monitoring at High Buckholmside (ML18), due to an operational error.



6. FINDINGS AND DISCUSSIONS

6.1 Noise

To accompany Appendix B, the spreadsheet containing all of the noise data and calculations, a summary table was created, which forms the first workbook of the spreadsheet and summarises our findings. An extract of the summary table is included as part of Table 3 below.



Table 3: Extracted Noise Information from Summary Table in Appendix B

Monitoring Location (ML)	Location	DAY Unacceptable Impact Level Exceedance (L _{Aeq})		NIGHT Unacceptable Impact Level Exceedance (L _{Aeq})		NIGHT Unacceptable Impact Level Exceedance (L _{Amax})
		Northbound	Southbound	Northbound	Southbound	
2	Avenue Road	NO	NO	NO	NO	YES - Northbound and Southbound
3	Bonnyrigg Road	NO	NO	NO	NO	NO
4	Westfield Bank	NO	NO	NO	NO	NO
4a	Westfield Bank	NO	NO	NO	NO	NO
5	Westfield Drive	NO	NO	NO	NO	Yes - Northbound
6	Hardengreen Lane	NO	NO	NO	NO	NO
6a	Dalhousie Station House	NO	NO	NO	NO	NO
7	Victoria Gardens	NO	NO	NTC	NO	NO
8	Station Road	NO	NO	NO	NO	NO
9	Dean Park	NO	NO	NO	NO	Yes - Southbound
10	Jenks Loan	NO	NO	NO	NO	NO



Monitoring Location (ML)	Location	DAY Unacceptable Impact Level Exceedance (L _{Aeq})		NIGHT Unacceptable Impact Level Exceedance (L _{Aeq})		NIGHT Unacceptable Impact Level Exceedance (L _{Amax})
		Northbound	Southbound	Northbound	Southbound	
10a	Private Road	NO	NO	NO	NO	NO
11	Granary 1	NO	NO	NO	NO	NO
12	Tynehead Farm	NO	NO	NO	NO	NO
13	Stagebank	NO	NO	NO	NO	NO
14	Fountainhall Village	NO	NO	NO	NO	NO
15	Stow Primary School	NO	NO	NO	NO	NO
16	Woodlea	NO	NO	NO	NO	Yes - Northbound and Southbound
18	High Buckholmside	NO	NO	NO	OTC	NO
19	Glenfield Road East	NO	NO	NO	NO	Yes - Southbound

Key:

Unacceptable Impact Levels

OTC – Only one train captured within relevant time reference period in southerly direction.



6.1.1 Unacceptable Impact Levels – Exceedances

During both the daytime (06:00 – 00:00) and night-time period (00:00 - 06:00) respectively and there were no exceedances of the L_{Aeq} Unacceptable Impact Levels.

There were seven exceedances of the night-time L_{Amax} Unacceptable Impact Level of greater than 82dB. These occurred at the following receptors:

- ML2: Avenue Road (during both a northbound and southbound train pass);
- ML5: Westfield Drive (during a northbound train pass);
- ML9: Dean Park (during a southbound train pass);
- ML16: Woodlea (during both a northbound and southbound train pass); and
- ML18: High Buckholmside (during a southbound train pass).

These monitoring locations will be targeted during the next round of noise monitoring.

6.2 Vibration

Vibration monitoring was undertaken at two properties, as requested by Network Rail. On all occasions the VDV levels were lower than the level at which the probability of adverse comment is considered to be low. The events recorded on-site are included as Appendix C and are summarised in the Table 4 below.



Table 4: Borders Railway Operation - Vibration Results

Event Number	Date	Monitoring Time	Location	VDV $m/s^{-1.75}$	Exceedance of Threshold
17	01.08.2016	DAY	ML18 High Buckholmside - External	0.003	NO
18	01.08.2016	DAY	ML18 High Buckholmside - Internal - in living room, at west facing wall	0.006	NO
19	02.08.2016	NIGHT	ML18 High Buckholmside - External	0.005	NO
20	05.08.2016	DAY	ML4a Westfield Bank - External	0.006	NO
21	05.08.2016	DAY	ML4a Westfield Bank - Internal - upstairs room, at east facing wall	0.008	NO
22	05.08.2016	NIGHT	ML4a Westfield Bank - External	0.011	NO



7. CONCLUSIONS

7.1 Noise Conclusions

Noise monitoring was undertaken at 20 monitoring locations between Monday 1 August and Wednesday 17 August 2016. IKM carried out noise monitoring in line with the document *Calculation of Railway Noise 1995*, and addressed Network Rail's requirements for the monitoring discussed on 15 June 2016.

There were no exceedances in the daytime and night-time L_{Aeq} Unacceptable Impact Level thresholds. Seven exceedances in the night-time L_{Amax} Unacceptable Impact Threshold level of greater than 82dB were noted. It is recommended that the next round of noise monitoring will target all monitoring locations where the night-time L_{Amax} threshold exceedances were noted during the Round 2 survey.



8. REFERENCES

Atkins 2015. Baseline Noise Survey and Station Operational Noise Assessment.

Atkins 2012. Detailed Assessment of Noise Barrier Requirements.

British Standards 2008. BS: 6472 Evaluation of Human Exposure to Vibration in Buildings Part 1: Vibration sources other than blasting

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Electronic Scot Rail Timetable (Edinburgh - Newcraighall - Tweedbank) Valid 20th March - 7th August 2016 (https://www.scotrail.co.uk/sites/default/files/assets/download_ct/edinburgh_-_tweedbank.pdf) accessed July 2016.

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APPENDICES

Appendix A
Calibration Certificates

Appendix B
Monitoring Data and Noise Calculations

Appendix C
Vibration Events

