Proposed
Associated British Ports (Hull)
Harbour Revision Order

Proof of evidence
of

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ACOUSTICS - NOISE - VIBRATION

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1. QUALIFICATIONS AND EXPERIENCE

1.1 My name is Rupert Maurice Thornely-Taylor. I am a Fellow of the Institute of Acoustics and have specialised exclusively in the subjects of noise, vibration and acoustics for more than thirty nine years. I have been an independent consultant in these subjects for the past thirty five years. I am also a director of Rupert Taylor Ltd which specialises in numerical methods of noise and vibration prediction. I am Chairman of the Association of Noise Consultants (ANC).

1.2 I was a member of the Noise Advisory Council chaired by the Secretary of State for the Environment for ten years and was a member of the Scott Committee on whose report the noise sections of the Control of Pollution Act 1974 were based. I was chairman of the Working Group on Noise Monitoring and deputy chairman of the Working Group on Noise as a Hazard to Health. In 1996 I carried out a research project for the then DoE to review its planning policy guidance note PPG24 Planning and Noise. My practice, jointly with Schal, is under contract to DEFRA for the project management of the Noise Mapping of England. I am a BSI nominated member of an ISO vibration working group (ISO TC108/SC2/WG8) and chairman of the ANC working group on BS 6472.

1.3 I have been particularly involved in the prediction and assessment of noise from port developments, having been noise and vibration consultant to ABP since 2000, for whom I appeared as expert witness in the Dibden public inquiry. In the course of that work I studied noise and vibration aspects of the construction and operation of a number of ports.

1.4 I was instructed in April 2003 to assist ERM in connection with their noise and vibration work on Quay 2005.

2 SCOPE OF EVIDENCE

2.1 My evidence covers the topics of vibration and noise, from the construction and operation of Quay 2005.

2.2 I do not propose to rehearse the conclusions of the Environmental Statement. Accordingly I first summarise subsequent further information, following which I address issues raised by Hull City Council and by objectors.

2.3 There being, in the United Kingdom, no prescribed approach to assessing and controlling noise from developments of this kind, section 4 provides a review of matters to be taken into account in assessing noise and vibration from the proposal, and in setting appropriate controls.

2.4 Finally I discuss ABP's proposed controls on noise and vibration including the draft noise management plan.

3 FURTHER INFORMATION SINCE THE ENVIRONMENTAL STATEMENT

3.1 Two reports, "Quay 2005: Assessment of Noise and Vibration from Construction", October 2002 and "Quay 2005: Assessment of Noise During Operations", May 2003 have been issued giving more detailed noise predictions and assessments that are contained in the Environmental Statement. These reports also form the basis of the noise sections of the Quay 2005: Supplementary Environmental Information report dated May 2003.

3.2 The noise predictions and assessments contained in these reports are considered in reaching the conclusions given below.

3.3 The proposed modifications to the Quay 2005 scheme, in particular the decision not to promote Work No. 2 (the Ro-Ro element) will not significantly affect the conclusions of the October 2002 report dealing with construction matters. There has however, since the publication of

the October 2002 report, been further clarification of the proposed construction techniques that may be applied at Quay 2005. These changes are aimed at reducing the impacts of noise and vibration resulting from the proposed piling works that will be required during the construction phase.

3.4 The vibration assessment given in the report *Quay 2005: Assessment of Noise and Vibration from Construction (ERM, October 2002)* assumed the use of an exceptionally large piling hammer for the purpose of driving piles into the chalk. Further consideration has taken account of the fact that other piling carried out in a location adjacent to Quay 2005 was achieved more easily than was assumed for the assessment, because the geotechnical conditions are, for upper layers into which the piles would be inserted, more favorable than assumed.

3.5 It now seems that even if a non-percussive vibratory insertion method cannot be definitely assumed, at least a smaller hammer will be required than the 500kJ per blow unit on which the assessment was based. This is particularly the case for the western return piles where the requirement for vertical load capacity is reduced due to the absence of cranes. The quay design, as proposed, relies on the piles being inserted until they reach the hard chalk below, and achieve either their design load capacity or reach "refusal". Refusal occurs when the increased depth of insertion of the pile during each blow drops significantly and hammering ceases in order to prevent the pile being overloaded. This is the moment when the highest predicted levels of vibration would result, briefly, as explained in the October 2002 report. Use of a percussive hammer of half the energy per blow would lower all the vibration to 70% of the predicted figures, in addition to which the highest levels are likely to exist for an even briefer period than that resulting from the original assumptions. Should the 500kJ hammer prove to be necessary it would be used for the deep water areas of the quay and therefore be a more remote location than the return walls.

4 ISSUES RAISED BY HULL CITY COUNCIL

4.1 Discussions have been held with officers of Kingston upon Hull City Council concerning the noise topic. A paper prepared for ABP was provided to HCC dealing with the approach to operational noise levels and available guidance, including BS 4142 and the WHO Guidelines on community noise. The main contents of that paper are included in section 7 below. Furthermore ABP's decision to delete the proposal for Ro-Ro operations at the western end of the quay had the effect of reducing predicted daytime noise levels.

4.2 The principal matter raised by HCC was the effect of, and control of, operational noise at night, and ABP have developed with HCC both a noise management scheme and the imposition of noise conditions which are set out in section 5 below.

4.3 The noise conditions would be subject to continuous monitoring for an initial period such as six months after the opening of the quay using a fixed microphone mounted at first floor window height in an accessible location relevant to the most exposed location in Corinthian Way.

5 ISSUES RAISED BY HULL & GOOLE PORT HEALTH AUTHORITY

5.1 I will update the inquiry on progress with regard to issues raised by the Port Health Authority.

6 ISSUES RAISED BY OBJECTORS

6.1 The reasons for objections made by third parties include construction and operational noise from the site, including additional road noise. Specific sources referred to include vehicles, vehicle reversing alarms and public address systems. The effect of noise on house prices is raised. Construction noise is claimed to lead to harmful effects on the state of mental and physical health of the populace.

6.2 Apart from the matter of property values, which is outside the scope of my evidence, the matters raised are all addressed in the ES reports and Supplementary Environmental Information from which I draw conclusions below.

7 REVIEW OF MATTERS RELATING TO THE ASSESSMENT AND REGULATION OF NOISE

7.1 PPG 24, "Planning Policy Guidance: Planning and Noise" states in its introduction (para 1) that the aim of the guidance is to provide advice on how the planning system can be used to minimise the adverse impact of noise without placing unreasonable restrictions on development or adding unduly to the costs and administrative burdens of business. It advises at paragraph 10 that "Much of the development which is necessary for the creation of jobs and the construction and improvement of essential infrastructure will generate noise. The planning system should not place unjustifiable obstacles in the way of such development. Nevertheless, local planning authorities must ensure that development does not cause an unacceptable degree of disturbance. They should bear in mind that subsequent intensification or change of use may result in greater intrusion and they may wish to consider the use of appropriate conditions." In Annex 3, paragraph 19, PPG 24 advises that the likelihood of complaints about noise from industrial development can be assessed where the Standard is appropriate, using guidance in BS 4142: 1990 [the current edition is BS 4142:1997]. It adds that in addition general guidance on acceptable noise levels within buildings can be found in BS 8233: 1987 [the current edition is BS 8233:1999].

7.2 BS 4142, "Method for rating industrial noise affecting mixed residential and industrial areas" describes (Foreword) a method of determining the level of a noise of an industrial nature, together with procedures for assessing whether the noise in question is likely to give rise to

complaints from persons living in the vicinity. The foreword adds in its third paragraph "Response to noise is subjective and affected by many factors (acoustic and non-acoustic). In general the likelihood of complaint in response to a noise depends on factors including the margin by which it exceeds the background noise level, its absolute level, time of day, change in the noise environment etc., as well as local attitudes to the premises and the nature of the neighbourhood"

7.3 Of the factors listed as those upon which the likelihood of complaint depends, only the first, the margin by which it exceeds the background noise level, is addressed by BS 4142. The second factor listed, the absolute level, is not addressed, for which purpose PPG24, as mentioned above, advises the use of BS 8233. The current version of BS 8233 makes clear that its purpose is to provide guidance on the design of buildings, so that on the face of it the guidance would not directly apply to the topic of new noise exposure to existing buildings. However, its guidance is effectively the same as that given by the World Health Organization, which is not limited in that way.

7.4 At this point, one may summarise the position by saying that noise assessment should be by means of BS4142 and by other sources giving guidance on absolute noise levels such as the World Health Organization. In the context of the planning and future control of noise from a new development, the guidance needs to be considered within the framework not only of decision-making but also of planning conditions or other controls as far as their reasonableness and capability for enforcement is concerned.

BS 4142

7.5 In summary, the procedure of BS 4142 is to compare the representative noise level of the source under investigation (after correction for acoustic features) with the representative background noise level measured during periods when it is typical for the periods

when the specific noise source will be operating. The words "representative" and "typical" are used advisedly (paras 6.1, 6.3.8, 7.1.2 and 7.1.4). Paragraph 6.3.8 advises "Take the measurement of the specific noise level, T_m, over a time interval which reflects all significant temporal and level variations of the specific noise", and adds in a note that "If [the noise] is cyclic or intermittent or varies randomly, a longer sample will be required to characterize it. It may be necessary to investigate the noise over relatively long periods to select an appropriate, representative measurement time interval."

7.6 There is no requirement to consider the minimum background level nor the worst case source noise level and the assessment should be based on representative and typical values. The acoustic feature correction is applied if the noise contains a distinguishable, discrete continuous note (whine, hiss, screech, hum, etc.); or the noise contains distinct impulses (bangs, clicks, clatters, or thumps); or the noise is irregular enough to attract attention.

7.7 Unscreened, unmitigated port noise tends to contain bangs and clatters from container handling. Whether or not they are "distinct" as required by BS 4142 depends on the effect of mitigation measures including the effect of noise barriers, which tend to reduce high frequency noise (particularly present in bangs and clatters) more than low frequency noise, thus having the effect of reducing the distinctiveness of the noise.

7.8 The assessment method of BS 4142 concludes that the greater the difference between the specific noise level with any required acoustic feature correction (i.e. the rating level) and the background level the greater the likelihood of complaint. A difference (i.e. background level subtracted from rating level) of around +10 dB or more indicates a likelihood of complaints; a difference of around +5 dB is of marginal significance. It the rating level is more than 10 dB below the measured background noise level then this is a positive indication that complaints are unlikely.

7.9 BS 4142 makes clear in its Foreword that the assessment of nuisance is beyond its scope.

World Health Organization

7.10 In 1999 a document was published by the World Health Organization entitled "Guidelines for Community Noise" (1999).

7.11 The document explains (para 4.1) that the guideline values presented "are essentially values for the onset of health effects from noise exposure. It would have been preferred to establish guidelines for exposure-response relationships. Such relationships would indicate the effects to be expected if standards were set above the WHO guideline values and would facilitate the setting of standards for sound pressure levels (noise emission standards). However, exposure-response relationships could not be established as the scientific literature is very limited."

7.12 Thus the WHO document does not seek to set noise standards.

7.13 At para 4.2.7 the guidance advises that, during daytime, few people are seriously annoyed by activities with L_{Aeq} levels below 55 dB; or moderately annoyed by activities with L_{Aeq} levels below 50 dB. Sound pressure levels during the evening and night should be 5-10 dB lower than during the day. Noise with low-frequency components requires even lower levels. It is emphasized that for intermittent noise it is necessary to take into account the maximum sound pressure level as well as the number of noise events. Guidelines or noise abatement measures should also take into account residential outdoor activities.

7.14 A table of guideline values is given related to adverse health effects, which refers to any temporary or long-term deterioration in physical, psychological or social functioning that is associated with noise exposure. There are several potential adverse effects ranging from annoyance, through sleep disturbance to hearing impairment, and when multiple adverse health effects are identified for a given environment,

the guideline values are set at the level of the lowest adverse health effect called, in the table, the critical health effect.

7.15 The guidance considers effects described as moderate and serious annoyance for "outdoor living areas", and "speech intelligibility and moderate annyance" for dwellings indoors. The guidance values representing the onset of the effects mentioned, i.e. levels at which there is no effect, are 50 dB $L_{Aeq,16h}$, 55 dB $L_{Aeq,16h}$ and 35 dB $L_{Aeq,16h}$ daytime and evening. Inside bedrooms the effect considered is sleep disturbance and the guidance values representing the level at which there is no effect, are 30 dB $L_{Aeq,8h}$ 45 dB $L_{Amaxeq,\ fast}$, for night time, with corresponding outdoor values, window open, of 45 dB $L_{Aeq,8h}$, and 60 dB $L_{Amax,\ fast}$.

Application of the guidance to Quay 2005

7.16 The ERM report "Quay 2005, Assessment of Noise During Operations" predicts worst case noise levels $L_{Aeq\ 1h}$ façade at 27 Corinthian Way of 47 dB for Lo-Lo operations, day or night.

7.17 Typical background noise levels are 40 dB L_{A90} at night and 38 dB L_{A90} at night at 27 Corinthian Way.

7.18 In terms of $L_{Aeq,8h}$ as used by the WHO guidance, the prediction for 1 Lo-Lo vessel rather than 3 Lo-Lo vessel of 46 dB is representative. The predicted L_{Amax} is 48 dB.

7.19 The WHO guidance, as explained above, does not set standards, but identifies the level at which the onset of adverse effects occurs, i.e., the level below which there is no effect at all. A predicted level of 46 dB is only 1 dB above this onset value, and PPG 24 goes no further than advising that local planning authorities must ensure that development does not cause an unacceptable degree of disturbance. In other words PPG 24 accepts that disturbance may occur, but that it should not be unacceptable. The WHO guidance does not seek to evaluate the acceptability of disturbance above its onset values. It is clear that if the

guidance were to set planning standards, the noise limits would be greater than the guideline values.

7.20 If higher levels than 46 dB $L_{Aeq\ 8h}$ were predicted, the disturbance would not necessarily be sleep disturbance, but merely the inconvenience of having to have a window open to a smaller extent.

7.21 As far as BS 4142 is concerned, it is important to note that the noise predictions have been converted to façade levels by the addition of 3 dB. BS4142 basically calls for noise levels to be measured at least 3.2m away from façades, except for measurements in locations above ground floor level.

7.22 When predictions, rather than measurements, are being made, the effect of the façade is difficult to predict—if the background comes from all-encompassing sources, the façade effect will be negligible, since it will shield out half the sources but double the intensity of the remaining half. As far as the source noise level is concerned, for sources which are not line sources such as roads and railways, the effect of the façade on the predicted source level depends on the geometry of the site. It is therefore better to following BS 4142's principal advice which is to use a location not in front of a façade.

7.23 The difference between the 27 Corinthian Way prediction, without façade correction, of 43 dB and the typical background is of the order of 5 dB by night, and 3 dB by day, if no acoustic feature correction is applied. This is of "marginal significance" by night and better than "marginal significance" by day. If it is argued that despite the effect of the noise screening effects (see above) there should be an acoustic feature correction of +5 dB, the daytime conclusion still does not reach the "complaints likely" threshold, and the night time conclusion just reaches it. However, given the parallel favourable conclusion of the WHO guidance, and the PPG24 guidance, this should not be grounds for refusal of powers for the development.

7.24 For Spinnaker Close, the background is about 5 dB lower than for Corinthian Way, but the noise predictions are 6 dB lower so that the position is better than at Corinthian Way, and this will be the case for the remainder of the residential development.

8 PROPOSED CONTROLS ON NOISE AND VIBRATION

8.1 Noise and vibration from Quay 2005 will be controlled in the following ways:

Construction

8.2 ABP will ensure that prior consents are obtained under the provisions of S61 of the Control of Pollution Act 1974. This will enable the local authority to ensure that the best practicable means for the control of noise and vibration are used in the carrying out of the construction work. Vibration during construction will cause no damage to property, but will be perceptible in the nearest houses.

Operation

8.3 ABP have agreed with officers of Hull City Council a set of planning conditions to form part of the Harbour Revision Order for the control of noise and vibration, and a Noise Management Plan. These are reproduced in Appendix II, and are set in terms of free-field noise levels for an accessible location relevant to the nearest and/or most exposed residential receptors. There will be negligible vibration from the operation of the port.

8.4 The noise management plan aims to ensure best practice to minimise noise emissions, and addresses matters including future improvements and new technologies, procurement and maintenance of plant to minimise noise emissions, noise barriers, noise control of warning alarms, vessel berthing preferences and procedures, community liaison and complaints response procedures.

9 CONCLUSIONS

Construction

9.1 The only activity which will occur at night, capital dredging, will be restricted to locations distant enough from the nearest houses to ensure that no sleep disturbance will occur.

9.2 By day, use of the provisions of prior consent procedure of S61 of the Control of Pollution Act will secure the application of the best practicable means to minimise noise. While piles for the quay wall are being driven closest to the nearest houses, there will be a significant noise effect for a period of a few weeks and perceptible vibration will occur which may give rise to adverse comment. At all other times there will not be a significant noise effect, and for most of the construction period the predicted noise levels will be low.

Operation

9.3 Noise from the operation of Quay 2005 will be controlled to levels which, at night, are within 1 dB of the World Health Organisation's guidance level for the onset of sleep disturbance, and, to the extent that it is relevant, the government's draft guidance MPS 2 for mineral extraction sites, being the only instance of absolute government guidance on noise from industrial sites. By day, the levels are 2 dB better than the MPS 2 limit, and within 1 dB of the World Health Organisation's guidance level for the onset of serious annoyance in "outdoor living areas".

9.4 These assessments assume open windows. With windows partially or fully closed, the indoor noise levels will be further reduced. There will be negligible vibration during operation of the port.

9.5 Overall, the proposals satisfy the guidance given in PPG 24, and the controls put forward will ensure that development does not cause an unacceptable degree of disturbance.

GLOSSARY

dB Decibel. The decibel scale measures levels relative to a reference, either a fixed reference when measuring absolute levels, or another level when expressing changes. If the quantity is power-like (i.e. could be expressed in watts) the level in decibels is 10 times the common logarithm of the ratio of the measured quantity to the reference quantity. If the quantity is a physical amplitude such as pressure or voltage, and the power of the quantity is related to the its square, then the decibel level is 20 times the common logarithm of the ratio of the measured quantity to the reference quantity. Thus doubling of power gives a 3 dB increase, while a doubling of pressure gives a 6 dB increase.

L_A A-weighted sound pressure level. The units are decibels, abbreviated dB (or dB(A) if the subscript A is omitted). A-weighting is a frequency weighting which discriminates against low frequency and very high frequency sound in order to approximate the frequency response of the human ear. The subscript *s* or *f* signifies that the time constant of the measurement is either 'slow' (1 second) or 'fast' (125 milliseconds)

L_{Amax} The maximum value of L_A reached during one or more noise events. (See reference to '*s*' and '*f*' subscripts above).

$L_{Aeq,T}$ Equivalent continuous sound level. The root mean square sound pressure level determined over time interval T expressed in decibels. May be regarded as the level of a notional steady sound which has the same energy in period T as an actual time-varying sound which occurs in the same period. Sound level, duration and number of events are treated such that doubling the number of events, or doubling the duration of an event, has the same effect as doubling the number of sources (i.e. doubling the energy), which in the decibel scale is an increase of 3 dB (see above).

L_{A10} The A-weighted sound level in dB which is exceeded for 10% of the time period stated.

ppv Peak particle velocity, the highest instantaneous velocity reached by a vibrating surface.

VDV Vibration Dose Value, the fourth root of the time integral of the fourth power of the frequency-weighted vibration velocity. The frequency weightings are specified in BS 6841:1987 and BS 6472:1992. The units are ms-1.75.

SEL_v Sound Exposure Level (or Single Event Level), the time integral of the squared sound pressure expressed in decibels. May be regarded as $L_{Aeq,T}$ normalised so that T is one second regardless of the actual duration of the event. Is used to construct $L_{Aeq,T}$ for a period containing many noise events, from knowledge of the SEL_v for each individual event.

APPENDIX I

Noise And Vibration Units

The noise levels to which I will refer are expressed using the decibel scale. The decibel scale has the characteristic that it measures proportions rather than absolute quantities, so that, for example, doubling the amount of energy in a sound (for example by putting two identical sound sources close together) always causes an increase of 3 decibels, whether it is a doubling of a large or of a small amount of noise energy. However, as I shall explain, the perceived loudness of a doubling of noise energy is quite small, and certainly much less than a doubling. A tenfold increase in the amount of energy gives an increase of 10 decibels, although, once again, the perceived increase in loudness is not nearly as great as the increase in energy would suggest and a ten fold increase in energy is certainly not a tenfold increase in loudness.

The kind of decibel scale most commonly used for overall noise assessment is known as the 'A-weighted decibel' or dB(A). The 'A-weighting' is a method of causing measuring instruments to respond in approximately the same manner as does the human ear, which is comparatively insensitive to low-pitched and very high-pitched sound. For example, two sounds which are perceived as the same loudness may have widely differing physical magnitudes if one is a low rumble and the other is a whistle. Without 'A' weighting, the low rumble would measure some 30 decibels more than the whistle, even though they both sound equally loud. In 'A-weighted decibels' both sounds would have the same decibel, or dB(A), level. Noise levels in dB(A), like the basic decibel scale, measure proportions so that a 10 dB(A) increase is a doubling of loudness and a 10 dB(A) decrease is a halving of loudness. Judgment of loudness is subjective, and dependent on the characteristics of the sound, but the '10 dB(A) increase is a doubling of loudness' rule is a useful general guide. For example, ten motor cycles close together sound only about twice as loud as one motor cycle, and certainly not

ten times as loud; the same is true of one motorcycle which emits ten times as much sound power as another. As a further guide, one may say that a sound level of less than 20 dB(A) is virtual silence, 30 dB(A) is very quiet. 50 dB(A) is a moderate level of noise, 70 dB(A) is quite noisy and in a noise level of 90 dB(A) one has to shout to be understood.

The measurement of sound levels in decibels involves a kind of averaging process in which the fluctuating pressure signal is squared, averaged, and the square root obtained. This process is known as r.m.s. averaging, and it takes place over a defined time. There are two standard averaging times, 1/8 second, known as 'F' response and 1 second, known as 'S' response. In the present context, the dB(A) levels to which I refer are to be measured using the 'S' response.

The basic dB(A) scale can only measure the instantaneous level of sound, and where the level of sound fluctuates up and down, as it normally does in the environment, the dB(A) level also fluctuates. When it is necessary to measure a fluctuating noise environment by means of single number, an index known as equivalent continuous sound level, or LAeq, is employed. LAeq (which in some documents is referred to as Leq rather than LAeq - the two terms have the same meaning) is a long term average of the amount of energy in the fluctuating sound, expressed in dB(A). In the case of a continuous, unchanging sound, its LAeq level is the same as its sound level in dB(A). Because a 3 decibel change is caused by a doubling or halving of sound energy, then it follows that if the sound energy entering an ear or a microphone over a particular period of time is doubled or halved, because the same sound went on for twice or half as long as it did previously, then the amount of energy received will be doubled or halved. The result is that the LAeq level will go up or down by 3 dB just as it would if the amount of energy in the sound, rather then the duration of the sound, had doubled or halved.

The consequence is that the L_{Aeq} scale will measure either the level of sound, or the duration of sound, or a combination of both such as the number and noise level of a series of train passages. Since the L_{Aeq} index is based on the dB(A) scale, it will measure loudness in the same way, that is, an increase of 10 units on the L_{Aeq} scale sounds like a doubling in loudness if the increase is due to the same sound just getting louder. Alternatively, a 10 unit increase could be due to a tenfold increase in the number of sounds all of the same individual loudness and duration.

Vibration

Although low frequency airborne noise from sources such as heavy lorries can cause perceptible movement of building elements, such as rattling of windows, which is described by people as vibration, in my evidence the term 'vibration' is restricted to displacement of the ground or of structures due to the propagation of waves through the ground.

Wave propagation in the ground takes several forms. Some waves spread out underground in a manner analogous to sound waves in air (although there exist both compressional and shear waves), others travel on the surface in a manner more analogous to the surface ripples of a pool of water. These waves travel at different speeds and are attenuated at different rates. The underground waves, or body waves as they are sometimes called, may undergo reflection from underground features such as rock strata.

In the case of trains running on the surface, surface waves are important. For railways in tunnel, body waves are of prime importance since these transmit ground-borne noise which may be radiated inside noise-sensitive buildings.

The basic units of vibration measurements relate to the movement of the surface which is vibrating. This can be measured either in units of velocity in metres per second (m/s) or of acceleration in metres per

second per second (m/s^2). For small values millimetres may be used instead of metres.

In fact, the decibel scale is sometimes used for the measurement of vibration as well as of noise, and for example, when velocity is measured in decibels above a reference level of one billionth of a metre per second then a velocity level of 120 dB is 1 millimetre per second (1 mm/s).

Again, as with noise, human sensitivity to vibration depends on the frequency of the vibration. There are weighting curves like the 'A-weighting' of noise measurements in dB(A). The sensitivity of a person to vibration depends to some extent on the direction of the vibration relative to their posture at the time - for example vertical vibration in the floor is perceived differently by a standing person and a person lying down. There are therefore different weighting curves for vibration in the vertical (up and down the spine), horizontal (front to back) and lateral (side to side) directions. The most sensitive is the vertical direction (known as 'z-axis'). Weighted acceleration of 'z-axis' in units of m/s^2 is approximately equal to velocity in units of m/s multiplied by 50, provided that the frequency of the vibration is greater than 8 cycles per second (8 Hz).

As is the case with noise, it is necessary to take account of the effect of intermittency on human response, when vibration is not continuous. Whereas with noise this is done using the L_{Aeq} index, for vibration the method used is to sum the fourth power of the weighted acceleration, and express the fourth root of the result as an index known as vibration dose value or VDV, which now forms the basis of advice given in the 1992 edition of British Standard 6472.

Vibration can also give rise to re-radiated airborne noise. In this case the noise is measured using the dB(A) scale, and for all recent railway projects where ground-borne noise has been an issue, the maximum

value of the re-radiated noise level measured on 'S' response, known as $L_{Amax,S}$ has been adopted as the assessment index.

APPENDIX II

Draft planning conditions

DRAFT AMENDMENTS TO THE HRO

(OPERATIONAL NOISE)

(1) Operational noise emitted from the site (excluding construction activities), shall be monitored in accordance with paragraph (2) below and, to the extent that it is under the control of A.B. Ports, controlled so as not to exceed the limits stated in Table 1 measured at the specified location.

Table 1 Limits for Operating Noise

Period	**Time**	**Noise Limit**	
Daytime: Monday – Friday Saturday	0700-1900 0900-1900	53 dB $L_{Aeq\ (1hr)}$	
Evening: Monday – Saturday Daytime: Sunday	1900-2300 0900-1900	46 dB $L_{Aeq\ (1\ hr)}$	
Night-time: Monday – Friday Friday – Sunday Sunday – Monday	2300-0700 2300-0900 1900-0700	44 dB $L_{Aeq\ (1hr\ )}$	48 dB L_{Amax}

Bank Holidays to be taken as Sunday.

$L_{Aeq\ 1\ hr}$ will be the highest recorded value over the time period.

Note 1: Measurements shall be disregarded if the wind speed measured at a relevant location exceeds 5 metres per second.

Note 2: Measurements shall be disregarded if the background noise determined using the same units in accordance with 2 (i) below is within 3 dB of the levels stated in Table 1.

(2) Before the commencement of operations at the site, a scheme for monitoring noise arising from operations on the site shall be submitted to and approved by Kingston upon Hull City Council (HCC). The scheme will provide for the following matters:-

(a) the supply, installation and maintenance of a monitoring system at the specified location, and at a location determined by calculation and/or measurement as suitable, by virtue of additional distance from the works such that site-related noise is at least 7 dB lower than at the specified location, for measurement of background noise for a period of not less than six months;

(b) the monitoring system to be capable of inspection and interrogation by HCC and A.B. Ports at any time;

(c) continuous measurement and recording of wind speed either at the specified location or at a location from which the wind speed at the specified location can be inferred.

Once approved, the scheme shall be implemented in accordance with its terms.

(3i) In the event that noise levels at the specified location exceed the limits in Table 1, subject to the provisos of Note 1 and Note 2, A.B. Ports shall undertake further measurements to investigate and such further measures as may be necessary to identify the cause, and insofar as the source of the noise is under their control, take remedial action to reduce noise emission from the site to within the limits in Table 1 and take all reasonable action to prevent any repetition of a breach of the limits.

(3ii) In the event that A.B. Ports is unable to identify the cause of increased noise levels, HCC, may, by itself or through its duly authorised agent and at the expense of A.B Ports, undertake such reasonable measurements and investigations as it deems necessary to identify the cause and in the further event that the cause is established by HCC, provided that the source is under A.B. Ports' control, shall submit a programme of reasonable remedial action to reduce noise emission and prevent repetition and A.B Ports shall promptly undertake, at its own expense, the action specified.

(4) In paragraphs 1 to 3 –
"the site" means the area of Work No. 1 and as constructed and any area dredged under article 9;
"the specified location" means at a free-field location 4m above local ground level near and to the south of 27 Corinthian Way.