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THE BRISTOL PORT COMPANY

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Tel: Fax: Telex:
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Thursday, 29th August 2002

Head of Freight Grants
Strategic Rail Authority
55 Victoria Street
London SW1H 0EU

30 AUG 2002

Dear

Portbury Rail Link

Thank you very much indeed for your letter dated 19th August concerning the noise problem on the above railway line.

We appreciate your interest and involvement in this problem and particularly for emphasising the seriousness of the situation with both Railtrack and EWS. We are aware of the actions that they are taking to mitigate the noise but do not feel that this will be either sufficient or quick enough to avoid a Prohibition Order.

We have now received the scientific report from our noise consultant who also did the original report which formed part of our planning application. You will see from his report that there is a problem and that the measurement range is from the high 70's to over 90 decibels which exceeds the 82 decibels level which is apparently sleep disturbing. His recommendation is to erect acoustic barriers over the offending length of track and he is confident that this would bring the noise level down below the level of justifiable complaint. You will also see from his report that there are many places within the UK which Railtrack have erected acoustic barriers and we do believe that Railtrack's reaction on this issue is more one of seeking to avoid the expense rather than setting a precedent.

We would be grateful if you could continue to assist us in applying pressure to Railtrack and EWS, both of whom should now be in receipt of the noise report. For our part, we will be seeking to persuade them to join with us in erecting these barriers immediately and splitting the cost three ways.

Yours sincerely

cc: Graham Turner, Chief Executive Officer, North Somerset Council

DAVID TREVOR-JONES ASSOCIATES

CONSULTANTS IN ACOUSTICS, NOISE AND VIBRATION

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Briefing Note for:

The Bristol Port Company
St Andrews House
St Andrews Road
Avonmouth
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ROYAL PORTBURY DOCK RAIL LINK
Noise survey

Briefing on noise control measures

By

DTJ345/BN2/3

27 August 2002

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1 INTRODUCTION

1.1 A study of train pass-by noise levels along the Royal Portbury Dock rail link has been undertaken in conjunction with North Somerset District Council since the start of the year. Its completion has been held up by the infrequency of train services over the spring/summer when conditions have been at least theoretically suitable for accurate outdoor noise measurements. The results obtained to date provide an encouraging reassurance that the noise levels being generated by trains on the rail link in practice are very close to the values predicted in the Environmental Assessment (EA) for the new line and reported in the mandatory Environmental Statement.

1.2 However, a distinct noise problem has emerged which was not foreseen in the EA study. Trains approaching the port through Pill are required to halt at the Stop Board situated close to the bottom of the decline from the Portishead branch junction, at the foot of the M5 Avonmouth bridge. As they are braked a piercing squeal is generated which has given rise to complaints from residents in parts of Pill. There is also an element in the squeal of wheel flange contact noise. The latter is understood to be being addressed through the installation of flange lubricators. The purpose of this Technical Briefing Note is to outline the options for addressing the brake wheel disc contact component of the noise.

2. EXECUTIVE SUMMARY

2.1 The preliminary results of a long term study of noise from trains entering and leaving the Royal Portbury Dock have tended to confirm that average pass-by and cumulative noise levels are consistent with the values predicted for the Environmental Assessment of the project. However, the prevalence of brake squeal and to a lesser extent, of flange contact squeal, has been found to be greater than anticipated. The range of strategies to address the noise, from control at source to lineside barriers and treatment of receiving facades, has been reviewed. Options for altering driving routines are understood to be under investigation. The installation of noise barriers appears to be an essential element in a complete solution.

2.2 An illustrative calculation based on available data and estimated source and receiver elevations has been undertaken to demonstrate that a noise barrier of modest height could significantly reduce the exposure of lineside houses to train pass-by noise, especially brake squeal. Because the noise source is by definition linear, an effective barrier would have to extend for a length spanning both the private siding and the branch line, to either side of the new junction.

2.3 To date complaints about the squeal are believed to have come only from Avon Road to the north of the junction and not from Lodway Close to the south. It is likely that the squeal equally affects both sides. If adopted as part of an abatement strategy, barriers would be required on both sides of the track. They would have to be acoustically absorbent in order to abate reflection from the opposite side to the houses.

2.4 There are a number of examples of barrier installations alongside various main and commuter railway lines in Britain. Railtrack is familiar with the technology and has applied it elsewhere. An industry standard design is emerging, buildable in reflective or absorbent versions, developed originally for use on the Channel Tunnel Rail Link (CTRL). This design has been licensed by Rail Link Engineering (RLE), the consortium building the CTRL, to Railtrack for widespread application in barriers for the upgraded West Coast Main Line.

2.5 The extent of the barriers potentially required to either side of the junction at Pill has been estimated assuming installation on both sides of the track and amounts in total to about 470metres of barrier length.

2.6 The all-in cost of the RLE barrier, including installation, is highly variable and driven by the foundation requirements and nature of the ground but averages £250 metre. The provisional barrier scheme sketched out on the basis of preliminary noise analysis and estimates of braking lengths would represent about £120,000 of investment.

2.7 Among the variables which require further investigation before the barrier dimensions (length and height) and design (reflective or absorbent) can be confirmed are the three dimensional geometry of the Pill site and opinions of residents and the local authority on the need to treat both sides or just the north side of the track.

3. INVESTIGATION AND CONSULTATION

3.1 Observations have been made from the field at the western end of Avon Road of trains arriving and departing. An automatic environmental noise level analyser has been left for periods at 27 Avon Road and at 25 Lodway Close almost immediately opposite on the south side of the track. A limited quantity of objective data have been obtained along with valuable subjective impressions.

4. RESULTS TO DATE

4.1 The following are preliminary findings. The conclusions to be drawn ultimately will be informed by further measurements and observations.

4.2 A preliminary analysis of train pass-by noise level data obtained at 27 Avon Road indicates that the actual ambient noise level at the facade overlooking the railway with trains operating is significantly less than predicted in the Environmental Statement. The noise impact of the trains does not exceed the predicted impact in quantity, but there is a significant factor in its quality.

4.3 The dominant feature of the train noise is squealing. This is particularly the case from the inbound empty stock workings. There are two sources exacerbated by the fact that the empty wagon bodies, undamped by load, tend to resonate in response to the excitation.

4.4 The greater source is the squeal as the brakes are applied to slow the train as it descends the bank from the junction towards the stop board under the M5 bridge. The length of the trains is such that as the brakes are applied the end wagons are still on the branch line passing the backs of houses on Avon Road and Lodway Close. When an incoming train comes to a stand at the stop board the end wagon has only just cleared the houses. Consequently, the houses are exposed to a prolonged and intense period of brake squeal.

4.5 This effect was not anticipated in the environmental assessment. Indeed, it was stated in the Environmental Statement that:

> *It has been assumed for all of the calculations that trains will not stop while passing through the residential area of Pill. The holding signal will be positioned at about the line of the M5 bridge and in normal operating conditions will not hold up incoming trains.*

4.6 The brake squeal is extremely penetrating owing to its high frequency and screeching character. It is followed by the crashing of buffers and jerking of couplings as the brakes are released. The instantaneous maximum levels (L_{Amax}) generated at the facade of 27 Avon Road and measured during the survey ranged from the high 70s to over 90dB. As a working rule of thumb, noise levels exceeding 82dB are potentially sleep disturbing.

4.7 The other, lesser, source of screeching noise is wheel flange squeal. This was considered during the environmental assessment but ruled out as a significant issue of concern on the grounds that the curve radius did not appear to be sufficiently tight. In reality the long wheel base class 66 loco bogies tend to make flange contact as do the type HAA wagons. The type HTA wagon bogies have a shorter wheel base and appear from a small sample of observations to be less prone to make flange contact.

4.8 In the long term the incidence of flange squeal will probably be reduced as the new type HTA wagons are introduced and displace the type HAAs. In the shorter term, it is understood that Railtrack is installing flange lubricators on the line. Presumably the curve from Pill Junction to the M5 bridge will be a candidate for such an installation. Flange squeal will not be considered further in this Note.

5. NOISE MITIGATION

5.1 The nature of the brake squeal and the instantaneous maximum noise levels associated with it are sufficient to warrant intervention to mitigate it.

5.2 Noise reduction strategies can be based upon any or a combination of:

- noise control engineering at source
- management of the source
- noise reduction measures on the propagation path
- noise reduction measures at the receiver

Noise control engineering at source

5.3 The brake squeal is the result of the contact between the brake discs and wheel discs. The friction contact causing the squeal is necessary by definition. However, there seems to be excessive squeal compared with, for example, that from passenger vehicles. Coal dust usually acts as a lubricant so presumably the noise is being generated by gritty dust from another source.

5.4 There may be scope for minimising squeal by changing the wagon maintenance routine to include the removal of gritty dust from the wheel and brake discs as often as possible.

Management of the source

5.5 It is understood that some alleviation of the braking noise might be possible through the actions of the drivers of the trains. A prime strategy for controlling the noise at source might be through appropriate driver training or the issuing of guidelines for drivers on the route. It is recommended that EW&S should examine this option and take whatever action is practicable to reduce the generation of brake squeal by modifying the drivers' approach to the Stop Board.

Noise reduction measures on the propagation path

5.6 The best option for permanently effective passive noise control is likely to be placement of noise barriers on the propagation path between the railway and the houses at the western end of Pill, principally Avon Road and Lodway Close

5.7 There are technical and practical questions to be answered in considering the effectiveness and practicability of barrier placement. These will be the principal subject of the remainder of this Technical Briefing Note

Noise reduction measures at the receiver

5.8 Noise attenuation at the receiver is sometimes justifiable on cost benefit grounds but is a measure of last resort. It usually involves offering householders a scheme of secondary glazing with acoustically treated powered ventilation. The scheme is specified in the Noise Insulation Regulations for statutory compensation and that prototype is usually adopted in discretionary schemes.

6. NOISE BARRIERS

Principles

6.1 A noise barrier is a solid fence which breaks the line of sight between the source of the noise to be attenuated and the receiver to be protected from it. It works by causing the noise to change its path. Noise does not actually propagate as rays but the ray model is easy to visualise and good enough to explain the mechanism. A 'ray' of noise diffracts over the top of a barrier to reach a receiver on the opposite side from the source. The greater the angle through which it has to bend to reach the receiver the weaker it will be when it gets there.

6.2 A barrier in front of a source can be visualised as casting a shadow. A receiver in the shadow zone 'sees' attenuation of the sound. The deeper into the shadow it is the weaker the sound reaching it. Sound does not only diffract over the top but also around the sides or ends of a barrier. If there is a space under it, sound can also diffract underneath.

6.3 A barrier will have a finite mass as well as a finite length and height. Sound will propagate through as well as over and around it. The effectiveness of the barrier is therefore a function of its continuity and impermeability and its mass as well as of its dimensions. To be optimally effective the barrier must have no gaps or holes through it (an important consideration with respect to timber plank fences which might open up through weathering and warping) and must be made of a sufficient thickness of a sufficiently dense material that less sound propagates by transmission through it than by diffraction over and round it

6.4 The diffraction effect is frequency dependent. Higher frequencies of sound lose progressively more energy in diffraction and lower frequencies less

6.5 A timber, concrete or metal barrier will reflect as well as diffract sound reaching it. The reflected component returns toward the source. If the barriers are intended to protect houses to either side of a corridor - a road or railway - the reflected component can compromise the end result by adding to the source sound that the barriers opposite are intended to attenuate. Multiple reflections across the gap between the source and the barrier, such as between a smooth-sided train and a barrier close to it at the trackside, reinforce the sound at the top of the barrier and thereby reduce its practical effectiveness. In some circumstances a significant benefit can be gained by making the inner face of the barrier, facing the source, acoustically absorbent.

6.6 There is a limit to the effectiveness of an ideal barrier. Varying its geometry to increase its effectiveness delivers diminishing returns. Beyond a certain point the diffraction of sound around and transmission through a real barrier cannot be further stopped. The effective limit lies at just over 20dB.

6.7 Drawing together these principles it can be seen that a barrier will best protect a given receiver from a given source if it is both long enough and high enough to optimise the shadow (optimised geometry) and is made of a solid, dense material which will not warp after years of weathering. It will be more effective against high frequency sound than low frequency sound from the source.

Barriers against railway noise

6.8 The principle of optimising the geometry suggests that a barrier will be most effective if it is either close to the source or close to the receiver. A barrier intended to protect houses set back from a railway will be most effective over the widest area if it is close to the trains. Since in the present case the sources of the noise of particular concern are the wheel discs any barrier, to be effective, must break the line of sight between the tops of the train wheel discs and the upper storey windows of the lineside houses. It must be higher than just to break that line of sight to be optimal, and its length will be critical because the trains themselves have a considerable length relative to the receiver and radiate noise from their whole length.

6.9 In the case of the trains approaching the Royal Portbury Dock through Pill the brake squeal is at very high frequencies and could therefore be effectively attenuated by a correctly optimised barrier. The diesel locomotive noise, which is concentrated at low frequencies and emerges from a source high on the roof of the vehicle and so is much less amenable to barrier attenuation, is not considered to be a problem. The geometry is such that the barrier would have to be mounted on the railway embankment as close as possible to the train wheels (but consistent with safety and means of escape requirements for trackside personnel) for maximum effectiveness. Its length and height would have to be carefully calculated from knowledge of the braking and stop points and from the frequency characteristics of the squeal.

6.10 In the remainder of this Note a very rough provisional calculation will be offered to illustrate how a barrier at Pill might work, and precedents for the provision of railway noise barriers will be reported with reference to an emerging industry standard design.

7. ILLUSTRATIVE CALCULATION

7.1 The author does not have accurate survey data either of the relative heights of the railway and lineside residential facades above datum or of the spectral energy density of the brake squeal. Relative heights have been estimated from photographs and the critical noise frequency information gained from the results of measurements made by Bristol City Council of trains braking at the Stop Board at Ashton Drive. The illustrative calculation presented here is reliable as an indicator of the achievable attenuation but is not sufficiently accurate to be the base for a design.

7.2 The spatial relationship between the source (the top of a wheel disc) and receiver (the top of the first floor window, 27 Avon Road) has been derived by scale drawing a section based on the 1:1000 map and on photographs (Figures 1, 2). The plan separation distances and relative heights of the source, barrier and receiver have been processed to derive received noise levels at the first floor window using Maekawa's diffraction relation. The results for a range of barrier heights are presented in Table 1 and the A-weighted resultants in Figure 3.

7.3 The illustrative results demonstrate two important general outcomes which will be realised in any real barrier installation. First, the benefit conferred by the barrier is greater at higher frequencies than at lower frequencies. Second, the presence of a barrier of any useful height confers a significant benefit (the lowest barrier height modelled, 1.2 metres, just breaks the line of sight between source and receiver in the example). As the height is raised a law of diminishing returns sets in which determines that beyond a certain value, increasing the height does not generate a worthwhile additional benefit.

7.4 In the illustrative example it appears that there is little additional benefit to be gained from additional height beyond the 2 metre barrier. The 2 metres barrier yields 15dB attenuation in the 8kHz octave band and 12dB in the overall A-weighted received level. These are significant reductions, equating with a halving and almost halving again of the principal squeal frequency and a halving of the overall train pass-by noise level.

7.5 The results are encouraging in that they demonstrate with a fair degree of certainty that a barrier on top of the embankment at Pill would significantly reduce the exposure of the lineside residents to train pass-by noise. The squeal would still be heard as a squeal, but slightly less prominently over the generality of the pass-by noise than at present and at a much reduced absolute level. Despite the reduction the noise and squeal would still be audible indoors but at an absolute level less than the generally adopted absolute level threshold marking the onset of a significant sleep disturbance risk.

8. PRECEDENTS

8.1 Lineside noise barriers have not been as widely used to reduce the exposure of dwellings to noise from trains in the UK as in other European countries, notably the Netherlands where the Dutch Railway has used them widely and has carried out important research into the efficiency of designs and profiles, and into passenger and by-stander attitudes to them.

8.2 However, barriers have become familiar in south east Britain and in France as a result of their widespread adoption along the inhabited stretches of high speed railway. Many kilometres of noise barrier have been mandated through the Act of Parliament authorising construction of the Channel Tunnel Rail Link. Many of the barriers are already in place and are visible in long lengths, especially around Ashford, from Connex trains on the existing Eurostar route and from the M20.

8.3 Further significant lengths of noise barrier are visible along the existing Channel Tunnel routes through Kent. Long lengths in the vicinity of Headcorn and Staplehurst were installed experimentally in the research phase of the CTRL design. Further lengths were installed throughout Kent to protect lineside dwellings from enhanced night time freight train noise under the Channel Tunnel (No.3) Act, which authorised various minor works to upgrade the existing railway and its signalling to accommodate the intensified services.

8.4 The author was involved in the design of an extensive barrier scheme in south London for precisely the same purpose (London was not included within the remit of the No.3 Act for operational and legal reasons). The British Rail Board agreed to fund and build the barriers 'without prejudice' and on condition that no precedent was set but unfortunately the scheme was unilaterally abandoned when the Board's assets were transferred to Railtrack.

8.5 Lineside noise barriers are appearing more widely over the network in piecemeal short sections often designed to protect new lineside housing developments. Without having especially researched locations the author can bring to mind several such installations along the South West main line between Waterloo and Southampton and along commuter routes out of London such as one noticed recently near West Ham on the Tilbury/Southend line.

8.6 Very long lengths of noise barriers will become a familiar sight on the West Coast Main Line as a result of the upgrade scheme presently under way. Many kilometres of lineside noise barriers of both reflective and absorbent designs, up to 4 metres high, are to be installed through the Trent Valley where the upgraded railway will carry tilting trains at in excess of 200km/h through the towns of Tamworth, Lichfield, Armitage and Handsacre. These barriers were proposed by Railtrack and mandated through the Transport and Works Act authorising engineering works to widen the formation (to accommodate additional tracks, not the barriers).

Design and construction

8.7 Proprietary barriers have been developed by a number of companies supplying road schemes. A very large programme of retrospective barrier construction is under way across the motorway network (e.g. long lengths on the M3 through Surrey and north west Hampshire and on the south west quarter of the M25). Some of the proprietary designs have been trialled for rail schemes, such as the 'Stenoak' timber design experimentally installed near Headcorn. The barriers on the London Tilbury and Southend route through east London are of concrete planks slotted into I beam stanchions.

8.8 Union Rail, the company created to design, build and operate the CTRL, has developed a basic design which can be varied as either a reflective or an absorbent barrier, to any height. The design now appears to be the intellectual property of Rail Link Engineering, the consortium building the CTRL, which has licensed it to Railtrack for the WCML scheme. This design is now *de facto* an industry standard one known to Railtrack and adopted by them for their own extensive installation.

9. CONCLUSIONS

9.1 While individual pass-by and cumulative lineside train noise exposures at the western end of Pill have been shown from the preliminary results of noise monitoring to be within the values predicted for the Environmental Assessment of the project, an unanticipated brake and flange contact squeal has emerged. The range of options available for addressing the squeal has been reviewed. The installation of noise barriers to either side of the junction between the Portishead branch line and Royal Portbury Dock private siding is likely to be an essential component of the noise control strategy.

9.2 The line of the potential barrier(s) is indicated on the preliminary sketch attached at Figure 4. The eastern extremity would be roughly at the end of the new over-bridge on the north side and at the eastern, inner end of the pier embankment on the south side. The western extremity needs still to be fixed by observation of maximum braking distance from the stop board. The lines indicated on the sketch plan amount in total to about 470metres of barrier length.

9.3 Rail Link Engineering, constructing the Channel Tunnel Rail Link and its many kilometres of noise barrier, have developed a barrier design which is becoming a railway industry standard. It has been adopted under licence by Railtrack for the West Coast Route Modernisation and further kilometres of barrier are to be installed along the newly quadrupled Trent Valley section. The all-in cost of the RLE barrier, including installation, is highly variable and driven by the foundation requirements and nature of ground but averages £250 metre

9.4 The provisional barrier scheme sketched out in Fig. 4 would represent about £120,000 of investment.

9.5 Among the variables which require further investigation before the barrier dimensions (length and height) and design (reflective or absorbent) can be confirmed are the three dimensional geometry of the Pill site and opinions of residents and the local authority on the need to treat both sides or just the north side of the track.

Table 1
Summary of barrier calculation results

Source: unknown train, brake squealing, measured by Bristol City Council
Receiver: 27 Avon Road, Pill, rear facade, first floor.

Octave band f(Hz)	63	125	250	500	1000	2000	4000	8000	A
Source [1] Leq,t dB	70	63	70	66	58	53	63	78	77
Barrier height [2]/ result[3]									
h= 7 + 2.2m									
Rec.Lin	64	57	63	57	48	42	50	63	
Rec.A	38	40	54	54	48	43	51	62	64
h= 7 + 2m									
Rec.Lin	64	57	63	58	49	42	51	64	
Rec.A	38	41	55	55	49	44	52	63	65
h= 7 + 1.8m									
Rec.Lin	65	57	64	59	50	44	52	66	
Rec.A	38	41	55	56	50	45	53	65	66
h= 7 + 1.6m									
Rec.Lin	65	58	64	60	51	45	54	67	
Rec.A	39	42	56	57	51	46	55	66	67
h= 7 + 1.4m									
Rec.Lin	65	58	65	61	52	47	56	70	
Rec.A	39	42	56	57	52	48	57	69	70
h= 7 + 1.2m									
Rec.Lin	65	58	65	61	53	48	58	73	
Rec.A	39	42	56	58	53	49	59	72	72

Notes

[1] Source levels are unweighted $L_{eq,t}$ (t=event duration, 12 sec) presumably at the facade; originally reported as a graph in 1/3 octaves which have been extracted and summed. (Source: Graph 1 appended to letter T Clarke to Bristol Port Co., 16 July 2002, provided also as copy of original by Bristol Port Co. 09 July 2002).

[2] Barrier height given in format 7 + K metres where embankment is 7m high and barrier of height K is mounted at edge of formation, K = height above local ground in metres;

[3] Result reported as octave band levels, Lin and A-weighted, plus A-weighted sum $L_{Aeq,t}$ dB.

Figure 1
Site photographs

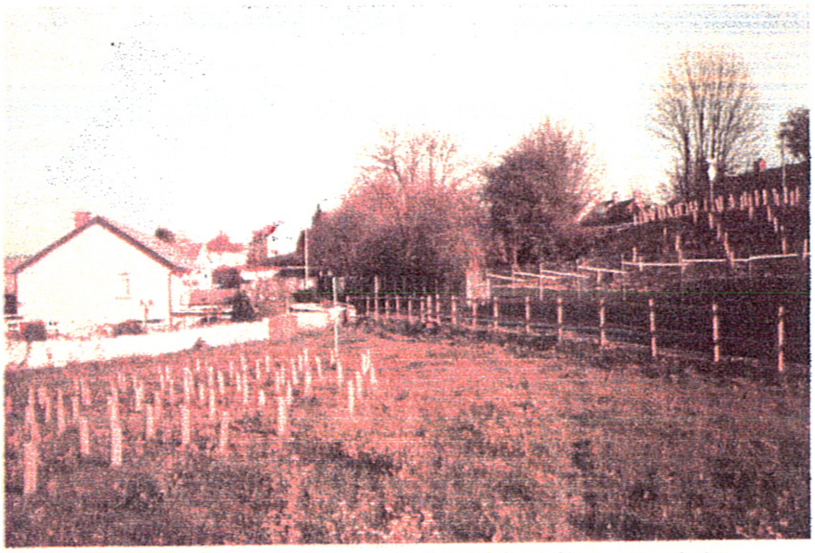


Figure 1a Elevation: 27 Avon Rd to left, railway to right

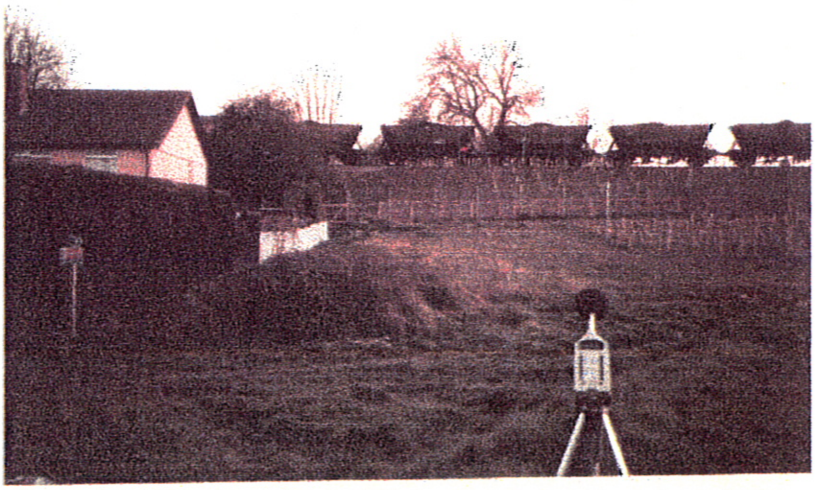


Figure 1b View to railway, HAA wagons passing Avon Rd

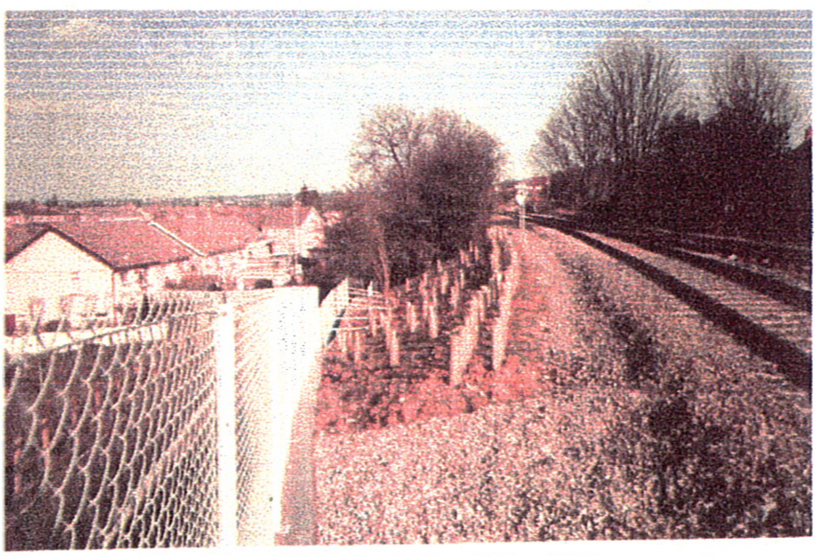
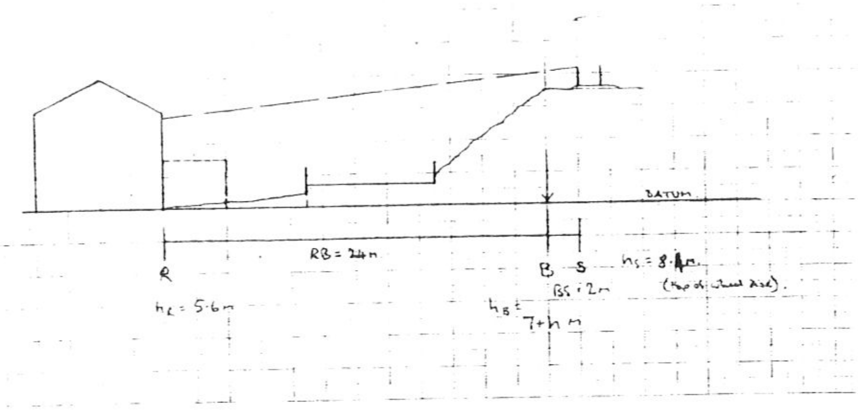


Figure 1c Elevation: 27 Avon Rd to left middle ground

Figure 2
Estimated cross section through 27 Avon Rd and railway
Based on scale plan and photographs. Figs 1a-c



Plan distances correct to scale
Heights estimated

R indicates location of Receiving façade h_R = 5.6m above datum
B indicates location of Barrier h_B = 7+Km above datum[1]
S indicates location of Source h_S = 8.4m above datum[2]

RB = 24m
BS = 2m
RS = 26m

Notes

[1] estimated embankment height = 7m; barrier height Km from top of embankment

[2] rail head 30cm above formation; wheel disc diameter 1.1m so $h_S = 7.0 + 0.3 + 1.1 = 8.4$m

Figure 3 Illustrative calculation of barrier effect: A-wtd resultant, 1st floor, 27 Avon Rd

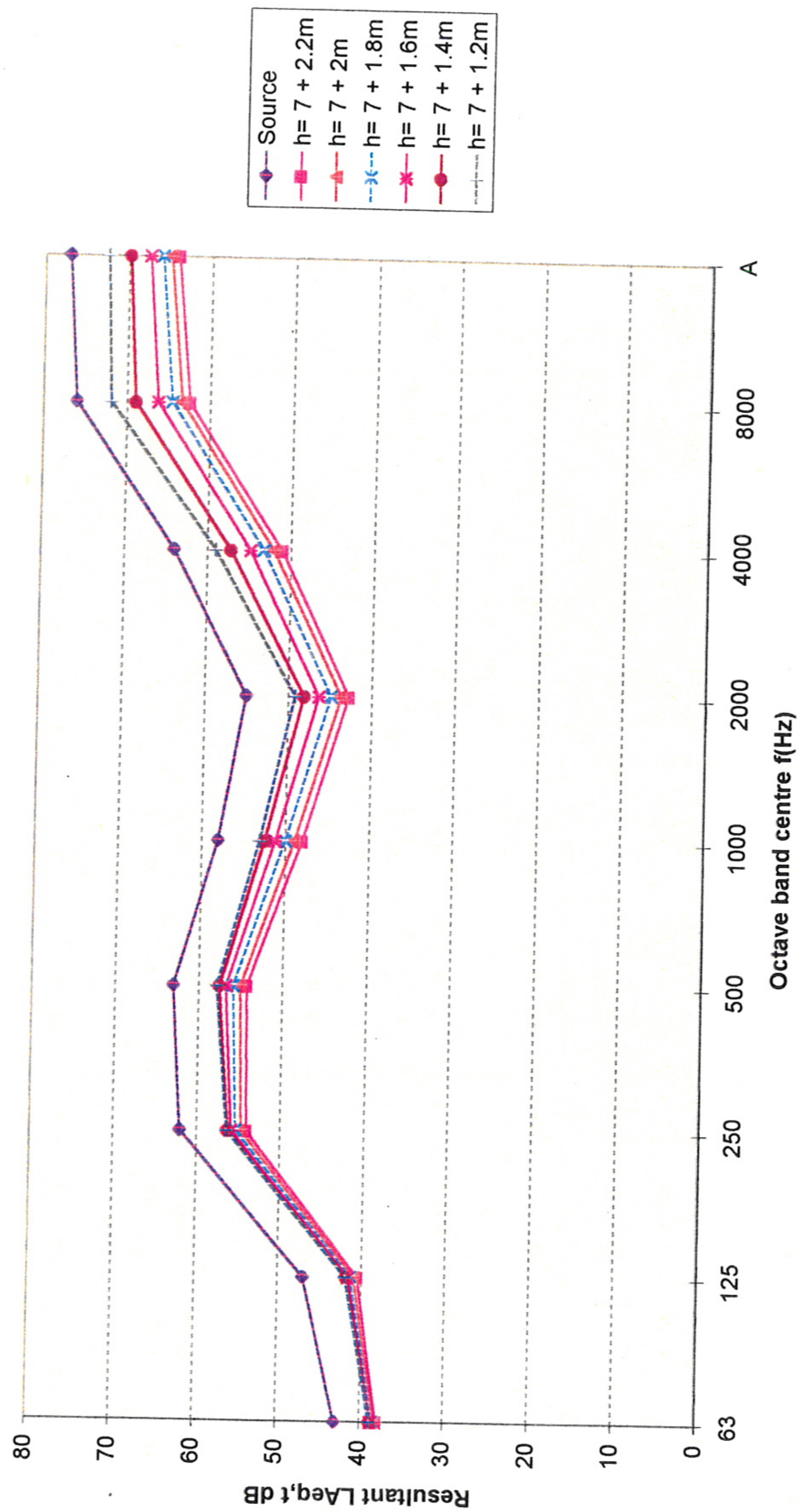
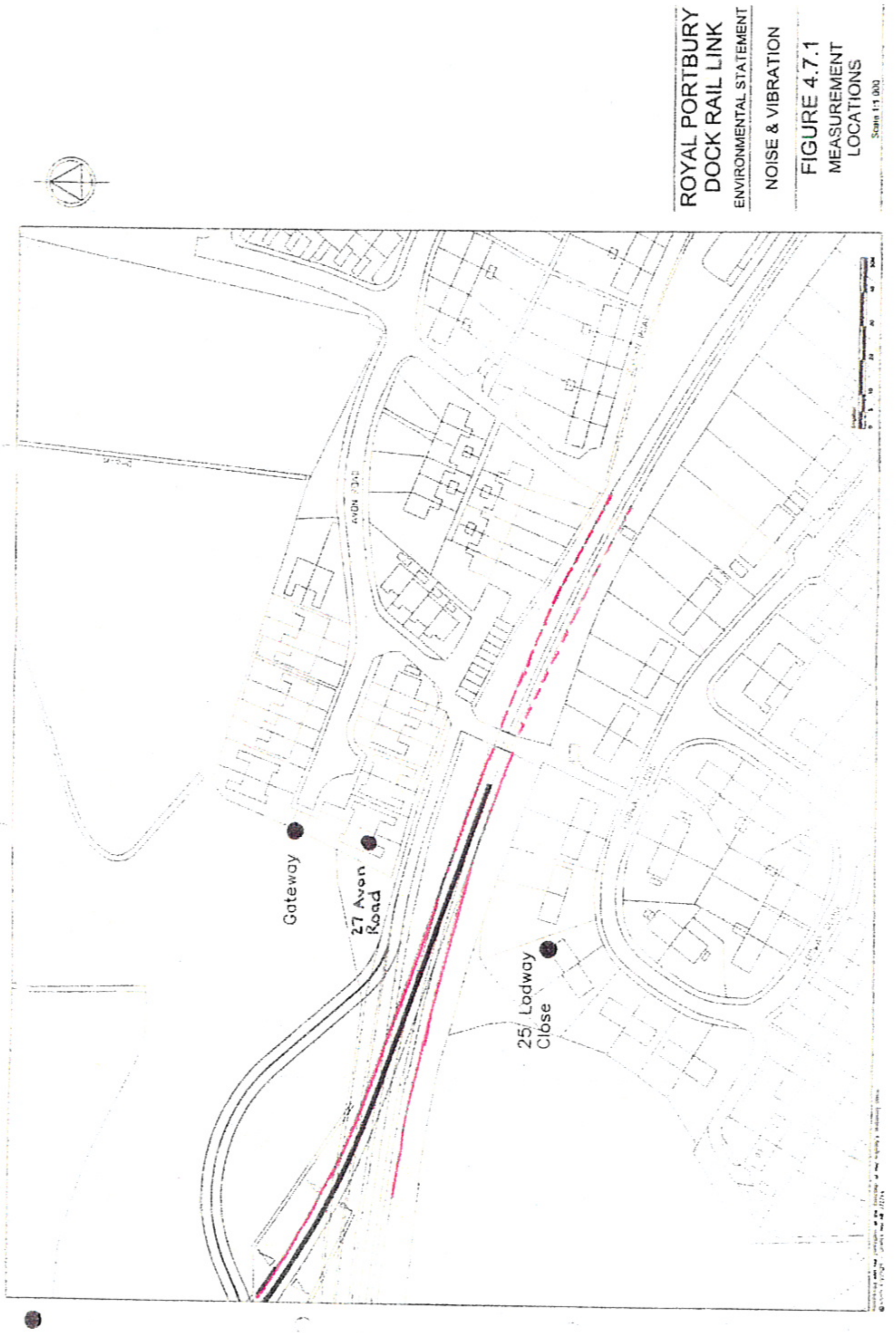


Figure 4
Sketch plan of potential barriers



Not to scale at this size
Solid red line: Potential barrier

Broken red line: barrier, eastern end to be fixed