16 Noise and Vibration

An assessment of noise and vibration for the proposed scheme has been carried out in line with national guidance, including DMRB, Volume 11 Section 3 Part 7 (2008).

Predictions of traffic noise across the study area have been made for scenarios with and without the proposed scheme (Do-Something and Do-Minimum scenarios respectively), in the scheme opening year (2017) and the future assessment year (2032).

Noise impacts were initially identified by assessing the noise level differences between the Do-Something scenario in 2032 and the Do-Minimum scenario in 2017. These data were then considered alongside other criteria set out in the Noise and Vibration Policy Statement (Appendix A16.2) and Noise Impact and Significance Criteria (Appendix A16.4) to assess which areas would be subject to potentially significant effects.

The scheme design includes various noise-reducing features such as earthworks. Following the identification of significant effects, the feasibility of specific noise mitigation (noise bunds and barriers) was investigated for each of the areas subject to adverse significant effects and mitigation designed as appropriate and where practicable.

Significant residual beneficial effects are predicted as a result of the substantial reduction in traffic on some existing roads: for properties in South Queensferry to both the east and west of the Forth Road Bridge approach road, and for properties in the southern edge of South Queensferry due to the decrease in traffic on the A904.

The mitigation proposed removes three significant adverse effects and reduces the majority of the remaining adverse effects. Nonetheless, significant residual adverse noise effects are predicted as a result of noise from the scheme's new roads at properties to the west of the Main Crossing southern approach, including properties at Linn Mill, and properties to the east of the Main Crossing southern approach in South Queensferry, including properties on Clufflat Brae, Springfield Lea, Springfield Place and Springfield Terrace.

No potentially significant vibration effects were identified.

16.1 Introduction

16.1.1 This chapter presents an assessment of the predicted operational noise and vibration impacts of the proposed scheme. Construction noise and vibration effects are described in Chapter 19 (Disruption due to Construction). The chapter is supported by the following appendices, which are cross-referenced in the text where relevant:

- A16.1: Noise and Vibration – Introduction and Terms;
- A16.2: Noise and Vibration Policy;
- A16.3: Baseline Noise Surveys; and
- A16.4: Noise Impact and Significance Criteria.

16.1.2 The assessment has been carried out according to methodology based on the guidance provided in DMRB Volume 11 Section 3 Part 7 (HA 213/08) 'Noise and Vibration' for a Detailed Assessment. The assessment of potential road traffic noise impacts on ecological receptors is provided in Chapters 10 and 11.

16.1.3 The Noise and Vibration Policy (Appendix A16.2) sets out the approach the Promoter, The Scottish Ministers, proposes to adopt to mitigate noise and vibration from the operation of the Forth Replacement Crossing which is proposed to be authorised by the Forth Replacement Crossing Bill. This assessment has been carried out in line with the advice included in the policy statement.

16.2 Approach and Methods

Policy and Guidance

16.2.1 The assessment and mitigation of road traffic noise and vibration is carried out according to established prediction and assessment methodologies that are governed or guided by the following key documents:

- DMRB Volume 11 Section 3 Part 7 (HA213/08), Noise and Vibration, which includes guidance on the assessment methods for noise and vibration from new highways. DMRB is adopted by Transport Scotland for new trunk road schemes. The latest revision, issued in August 2008 has been used in this assessment and is referred to as 'DMRB (2008)'.
- DMRB Volume 11 Section 2 Part 5 (HA 205/08), Assessment and Management of Environmental Effects.
- Calculation of Road Traffic Noise (CRTN) (Department of Transport Welsh Office, 1988) prediction of traffic noise methodology as required by DMRB (2008).
- The Environmental Impact Assessment (Scotland) Regulations 1999 (as amended).
- Noise Insulation (Scotland) Regulations (NISR) 1975 (HMSO, 1975). The NISR define the scenarios under which dwellings are eligible for noise insulation to control internal noise levels when it has not been possible to control external noise within defined criteria. The qualification threshold was derived from the Noise Advisory Council guidance (HMSO, 1974).

Consultation

16.2.2 Consultation has taken place with the relevant local authorities (City of Edinburgh Council, West Lothian Council and Fife Council) and Transport Scotland as part of the assessment (Appendix A6.3 provides a summary of key consultation issues).

16.2.3 During the consultation, the approach to the assessment, potential mitigation and mitigation criteria were discussed. This also provided opportunities for the consultees to highlight any areas considered particularly sensitive, and to agree the locations used for baseline noise monitoring. As noted in Chapter 6 (Consultation and Scoping), public exhibitions were held in January 2009 and there has also been a series of meetings with local community groups. These provided the opportunity for local stakeholder groups and members of the public to raise queries and concerns to Transport Scotland and Jacobs Arup environmental representatives on noise and other issues.

Identification of Noise and Vibration Sensitive Locations

16.2.4 DMRB (2008) provides examples of noise sensitive receptors. These include dwellings, hospitals, schools, parks, and public rights of way such as footpaths.

16.2.5 For the purposes of the assessment, noise sensitive receptors were identified primarily using Ordnance Survey (OS) Address Point data, which lists the postal addresses of all properties within the noise study area (the noise study area is defined later in this section). Using these data, all residential properties were located, and keyword searches used to identify schools, hospitals, care homes etc. The non-residential noise-sensitive receptors identified are shown on Figure 16.1.

16.2.6 The major sites of cultural heritage interest in the noise study area that may be potentially sensitive to noise impact have been identified as follows: St Margaret's Hope (also known as Admiralty House), Port Edgar, Dundas Mains, Inchgarvie House, Echline Farm House and Echline Cottages.

16.2.7 Major sites of ecological interest (Chapter 11: Estuarine Ecology) that may be potentially sensitive to noise impact have been identified as Long Craig Island and Port Edgar.

16.2.8 Noise impacts at all these noise sensitive receptors have been evaluated for the proposed scheme design.

Assessment Methodology for Operational Noise and Vibration

Road Traffic Noise

16.2.9 Geographical Information Systems (GIS) have been used to construct a 3-dimensional noise model of the study area. The model includes terrain data, buildings and other structures that might screen or reflect noise, ground cover types and road links. Design drawings of the proposed road alignments and groundworks, including the proposed Main Crossing design, were incorporated to ensure an accurate representation of the proposed scheme.

16.2.10 For each road link in the model, data on traffic flow, speed, proportion of heavy goods vehicles (HGVs) and road surface type were entered into the model. Noise level calculations according to CRTN were carried out using proprietary 'off-the-shelf' noise modelling software. Traffic noise levels were calculated across a grid of receiver positions over the study area, and contours of noise level exposure were established. Additional calculations were also conducted at each property facade to establish noise and nuisance change at each dwelling.

16.2.11 The traffic data used in the model were those projected with and without the proposed scheme both in the baseline year (2017) - i.e. opening year - and those projected in the future assessment year i.e. the year of maximum projected traffic flow within 15 years of opening – in this case, 2032. These traffic data were combined with the physical data to produce the following four scenarios:

- Do-Minimum (without the proposed scheme) in the opening year (2017);
- Do-Minimum (without the proposed scheme) in the future assessment year (2032);
- Do-Something (with the proposed scheme) in the opening year (2017); and
- Do-Something (with the proposed scheme) in the future assessment year (2032).

16.2.12 The noise study area is defined as 600m around new or altered highways and sections of existing roads within 2km of the new works that are predicted to be subject to a change in noise level of more than 1dB(A) as a result of the proposed scheme on opening. Collectively these are called 'affected routes'. Existing roads subject to a change of 1dB(A) or more were identified by traffic forecasts predicting, as required by DMRB (2008), an increase in flow by at least 25% or decrease by 20% in the scheme opening year (although ignoring those where the predicted traffic flow was <1000 in both with-scheme and without-scheme scenarios[1]).

16.2.13 Figure 16.1 shows the noise study area and the road links used to define it.

16.2.14 The noise model was used to calculate noise levels within the noise study area, at a height of 4m above local ground, in terms of the free-field $L_{A10,18h}$ index in accordance with CRTN methodology, (as required by DMRB (2008)), for each of the four scheme scenarios as listed previously in paragraph 16.2.11.

16.2.15 The $L_{A10,18h}$ index represents the arithmetic mean of all the hourly values of L_{A10} (A-weighted sound level in decibels that is exceeded for 10% of the measurement period) during the period between the hours of 06:00 and 24:00. The CRTN procedures assume typical noise propagation scenarios which are consistent with moderately adverse wind velocities in all directions. The additional advice given in DMRB (2008) has been adopted regarding CRTN procedures. These include revisions to vehicle classification, traffic data and corrections due to road surface.

[1] Eighteen hour flows <1000 were excluded as CRTN considers predictions of noise based on such flows to be unreliable.

16.2.16 Baseline noise survey results (as detailed in Appendix A16.3) were used to verify the predicted noise levels (Section 16.3).

16.2.17 Noise difference contour maps were produced using the results from the calculations to graphically represent the noise changes within the noise study area. These noise maps are referenced in Section 16.4 and Section 16.6.

16.2.18 As part of the procedure for a Detailed Assessment, DMRB (2008) requires that the magnitude of the noise impact is reported using a suggested scale of magnitude to describe the increase or decrease in noise level associated with the proposed scheme. The magnitude scale is described in more detail in a later section, in Appendix A16.4 and is included in Table 16.1. This assessment of impact magnitude is required for the following scenarios:

- Do-Something scenario in the 2017 baseline year against the Do-Minimum scenario in the 2017 baseline year; and
- Do-Something scenario in the 2032 future assessment year against Do-Minimum scenario in the 2017 baseline year.

16.2.19 To complete the Assessment Summary Tables also required by DMRB (2008) the noise model was also used to calculate the noise level at 1m from the centre of every façade longer than 2m of every building in the noise study area, at a height of 4m above local ground. Professional judgement was used to establish that due to the number of façades on some complex buildings it was reasonable to exclude façades <2m in length as most facades of this length would not contain a sensitive window.

16.2.20 To populate the Assessment Summary Tables, dwellings are classified according to their façade noise levels in the Do-Minimum baseline year in 3dB(A) bands (47.5dB(A) to 83.5dB(A)) with a band for noise less than 47.5dB(A) and greater than 83.5dB(A) as required by DMRB). In the event that there is predicted to be a decrease on one façade and an increase on another, the worst case predicted noise change in noise level is reported, i.e. the largest increase. However, for a scheme such as FRC where there are significant decreases in noise along some existing highway corridors and so the consequences of assuming the worst case noise change should be considered. Standard ASTs and a number of supplementary ASTs are therefore provided (see Section 16.4), presenting the results of the scheme wide assessment of dwellings and other sensitive receptors subject to noise change and change in noise nuisance.

16.2.21 The traffic noise nuisance changes required by the ASTs have been calculated according to the DMRB (2008) method and presented in bands as follows: <10 percentage points, 10<20 percentage points, 20<30 percentage points, 30<40 percentage points and ≥40 percentage points.

16.2.22 For the Do-Something scenario, it is the highest increase in nuisance that occurs between the opening and future assessment years that is reported; this often occurs in the opening year. This is because the short-term response curve used to calculate the nuisance level immediately after opening is likely to calculate a higher nuisance level than the steady-state curve which is used for the future year. The full details and background of the response curves described above is described in DMRB (2008). This is discussed further in Section 16.4 and 16.6.

16.2.23 For dwellings between 600m and 2km of the proposed scheme, that fall outside the Noise Study Area, an assessment of noise changes using Basic Noise Levels (BNLs) has been undertaken where dwellings lie within 50m of affected routes as defined in paragraph 16.2.12. The Basic Noise Level is the noise level at a reference distance of 10m from the carriageway edge, derived using CRTN methodology.

16.2.24 DMRB (2008) requires a qualitative statement regarding prevailing wind and whether that could influence the comparison between the Do-Minimum and Do-Something scenarios. The CRTN prediction methodology allows for moderately adverse wind velocities in all directions, which will be consistent in both the Do-Minimum and Do-Something prediction scenarios.

16.2.25 DMRB (2008) also requires that an assessment of the cumulative noise and vibration effects is undertaken. This includes identifying likely compound effects of noise or vibration with other environmental topic-specific impacts upon people, dwellings and other sensitive receptors. This is presented in Chapter 21 (Cumulative Impact Assessment). The cumulative noise and vibration effects on the proposed scheme and other currently planned projects within the noise study area are also considered within Chapter 21.

16.2.26 In addition to the above, a night-time noise assessment was conducted to establish if particular receptors may be more affected at night than during the daytime. This can occur due to disproportionately heavy night-time traffic volumes or because of atypical increases in the proportion of heavy vehicle traffic at night. The assessment is described in Section 16.4.

16.2.27 The results of all the assessments have been used to develop appropriate noise mitigation. This is discussed further later in this section, which covers noise-reducing design features of the base scheme, and in Section 16.5 that considers mitigation to reduce or remove significant effects evaluated for the base scheme. The resulting noise levels and residual significant effects following mitigation are assessed in Section 16.6.

16.2.28 Effects on fauna are addressed within Chapter 10 (Terrestrial and Freshwater Ecology) and Chapter 11 (Estuarine Ecology) based on the measured and predicted noise levels presented in this chapter.

Road Traffic Vibration

16.2.29 DMRB (2008) recommends that the effects of vibration should also be considered where appropriate. In the case of ground-borne vibration, the likelihood of perceptible vibration being caused is particularly dependent upon the smoothness of the road surface. Research has shown that vibration levels caused by heavy vehicles travelling at 110kph over a 25mm hump (i.e. a large discontinuity consistent with poorly backfilled trench) could cause perceptible vibration at up to 40m from the road (Watts, 1990). This would infer that it is unlikely that significant levels of vibration would be generated at distances greater than this. Also, with a newly laid road surface it is a requirement of new highway construction specification that the surface would be smooth and free from any discontinuities of this magnitude. Paragraph A2.26 of DMRB (2008) states: 'Such vibrations are unlikely to be important when considering disturbance from new roads and an assessment would only be necessary in exceptional circumstances'. As noted the Noise and Vibration Policy (Appendix A16.2) no such exceptional circumstances are envisaged for the FRC and hence no impacts or effects from groundborne vibration are predicated.

16.2.30 The DMRB (2008) covers the potential for airborne noise, from heavy goods vehicles, to cause vibration nuisance close to main roads. As an indication of the scale of impact relative to noise effects, the guidance in DMRB (2008) paragraph A3.22 states that for a given level of traffic noise exposure the percentage of people bothered very much or quite a lot by airborne vibration is 10% lower than the corresponding amount for noise nuisance. It is noted in paragraph A3.22 that airborne vibration is expected to affect a very small percentage of people at exposure levels below $58dBL_{A10,18h}$. Also, the significance of any change in airborne traffic vibration can be considered proportional to the significance of changes in traffic noise. As such the assessment of airborne vibration can be considered included within the assessment of airborne noise.

16.2.31 The impact of vibration effects is discussed further in Section 16.4.

Baseline Scenarios

16.2.32 Baseline noise levels within the study area were predicted using the noise model for the Do-Minimum baseline year (2017) traffic scenario as required by DMRB (2008), paragraph 3.45. The CRTN prediction method is described earlier in paragraph 16.2.10. This provides noise forecasts across the entire study area under consistent scenarios (i.e. not subject to traffic flow variations, or meteorological variations that would affect propagation scenarios). The CRTN procedure assumes

a moderately adverse wind scenario; that is with the wind blowing from the source to the receiver (as described in CRTN paragraph 4).

16.2.33 The noise environment in the whole of the study area is generally dominated by traffic noise (and therefore predictable using the road traffic noise model). In some locations there may be some contributions from other noise sources including rail and aircraft noise, although at all of the attended noise survey positions road traffic formed the dominant source of noise (Appendix A16.3). This method of using the traffic model to quantify baseline noise levels is standard practice for highway noise assessment with the predicted levels for areas further from traffic noise sources or areas close to non-traffic sources being checked against noise survey measurement data.

Noise Measurement Survey

16.2.34 The survey methodology, results and survey locations are presented in Appendix A16.3 (Baseline Noise Surveys).

16.2.35 A baseline noise survey was conducted to establish existing noise levels at a sample of sensitive locations within the study area according to guidance provided in DMRB (2008). These site investigations were also considered important to determine if certain parts of the study area are influenced by noise from sources other than traffic. At all of the attended noise survey positions, road traffic formed the dominant source of noise (Appendix A16.3).

16.2.36 As discussed later, the survey data have also been used to check the Do-minimum noise prediction. It should be noted that some variance between existing measured noise levels and predicted noise levels for the baseline scenario prior to opening of the proposed scheme would be expected. For example, this might be due to differences in traffic flow levels between the present and the opening year or meteorological scenarios at the time of the survey.

Receptor Sensitivity

16.2.37 DMRB does not define a scale of noise sensitivity relating to different building types or other receptor locations. DMRB requires the author of a noise assessment to use professional judgement in this area (Appendix A16.4). Residential receivers are regarded as some of the most sensitive receptors, although other noise-sensitive receptors are described in DMRB (2008) such as hospitals, schools, parks and public rights of way. The relative sensitivity of the receptors is dependent on the exact nature of use and various other parameters which cannot be ranked simply by the type of receptor. These would include:

- type of communication taking place e.g. teaching, sports, public meeting;
- typical time of use, e.g. use of community facilities during the evening or weekends may be during periods when traffic noise is lower than typical daytime exposures;
- internal noise levels, e.g. hospitals often have relatively high internal levels (IOA/IEMA, 2002); and
- outdoor sites of historic interest may be regarded as more sensitive than general outdoor areas used for leisure/recreation as the setting, which may be part of the important character of the site, will be affected by a change in noise climate (IOA/IEMA, 2002).

16.2.38 Therefore evaluation of the sensitivity of non-residential properties is undertaken on a case-by-case basis as part of evaluating whether a non-residential receptor is likely to be subject to a significant noise effect arising from the scheme (refer to the next sub-section and Appendix A16.4).

Impact and Significance Criteria

16.2.39 Appendix A16.4 provides background and justification for the Impact and Significance Criteria presented in this chapter.

Fundamental Requirement

16.2.40 Consistent with the parent EU Directive (European Commission Directive 85/337/EEC as amended by Directive 97/11/EC), the Environmental Impact Assessment (Scotland) Regulations (Part III Roads) state that the fundamental requirement is to identify significant effects (both positive and negative) and to provide a description of the measures envisaged in order to avoid, reduce and, if possible, remedy significant adverse effects.

16.2.41 The critical requirement therefore is to identify likely significant effects.

16.2.42 The likely significant effects identified for a project are key because:

- under the EU Directive, they drive the need to consider mitigation and the efficacy of any mitigation proposed; and
- they are material considerations brought to the attention of the decision makers by the ES.

Approach to Noise Impact and Significance Criteria adopted for the Proposed Scheme

16.2.43 In this assessment the identification of significant noise effects is dependant on an assessment of likely noise levels arising from the proposed scheme, an understanding of communities exposed to the noise and within each community an understanding of individual receptors and their use (hence the receptor's sensitivity to any noise impact arising from the proposed scheme).

16.2.44 Long term[2] and short term noise levels have been calculated with and without the scheme as discussed earlier in this Section. As defined in DMRB (2008) the change in noise level climate brought about by a scheme is used as the basis for evaluating noise impacts and hence effects. The predicted noise levels have been used to calculate noise change that would occur as a consequence of the scheme's operation.

16.2.45 As a first step, DMRB provides guidance on noise impact magnitudes and paragraph 3.42 of HA213/08 Noise and Vibration states that *'…a change of 1dB(A) in the short-term (e.g. when a project is opened) is the smallest that is considered perceptible. In the long-term a 3dB(A) change is considered perceptible, and such an increase should be mitigated if possible…'*.

16.2.46 Given that under the Environmental Impact Assessment (Scotland) Regulations, this assessment should provide a description of the measures envisaged in order to avoid, reduce and, if possible, remedy significant adverse effects, the criteria that trigger the identification of a significant effect are also the criteria that trigger consideration of mitigation. It follows therefore from paragraph 3.42 of DMRB (2008) that a change of 3dB(A) or more in the long term, noise caused by the scheme is the initial indication of a significant noise effect.

16.2.47 The full criteria for quantifying significant noise effects are defined in Table 16.1. Appendix A16.4 sets out the basis for the criteria, how they reflect the guidance in DMRB (2008). The notes to the Table set out how the criteria take account of information about the receptors and communities subject to a noise impact.

[2] Long term noise levels refer to the design year (2032) and short term to the year of opening (2017).

Table 16.1: Significance Criteria for Traffic Noise

Long-term Change in Noise Level $L_{A10,18h}$ (dB)	Magnitude of Impact	Initial Indicator of Significance	Criteria to Confirm Significant Effects
> 5.0	Major adverse	Potentially significant	Refer to A) and B) below
3.0 to 4.9	Moderate adverse		
1.0 to 2.9	Minor adverse	Unlikely to be significant	
0.1 to 0.9	Negligible	Not significant	
0	No Change		
-0.9 to -0.1	Negligible		
-2.9 to -1.0	Minor beneficial	Unlikely to be significant	Refer to A) and B) below
-4.9 to -3.0	Moderate beneficial	Potentially significant	
> -5.0	Major beneficial		

A) Significant Effect Criteria – Residential

16.2.48 Significant effects on residential receptors are identified using professional judgement based on the following criteria:

- number of receptors subject to the noise impact;
- the proportion of the community within which the receptors reside subject to the impact;
- the magnitude of the impact; and
- existing absolute noise levels (particularly very noisy and quiet/tranquil areas).

16.2.49 As an example against the last bullet point, in very noisy locations potentially significant effects (which will trigger the requirement to consider mitigation) will be identified where, whilst the noise change may be less than 3dB(A), absolute noise levels for the scheme are predicted to exceed the threshold of 68dBL_{A1018h} defined in the Noise Insulation (Scotland) Regulations. This also provides consistency with the Action Plans being drafted for existing roads under the Environmental Noise Regulations.

B) Significant Effect Criteria – Non Residential

16.2.50 Significant effects on non-residential receptors are identified using professional judgement based on the following criteria:

- receptor use (e.g. educational, healthcare, religious buildings or community uses) and hence relevant guidance on noise (that will also take account of the likely sensitivity of the occupants);
- the times of use;
- the design of the receptor (especially windows, doors and ventilation systems) and hence ability of receptor to experience changes in external noise environment without significant change in internal noise conditions);
- the magnitude of the impact; and
- ambient noise levels (internal and external).

Eligibility for noise insulation (Noise Insulation (Scotland) Regulations)

16.2.51 As set out in Table 16.1 and its supporting notes in paragraphs 16.2.48-16.2.50, exposure to noise from the scheme that potentially exceeds the qualification criteria defined in the Noise Insulation (Scotland) Regulations (NISR), (HMSO, 1975) would be a consideration in identifying significant effects. Therefore, as set out in Appendix A16.2 (Noise and Vibration Policy), noise mitigation

measures would be applied, if practicable, to ensure that noise exposure at dwellings alongside the proposed scheme is controlled below the qualifying criteria.

16.2.52 In summary, noise insulation qualification criteria require that: the facade noise threshold of 68dBL_{A1018h} is met or exceeded; that there must be a noise increase of at least 1dB(A) compared to the prevailing noise level immediately before the construction of a highway or an additional carriageway were begun; and that the property is 300m or less from the nearest point on the carriageway of a highway to which the NISR applies. Further details are presented in Appendix A16.2.

16.2.53 The mandatory application of NISR to a highway scheme is not linked to the Environment Impact Assessment Regulations nor to DMRB. As noted in the Noise and Vibration Policy (Appendix A16.2), the promoter will, as is common for any highway project, fulfil the mandatory requirements of NISR at a later stage once the proposed scheme design is finalised. However, the provision of noise insulation is a form of noise mitigation as noted in the NVP. Thus it is good practice to estimate the number and location of properties considered likely to be eligible for insulation so that the information can be presented in the ES as part of the mitigation to be provided in conjunction with the scheme.

16.2.54 The NISR (HMSO, 1975) require the use of the prediction methodology provided in The Memorandum to Regulations 3 and 6 of the NISR rather than the Calculation of Road Traffic Noise (CRTN, 1988). The NISR methodology would be applied as part of the formal application of the regulations. However for the estimates presented in this assessment, CRTN (1988) has been used as it is the methodology required by DMRB. The following paragraphs confirm that the estimates of noise insulation qualification made with CRTN (1988) are not inconsistent with those that would have been made using the NISR method.

16.2.55 The NISR methodology is based on the Building Research Establishment (BRE) Digest 153 which was also the basis of the original CRTN method published in 1975. The CRTN procedure was revised in 1988 to develop a more comprehensive noise prediction model taking into account a greater number of parameters affecting the generation and propagation of traffic noise. The prediction algorithms were derived from large samples of empirical data. The revision of the model sought to address some of the inaccuracies of the earlier method but also to extend the use of the model over a much wider range of scenarios. The accuracy of the method was improved such that the mean prediction error of CRTN 1988 noise results is reported to be +0.1dB(A) with an rms error of 1.9dB(A). This is an improvement on the CRTN 1975 method which, for the same data sample, gave a -0.4dB(A) mean prediction error with an rms error of 2.1dB(A) (Abbott PG and PM Nelson, 1989).

16.2.56 It can be concluded that the CRTN 1988 method, used for this assessment, is a more highly developed and accurate method of determining traffic noise levels over a wide range of scenarios and hence it will provide a reasonable estimate of the properties that could qualify for noise insulation.

Limitations to Assessment

16.2.57 The accuracy of predictions of road traffic noise effects is subject to the accuracy of the data entered into the model, i.e. traffic model, road design details and topography.

16.2.58 The traffic information used to develop the noise models is extracted from the Transport Model for Scotland as described in paragraph 4.6.30 of Chapter 4 (The Proposed Scheme) and in more detail in the Stage 3 DMRB Scheme Assessment Report, Part C (Jacobs Arup, 2009). This model is a national strategic model and is expected to reflect traffic patterns on the national trunk road network, however the model may not fully reflect traffic levels as accurately on local roads. However, the ambient noise in the noise study area is generally dominated by national trunk roads and hence the traffic model is considered an appropriate basis for this assessment. In considering indirect and remote effects of the scheme (e.g. changes in traffic patterns and noise on local roads

caused by the scheme or occurring for other reasons within the assessment period) a more detailed local review of traffic patterns has been undertaken. Where this has indicated that the strategic national model may not fully reflect local scenarios and that this might influence the noise assessment comment is made in the assessment in Sections 16.4 and 16.6.

16.2.59 As previously stated, noise predictions have been produced in accordance with CRTN methodology. CRTN methodology considers airborne noise arising from road traffic but there is no mechanism to account for structure-borne sound radiated from the bridge structure itself. As an example, properties close to the underside of the bridge would be predicted to be subject to lower road traffic noise than they are likely to be subject to in reality because of additional noise radiated from the bridge structure and expansion joints.

16.2.60 A wide range of road types are considered within the study area including a number of roads that have very low traffic flows. Once traffic flows reduce to around 1000 vehicles per day or less, it is accepted that CRTN noise calculations can over estimate the change in noise caused by a change in traffic volumes.

16.2.61 It is considered that all data inputs for this assessment are of an adequate level to support a 'Detailed' level of assessment as defined in DMRB (2008).

Base Scheme Description

16.2.62 The base scheme assumes the incorporation of various design features which will act to help reduce traffic noise and vibration levels, as described in the following sub-sections. Section 16.5 presents further, noise-specific mitigation identified based on the assessments of significant noise effects for the base scheme (Section 16.4).

Road Traffic Noise

16.2.63 Low-noise surfaces are available which typically produce traffic noise approximately 3dB(A) lower than a surface such as hot-rolled asphalt for traffic travelling at 75km/h or more. This assessment has assumed the inclusion in the design of low noise road surfaces throughout for new and altered roads (although such a design feature may not be required in all locations as mitigation).

16.2.64 Engineering earthworks especially cuttings can help reduce noise levels. For example the cutting required for the main carriageways to pass under the grade separated Queensferry Junction would provide a significant noise reduction for receptors on the southwestern corner of South Queensferry (Echline Estate).

16.2.65 The base scheme includes some line-side landscaping, for example using cut material that would otherwise have to be disposed off-site. In some locations, especially north of Queensferry Junction and to the south of the new route between the A8000 and Queensferry Junction, the landscaping included in the base design would help reduce noise levels at neighbouring noise sensitive receptors.

Main Crossing – Potential for Wind Generated Noise

16.2.66 Wind barriers are proposed as part of the parapet structure of the Main Crossing to reduce the effect of cross-winds on traffic. Wind noise can be associated with such structures, caused by turbulent air-flow across the elements that make up the barriers. Wind barriers on other bridge structures demonstrate that it is possible to avoid significant noise effects by appropriate design.

Main Crossing – Potential for Noise from Expansion Joints

16.2.67 Expansion joints are required at each end of the Main Crossing to safely accommodate the movement expected from the bridge structure, as a result of thermal expansion etc. The expansion

joints will be located at the northern and southern abutments at approximate ch6980 and 4330 respectively.

16.2.68 Expansion joint noise generation is likely to result from the following interactions:

- interaction of the wheel tread with the expansion joint discontinuity resulting in airborne noise propagation from the top surface of the road/Main Crossing;
- interaction of the wheel tread with the expansion joint discontinuity resulting in airborne noise propagation from the under side of the expansion joint; and
- impact vibration in the Main Crossing structure caused by each wheel passing over the joint resulting in structure radiated noise.

16.2.69 All three noise sources are dependant upon the detailed design of the joint. A range of expansion joints are now available that by design reduce the level of noise generated.

16.2.70 Low noise expansion joints will be employed on the Main Crossing.

16.2.71 Measured data indicate that, when measured at grade (i.e. airborne noise from the top surface), the best performing expansion joints currently available provide up to a 6dB reduction in maximum noise levels compared to other joints.

16.2.72 For both abutments and subject to other engineering constraints, the base scheme design will include proprietary noise control measures on the underside of the expansion joints. Such measures might typically involve a hinged steel enclosure and the provision of sound absorbing surface treatment to the inner surface. Manufacturers data suggest that such measures can provide between 14 and 23dB(A) of attenuation compared to an unmitigated expansion joint.

16.2.73 The expansion joint will be located as part of the Main Crossing abutments. Both abutments will accommodate equipment, workshops, storage and welfare facilities. These abutment structures will provide significant reductions in airborne and structureborne noise from the underside of the expansion joint.

16.3 Baseline Conditions

16.3.1 For the purposes of the noise assessment, the baseline scenario is represented by the predicted ambient noise levels immediately before the change produced by the proposed scheme, as set out in DMRB (2008). This is taken as the noise levels from the existing roads i.e. the Do-Minimum scenario in 2017. Figure 16.3 shows noise contour maps for the existing roads with noise levels shown at 3dB(A) intervals to represent the Do-Minimum scenario in 2017. Figure 16.4 shows noise contours maps for the existing roads in 2032.

16.3.2 The predicted change in noise level between 2017 Do-Minimum and 2032 Do-Minimum (i.e. without the proposed scheme), is shown in Figure 16.5.

16.3.3 The baseline noise predictions are supplemented by both long-term noise surveys (noise logging equipment installed at six locations for a number of weeks) and short-term attended noise surveys (carried out at 23 locations across the noise study area) which are detailed in Appendix A16.3. The results from the long-term noise surveys, carried out in 2008 and 2009, have been used to verify the results of the noise mapping exercise. It is important to keep in mind that a potentially significant component of any apparent difference between predicted and measured levels may actually be due to variance in the measured data (e.g. due to diurnal traffic variations, changes in meteorological and other conditions).

16.3.4 The 2008 and 2009 noise survey data were compared to those predicted by the noise model for 2012. There is a reasonable correlation between the predicted and measured $dBL_{A10,18h}$ results in the majority of instances. The comparison of predicted and measured data is summarised in Table

16.2. On average, the measured levels exceed the predicted levels by 2.6dB(A) showing that the predictions err on the side of caution as the predicted baseline may be slightly lower than the actual baseline levels and thus the calculations represent the worst case.

Table 16.2: Comparison of Predicted Levels and Long-term Survey Levels (not corrected for façade reflection)

Sample Location	Predicted $dBL_{A10,18h}$	Measured $dBL_{A10,18h}$
Whinny Hill Crescent, Inverkeithing	54.5	57.2
Tigh-na-grian, North Queensferry	54.1	57.6
Port Edgar, Queensferry	53.0	54.9
Mucklehill Park, Inverkeithing	59.1	65.6*
Clufflat Brae, Queensferry	47.8	47.2
Kirklands Park Grove, Kirkliston	64.3	65.9

*The measured long term survey results at Mucklehill Park are particularly high as compared with the predicted noise levels. A lower predicted baseline, however, would ensure a worst-case predicted impact from the proposed scheme.

16.3.5 The following sub-sections describe the anticipated baseline noise levels in the year of opening (2017). The baseline data are presented working generally from north to south.

North of the Firth of Forth

16.3.6 The following text should be read in conjunction with Figure 16.3, which displays the noise levels at scheme opening year for the Do-Minimum scenario.

Residential Receptors in Inverkeithing and Rosyth

16.3.7 The most northeasterly part of the study area surrounds the B981 (North Road), reaching 400m north of its junction with Masterton Road. The only residential properties in this area are Dales Steading and Dales Farm Cottages. Dales Steading would be subject to baseline levels of 50.5-53.4$dBL_{A10,18h}$ on the south and west parts of the east façade, 53.5-56.4$dBL_{A10,18h}$ on the north façade and northern end of the west facade and 56.5-59.4$dBL_{A10,18h}$ on the furthest northern façade.

16.3.8 Continuing south of the B981 North Road/Masterton Road junction into Inverkeithing, the residential area in the northwestern side of Inverkeithing would be subject to noise levels of 50.5-53.4$dBL_{A10,18h}$ furthest from the main roads. Properties along Hillfield Road in the northwest area of Inverkeithing would be subject to noise levels less than 47.5$dBL_{A10,18h}$. The noise ranges described above are generally considered to be relatively quiet for a suburban area.

16.3.9 There are similar noise levels around properties adjacent to Queensferry Road in Rosyth, northwest of its junction with Admiralty Road.

16.3.10 Residential properties on Ferry Toll Place and Grampian Road, Rosyth, would be subject to less than 47.5$dBL_{A10,18h}$ and again this would be considered to be a quiet area.

16.3.11 The small number of properties in Mucklehill Park, Inverkeithing, overlooking the A90 would be subject to noise levels of 59.5-62.4$dBL_{A10,18h.}$

16.3.12 The large number of properties with façades facing onto Dunfermline Wynd/Hill Street, Inverkeithing, would be subject to 53.5-56.4$dBL_{A10,18h.}$

16.3.13 The properties facing onto King Street/Alma Street, Inverkeithing, would be subject to 59.5-62.4$dBL_{A10,18h.}$

16.3.14 Properties on Spittalfield Crescent/Preston Crescent, Inverkeithing, would be subject to less than 47.5dB$L_{A10,18h}$.

16.3.15 Properties on Whinny Hill Crescent, Inverkeithing, closest to the A90 would be subject noise levels of between 53.5-56.4dB$L_{A10,18h}$ at the southern end and 56.5-59.4dB$L_{A10,18h}$ further north.

Residential Receptors in North Queensferry

16.3.16 In North Queensferry, dwellings forming the western collection (including Ferry Barns Court and Inchcolm Drive) would be predominantly subject to noise levels of 50.5-53.4dB$L_{A10,18h}$.

16.3.17 To the west of North Queensferry, the Queensferry Hotel would be subject to 53.5-56.4dB$L_{A10,18h}$ on the northeastern façade and 59.5-62.4dB$L_{A10,18h}$ on the south and south east façades. Predicted noise levels are 62.5-65.4dB$L_{A10,18h}$ on the southwestern façades and 59.5-62.4dB$L_{A10,18h}$ on the hotel's western facade.

16.3.18 Further to the west, St. Margaret's Hope Lodge (residential) would be subject to 56.5-59.4dB$L_{A10,18h}$ on the north, west and south façades and 59.5-62.4dB$L_{A10,18h}$ on the east façade. ,St. Margaret's Hope (known as Admiralty House, in commercial use) would be subject to 53.5-56.4dB$L_{A10,18h}$ on the north, east and part of the southern facades and 50.5-53.4dB$L_{A10,18h}$ on the west façade.

16.3.19 Properties on Brock Street, North Queensferry, would be subject to <47.5dB$L_{A10,18h}$.

Non-Residential Receptors

16.3.20 The baseline noise levels at the non-residential noise sensitive receptors identified in the north of the study area (as shown on Figure 16.1) would be:

- Park Road Primary School (Rosyth) would be subject to 62.5-65.4dB$L_{A10,18h}$ on the façades facing the M90, 59.5-62.4dB$L_{A10,18h}$ on the south and north facades and 56.5-59.4dB$L_{A10,18h}$ on the east façade.
- Camdean School (Rosyth) would be subject to 62.5-65.4dB$L_{A10,18h}$ at the most easterly point and to 53.5-56.4dB$L_{A10,18h}$ on the north and the rest of eastern facades. The predicted noise levels at the remaining facades would be 50.5-53.4dB$L_{A10,18h}$.
- Kings Road Primary School (Rosyth) would be subject to 56.5-59.5dB$L_{A10,18h}$ on the north-western facade reducing to 53.5-56.4dB$L_{A10,18h}$ and then to 50.5-53.4dB$L_{A10,18h}$ on the northern façade the greater the distance from the B980. The facades facing and closest to the B980 road would be subject to a noise level of 65.5-68.4dB$L_{A10,18h}$.
- St. John's Primary School (Rosyth) would be subject to levels less then 47.5dB$L_{A10,18h}$.
- Hilton Court Care Home (Rosyth) would be subject to 53.5-56.4dB$L_{A10,18h}$ on the north façade, 56.5-59.4dB$L_{A10,18h}$ on the northern-west and south facades and to 53.5-56.4dB$L_{A10,18h}$ on the eastern facade.
- North Queensferry Primary School would be subject to 50.5-53.4dB$L_{A10,18h}$ on the north, west and southerly façades and 53.5-56.4dB$_{LA10,18h}$ on the eastern façade.
- North Queensferry Community Centre is situated on top of a hill in the north-west of North Queensferry. It overlooks the Queensferry Hotel on the other side of the A90. The centre would be subject to 53.5-56.4dB$L_{A10,18h}$ on the western and southern façades; 50.5-53.4dB$L_{A10,18h}$ on the eastern façade and 47.5-50.4dB$L_{A10,18h}$ on the northern façade.

Predicted Traffic Noise Changes Without Proposed Scheme

16.3.21 Traffic volumes and hence noise are predicted to change, mainly increase, between opening year and design year (2032). Figure 16.5 presents the predicted difference in noise levels around the existing roads between 2017 and 2032. This figure represents the changes that would occur in the

absence of the proposed scheme due to traffic change on the network. North of the Forth the changes are mostly in the 0-1dB(A) increase range. The areas around the B981 (North Road) and the areas either side of the A90 around Lothians View (Rosyth)/Dunfermline Wynd (Inverkeithing) would be subject to an increase of 1-3dB(A). The Hillend Road (Inverkeithing) is predicted to be subject to decreases of 1-3dB(A). These changes are attributable to natural traffic flow changes.

16.3.22 There is a development site of 10 houses on the western fringe of Inverkeithing. Traffic modelling shows that trips generated by this development would not materially influence traffic flows within the study area. This site is predicted to be subject to a change of 0-1dB(A) between 2017 and 2032 with an absolute predicted baseline noise level of 50.5-53.4dB$L_{A10,18h}$.

Firth of Forth

16.3.23 Noise levels on the Firth of Forth are predicted to be predominantly within the range 50.5-53.4dB$L_{A10,18h}$. Noise receptors directly under the Forth Road Bridge are predicted to receive traffic noise levels lower than receptors slightly further away, due to the shielding effects of the road deck. However, areas beneath and directly adjacent to the bridge abutments are subject to impulsive noise caused by vehicles passing over bridge expansion joints.

South of the Firth of Forth

Residential Receptors in Linn Mill and South Queensferry

16.3.24 The proposed Main Crossing makes landfall on the south bank and then passes through fields between Linn Mill and the main residential area of South Queensferry. To the west of the proposed route, Linn Mill and Inchgarvie House properties would be subject to future noise levels of 47.5-50.4dB$L_{A10,18h}$.

16.3.25 To the east of the proposed scheme, in northwestern South Queensferry, a number of properties face onto the proposed scheme including properties on Clufflat Brae, Springfield Place, and Springfield Lea. These properties would be subject to noise levels ranging from 47-50.4dB$L_{A10,18h}$. Most other houses further east of the proposed route and to the north of Bo'ness Road would be subject to similar noise levels, increasing to 59.5-62.4dB$L_{A10,18h}$ closer to the Forth Road Bridge.

16.3.26 The western end of the Echline Estate in the southwest of South Queensferry would be subject to a range of noise levels of 47.5-50.4dB$L_{A10,18h.}$ Closer to Bo'ness Road the levels would be higher, e.g 56.5-59.4dB$L_{A10,18h.}$ The properties in South Queensferry adjacent to the Forth Road Bridge approach (western side) would be subject to a level of 47.5-50.4dB$L_{A10,18h}$ at the western periphery increasing to 65.5-68.4dB$L_{A10,18h}$ close to the A90. The properties in South Queensferry adjacent to the Forth Road Bridge Approach (eastern side) would be subject to a level of 50.5-53.4dB$L_{A10,18h.}$ at the eastern periphery increasing to 62.5-65.4dB$L_{A10,18h}$ close to the A90. The properties on Echline Estate facing onto the A904 (Builyeon Road) would be subject to 65.5-68.4dB$L_{A10,18h.}$

16.3.27 The area of South Queensferry to the east of the existing Forth Road Bridge approach road, bounded by the B924, the B907 and the A8000, would be subject to noise levels ranging from 47.5-50.4dB$L_{A10,18h}$ to 62.5-65.4dB$L_{A10,18h}$ depending on the proximity to the road links.

Residential Receptor at Dundas Mains, Dundas Castle and Dundas Home Farm

16.3.28 Dundas Castle and properties in the vicinity (Green Acre, Blue Acre and Clock House) would be subject to levels less than 47.5dB$L_{A10,18h.}$ This is a quiet area although distant road traffic noise is audible.

16.3.29 The properties at Dundas Mains would be subject to levels less than 47.5dB$L_{A10,18h}$. This is a quiet area although distant road traffic noise is audible.

16.3.30 Properties to the east of Dundas Home Farm would be subject to noise levels ranging from 59.5-62.4dB$L_{A10,18h}$ to 62.5-65.4dB$L_{A10,18h}$ closer to the A8000.

16.3.31 For the main cluster of buildings at Dundas Home Farm, properties would be subject to a range of noise levels of 50.5-53.4dB$L_{A10,18h}$ at the south and west facades and 53.5-56.4dB$L_{A10,18h}$ at the north and east facades that face A90 and A8000 respectively.

Residential Receptors in Kirkliston

16.3.32 Properties on the western fringes of Kirkliston would be subject to noise levels of 56.5-59.4dB$L_{A10,18h}$ reducing with distance from the M9 and M9 spur.

16.3.33 The small cluster of properties to the southwest of M9 Junction 1A, which includes Overton Cottages, would be subject to noise levels raging from 53.5-56.4dB$L_{A10,18h}$, for those furthest from the Junction, increasing to 56.5-59.4dB$L_{A10,18h}$ for those closest to the junction.

16.3.34 The properties to the southwest of Kirkliston, adjacent to M9 and facing to the road would be subject to 62.5-65.4dB$L_{A10,18h.}$

16.3.35 The properties facing onto Main Street, Kirkliston, east of the B800 would be subject to 62.5-65.4dB$L_{A10,18h.}$

Residential Receptors in other Areas

16.3.36 A small area of the suburb of Newbridge is predicted to fall within noise levels range of 53.5-56.4dB$L_{A10,18h}$ reducing further with increased distance from the main roads. Properties fronting onto the A89 would be subject to 65.5-68.4dB$L_{A10,18h}$.

16.3.37 The properties near the junction of B8020 and B9080 (Winchburgh) would fall in the levels ranging from 53.5-56.4dB$L_{A10,18h}$ to 50.5-53.4dB$L_{A10,18h}$. The noise levels can be attributed to traffic movements related to developments un-connected to the proposed scheme.

16.3.38 Many properties along the A904 in Newton would be subject to noise levels in the range of 68.5-71.4dB$L_{A10,18h}$, i.e. very noisy.

16.3.39 Properties near the junction of B8020 and A904 would be subject to noise levels in the range of 59.5-62.4dB$L_{A10,18h}$, and to higher levels of 62.5-65.4dB$L_{A10,18h}$ to 71.5-74.4dB$L_{A10,18h}$ (very noisy) for those adjacent to the A904.

Non-Residential Receptors

16.3.40 The baseline noise levels at the non-residential noise sensitive receptors identified in the south of the study area (Figure 16.1) would be:

- Echline Primary School in South Queensferry would be subject to noise of 53.5-56.4dB$L_{A10,18h}$ at the northern façade, 47.5-50.4dB$L_{A10,18h}$ at most of the east and the south facades and <47.5dB$L_{A10,18h}$ at most of the west facades.
- Queensferry Primary School in South Queensferry would be subject to 50.5-53.4dB$L_{A10,18h}$.
- The Queensferry Churches Care in the Community Project would be subject to 50.5-53.4dB$L_{A10,18h}$ at the north, east and south facades and 47.5-50.4dB$L_{A10,18h}$ at the west facades.
- St. Margaret's RC Primary School would be subject to 50.5-53.4dB$L_{A10,18h}$ at the north-western façades, 53.5-56.4dB$L_{A10,18h}$ at the northeastern façades and 59.5-62.4dB$L_{A10,18h}$ at the west, south and east façades.
- Dalmeny Primary School would be subject to 53.5-56.4dB$L_{A10,18h}$ at the north façade, to 56.5-59.4dB$L_{A10,18h}$ at the west and east façades and 59.5-62.4dB$L_{A10,18h}$ at the south façades.

- Leonard Cheshire Home in Kirkliston would be subject to 50.5-53.4dB$L_{A10,18h}$.
- Kirkliston Primary School would be subject to 56.5-59.4dB$L_{A10,18h}$ at the north façade, to 53.5-56.4 dB$L_{A10,18h}$ at the west and east facades and 50.5-53.4dB$L_{A10,18h}$ at the south façade.

Predicted Traffic Noise Changes Without Proposed Scheme

16.3.41 Figure 16.5 presents the difference in noise level between 2017 and 2032. This shows the changes that would occur in the absence of the proposed scheme due to predicted changes in traffic. South of the Firth of Forth, the changes fall mostly in the 1-3dB(A) increase range on the western side of the proposed scheme with parts of the B8020 subject to an increase of 3-5dB(A). The change along the B8020 may be attributable to the development allocation at Winchburgh (not related to the proposed scheme) increasing traffic volumes from approximately 4300 to 8200 per 18-hour day and the proportion of HGV traffic increasing from 10% to 15% according to the output of the strategic traffic model.

16.3.42 The majority of Kirkliston would also be subject to a 1 to 3dB(A) increase in the predicted $L_{A10, 18h}$. The road on the eastern edge of Kirkliston would be subject to an increase of 3-5dB(A). This is due to increases in traffic flow (approximately 3600 to 6500) and the proportion of heavy goods vehicles (21% to 31%) likely due to the development allocation at Kirkliston North.

16.3.43 There are other development allocations south of the Firth of Forth including Society Road Housing Development. This area would be subject to a change of 0-1dB(A) between 2017 and 2032. Springfield Housing and Environmental Improvements site would be subject to changes between 2017 and 2032 of 0-1dB(A) to the north of the site and 1-3dB(A) at the southern end of the site closer to the A904 and Bo'ness Road.

16.4 Potential Impacts

Introduction

16.4.1 This section describes the changes in noise levels predicted as a result of the operation of the proposed scheme without mitigation (other than the design features included in the base scheme such as engineering earthworks and lower noise surfacing) and the impacts and significant effects that are predicted to occur as a consequence. Specific noise mitigation, i.e. roadside barriers, is described in Section 16.5.

16.4.2 Figures 16.6 and 16.7 show the predicted absolute free-field noise levels in the Do-Something scenarios in 2017 (opening year) and 2032 (future assessment year) respectively, presented in 3dB(A) contours consistent with the DMRB absolute noise categories.

16.4.3 Figure 16.8 shows predicted changes in noise level between the base case Do-Something and Do-Minimum in the opening year (2017). Figure 16.9 shows the differences in predicted noise levels between the Do-Something in the future design year (2032) and Do-Minimum 2017. These figures show the changes in noise level in colour bands corresponding to the noise change ranges set out in Table 16.1. Based on the significance criteria set out earlier, it would be assumed that potentially significant effects could be associated with noise impacts associated with noise changes of 3dB(A) or more depending on the nature of the receptor and the context.

16.4.4 It should be noted that the noise contour results shown in these figures do not take into account the effect of façade reflections which result in a localised increase of 2.5dB(A) at one metre in front of a building's façade (as specified in CRTN). This also applies to the measured survey results.

16.4.5 Impacts are generally reported based on calculations of noise made at 4m above local ground level (first floor level). For buildings of more than three habitable floors, further calculations have been carried out for the upper floors.

Ground-borne Vibration

16.4.6 No ground-borne vibration impacts are forecast. This is because, in accordance with highway construction standards (Appendix A16.2), the surface of the proposed upgraded roads would be smooth with no surface irregularities of sufficient size to generate significant levels of ground-borne vibration. It is a standard requirement under the specification for new highways that the new road surfaces would be free of significant discontinuities. The size of irregularities necessary to cause perceptible ground-borne vibration is only expected in 'exceptional circumstances' as discussed in Section 16.2. It is not considered that any such exceptional circumstances would arise during operation of the proposed scheme.

Airborne Vibration

16.4.7 DMRB (2008) notes that the percentage of people bothered very much or quite a lot by airborne vibration is 10% lower than the corresponding amount for noise nuisance. It can be assumed then that significant effects associated with airborne vibration would be approximately equivalent to, but no greater than those effects reported for noise. Hence, the assessment of airborne vibration effects has not been separated from the assessment of airborne noise effects as they would be approximately in proportion to each other. Mitigation provided for airborne noise effects would also reduce airborne vibration.

Night-time Noise

16.4.8 The revised DMRB noise guidance (2008) indicates that consideration should be given to the requirement for night-time noise assessment. DMRB (2008) states that an assessment may be necessary when there are changes in night-time noise considered to be significant, or where the difference between daytime and night-time levels is within 10dB(A). An example link on the A90 was chosen by Jacobs Arup traffic specialists as being representative of the daily levels and potential levels through the night together with calculated percentage of HGVs. This information has been taken from observed patterns at an automatic traffic counter to the south of the Forth Road Bridge and these patterns are considered to represent other adjacent mainline links within the base scheme corridor. Although traffic volumes may vary, the relationship between day time and night time levels is expected to be similar or better elsewhere in the noise study area.

16.4.9 Whilst the existing traffic flow on the major trunk roads is relatively high at night-time (midnight until 06:00 hours) versus daytime (06:00 hours until midnight) compared to other road classes, the investigation made into A90 noise levels indicates that night-time noise is currently within 10dB(A) of the daytime level. However, the ratio of night-time traffic flow to daytime traffic flow is not predicted to increase substantially as a consequence of the scheme and hence it has been concluded that noise impacts and effects can be assessed using daytime noise levels ($L_{A10,18h}$ indicator).

Daytime Noise

16.4.10 The following sub-sections consider first the magnitude of noise impacts according to the predicted noise change north and south of the Firth of Forth, as defined in Table 16.4. The effect of the noise impacts on the receptors is then considered, taking account of the nature of the receptors and their use as well as the additional parameters described as part of the significance criteria.

16.4.11 The assessment sections split the reported impacts into two categories: direct (those impacts arising directly from the new and altered road links which make up the proposed scheme) and indirect (those impacts arising from changes in traffic flow on existing roads that occur as a consequence of the proposed scheme).

16.4.12 The assessment text below should be read with reference to the 'noise difference' maps, Figures 16.8 and 16.9 (these show the changes in noise level with the base scheme in operation for the opening year and the future assessment year respectively) as well as Figures 16.3 to 16.7.

16.4.13 The assessment is presented in three route windows:

- north of the Firth of Forth;
- the Firth of Forth; and
- south of the Firth of Forth.

16.4.14 In each window, the assessment considers first direct effects and then indirect effects. The assessment considers each community area generally working north to south.

North of the Firth of Forth

Direct Impacts on Residential Receptors

16.4.15 A small number of dwellings on Mucklehill Park, Inverkeithing, which overlook a modified section of the A90 would be subject to minor adverse impacts on scheme opening, rising to moderate adverse by future assessment year. There is one property, 9 Mucklehill Park, that could potentially qualify for insulation under the NISR. However, given that only very few properties are subject to the moderate impact, that the number of properties is only a very small proportion of the local community and given that these impacts exceed the moderate adverse threshold value of 3dB in the future assessment year by less than 0.5dB, they are not considered to constitute a significant adverse effect in the context of the scheme.

16.4.16 Properties on Whinny Hill Crescent, Inverkeithing, would be subject to minor adverse impacts on scheme opening. These impacts will remain as minor adverse by future assessment year.

16.4.17 There are three residential buildings with four habitable floors on Whinny Hill Crescent. DMRB (2008) recommends that special consideration should be given to dwellings of over three habitable floors. For these properties, therefore, noise impacts have been assessed at different heights and found to vary slightly across floors; however, the impacts at all heights remain as minor adverse on scheme opening and at future assessment year and are therefore not significant.

16.4.18 In North Queensferry, the vast majority of western housing estate (including Ferry Barns Court and Inchcolm Drive) would be subject to a variety of impacts ranging from to minor beneficial (east side of the community) to minor adverse (west side of the community) on scheme opening. By future assessment year, these impacts magnitudes remain unchanged, and are not significant. There are a small number of moderate and major adverse impacts predicted by the air-borne noise model for the westernmost dwellings on Ferry Barns Court. However, the without-scheme do-minimum noise predictions do not take into account noise radiated from the underside of the Forth Road Bridge and hence impacts very close to the Forth Road Bridge will be over-predicted by the model. Measurements taken at a nearby position on the attended noise survey (location 5) confirm this. Therefore, no significant noise effects have been identified in this area.

16.4.19 St. Margaret's Hope Gatelodge (a small residential property) would be subject to major adverse impacts, arising from the proposed scheme, on scheme opening. St. Margaret's Hope Gatelodge would potentially qualify for noise insulation under the NISR. Given that there is only one property subject to the impact and that it is owned by Transport Scotland, this is not considered to constitute a significant adverse noise effect.

16.4.20 The remainder of North Queensferry which lies within the noise study area would be subject to a range of impacts. In the south of this community area, the impacts are predominantly negligible, with some small areas of minor beneficial and minor adverse impacts on scheme opening and at future assessment year. For properties on Brock Street, on scheme opening, there would be some minor adverse and a small number of moderate adverse impacts. These impacts would result from the proposed road alignments to the south of Ferrytoll Junction being afforded less shielding by the intervening topography than the existing alignments. By future assessment year, these impacts will remain as predominantly minor adverse, with a small number of moderate adverse. However, due to the small number of properties (approximately 10) which would be subject to moderate adverse

impacts and the small proportion of the community which this would represent (the total community comprises around 150 properties), these impacts are not considered to constitute a significant adverse effect.

Direct Impacts on Non-residential Receptors

16.4.21 The following non-residential noise sensitive receptors were identified in the north of the study area. The locations of these receptors are shown in Figure 16.1:

- Park Road Primary School (Rosyth) would be subject to negligible impacts, arising from the A90, the dominant noise source, at both scheme opening and future assessment years. The predicted noise level difference between the baseline scenario and the scenario with the proposed scheme in operation is expected to be less than 1dB at both scheme opening and future assessment years.
- Camdean School in Rosyth would be subject, on scheme opening, to negligible impacts (less than 1dB) arising from the new road alignments. By future assessment year, the school would be subject to minor adverse impacts.
- Kings Road Primary School (Rosyth) and St John's Primary School (Rosyth) would be subject to negligible impacts at both scheme opening and future assessment years.
- Hilton Court Care Home (Rosyth) would be subject to negligible impacts on scheme opening; and minor adverse impacts at future assessment year.
- North Queensferry Primary School would be subject to minor adverse impacts at both scheme opening and future assessment years.
- North Queensferry Community Centre is situated on top of a hill in the northwest of North Queensferry. It overlooks the Queensferry Hotel on the other side of the A90. On scheme opening and at future assessment year, its eastern, southern and western facades will be subject to minor adverse impacts. The northern façade is currently well screened from the A90 by a steep-sided cutting. The proposed scheme alignments run further away from the Community Centre than the existing A90. However, the intervening terrain provides less shielding as the new alignments do not run in deep cutting. As a result of this, the northern façade is subject to a major adverse impact on opening year and at design year. In the future assessment year, the northern façade would experience an absolute level of 54dBLAeq. Given the design and construction of the northern façade, this is not likely to result in an internal level which would affect the internal noise climate. Following this analysis the impact of the proposed scheme is not considered to result in a significant effect.
- The Queensferry Hotel. On scheme opening would be subject to major adverse impact on its north-western facades, but major beneficial impact on its south-eastern facades. The hotel has guest bedrooms on both west and east elevations and the number of rooms subject to adverse impacts is similar to beneficial impact. On this basis it is concluded that the scheme has a neutral noise effect on the hotel.
- St Margaret's Hope (also known as Admiralty House, a commercial property and a category B listed building) is situated to the west and below the Main Crossing and would be subject to moderate to major adverse noise impacts in the design assessment year. The building is currently used as offices, relying on openable windows for ventilation. The highest noise level predicted outside the property in 2032 is 58dB$L_{A10,18hr}$. This converts to approximately 56dB L_{Aeq} freefield around the worst affected aspect of the building. As also noted in Planning Advice Note (PAN) 56, a partially open window would be expected to reduce internal noise levels by 10 to 15dB compared to external noise. Thus, in the design year (2032) the highest internal noise levels inside St Margaret's Hope due to the operation of the proposed scheme are forecast to be 41 to 46dBL_{Aeq}. British Standard 8233 notes that indoor ambient noise levels in cellular offices should be between 40dBL_{Aeq} (good) and 50dBL_{Aeq} (reasonable). Hence it has been concluded that operation of the base scheme would not give rise to a significant effect on St Margaret's Hope.

Indirect Impacts

16.4.22 The most northeasterly part of the study area surrounds the B981 (North Road), reaching 400m north of its junction with Masterton Road. The only residential properties in this area are Dales Steading and Dales Farm Cottages. Noise impacts around these receptors are projected to be negligible or minor adverse on scheme opening (2017). Impacts would rise to minor adverse and moderate adverse by future assessment year (2032). Due to the small number of dwellings affected by noise increases (approximately four properties), and the fact that the majority of the noise increase experienced by future assessment year would occur in the absence of the scheme (i.e. natural traffic growth), these noise effects have been rated as not significant.

16.4.23 Most receptors within the study area located within Inverkeithing and Rosyth (with some exceptions detailed below) would be subject principally to negligible and minor adverse impacts on scheme opening. These impacts vary from negligible to minor adverse by future assessment year. These impacts arise from small changes in traffic patterns on unmodified sections of the A90 and other roads in the local network as a consequence of the scheme.

16.4.24 There are a number of properties predicted to be subject to moderate beneficial noise impacts projected in the future assessment year on Queensferry Road in Rosyth, northwest of its junction with Admiralty Road. The projected noise changes are due to the large changes in the proportion of heavy goods vehicles using the road. However, the traffic flows on these roads fall at the very lowest limits of the validity of CRTN and hence it is likely that the magnitude of the impact has been over-estimated. These impacts are therefore not being treated as a significant noise effect.

16.4.25 A large number of dwellings facing onto Dunfermline Wynd (Inverkeithing)/Hill Street (Rosyth) are predicted to be subject to minor adverse impacts on scheme opening, increasing to moderate adverse impacts by future assessment year. These noise level increases are caused by a predicted increase in traffic flow on Dunfermline Wynd/Hill Street from 1000 (assumed minimum flow for purpose of model - see paragraph 16.2.14) to approximately 2000 per 18-hour day. It is considered that the predictions are likely to have over-estimated the increase in traffic and noise along this road and that it is unlikely that the changes will give rise to a significant adverse indirect effect.

16.4.26 A large number of dwellings along King Street and Alma Street are predicted to be subject to minor beneficial impacts on scheme opening. By future assessment year, these impacts are projected to be moderate beneficial. The projected noise changes are due to the large changes in the proportion of heavy goods vehicles using the road. Also, the traffic flows on these roads fall at the very lowest limits of the validity of CRTN. These two factors combined increase prediction uncertainty and as such, these noise level predictions should be treated with circumspection as discussed in Section 16.2. These impacts are therefore not considered to constitute a significant effect.

16.4.27 A very small number of dwellings on Spittalfield Crescent in southeastern Inverkeithing are predicted to be subject to minor adverse impacts on scheme opening, rising to moderate adverse by future assessment year. However, due to the very small number of properties subject to moderate adverse impacts and the very small proportion of the local community these properties constitute, these impacts are not considered to be a significant effect.

Indirect Impacts Outside the Noise Study Area but within 2km of the Proposed Scheme

16.4.28 DMRB requires that for dwellings and other sensitive receptors that are within 2km of the proposed scheme boundary but not within 600m of an affected route, a qualitative assessment of noise impact should be undertaken. North of the Firth of Forth, noise sensitive areas within 2km of the proposed scheme which are not covered by the noise study area are described below:

- To the northwest of Rosyth, the area surrounding the junction of the A823(M), A823 and B980 would be subject to negligible or minor noise impacts from the new roads in the scheme opening and future assessment years.

- Properties in the northern east of North Queensferry (on and around Scaur Hill) will be likely to be subject to minor adverse impacts from the new road alignments on scheme opening and at future assessment year. Properties in the southern half of this area are likely to be subject to minor beneficial impacts on scheme opening and at future assessment year.
- A small stretch of the bank of the Firth of Forth to the west of St Margaret's Marsh, including the port of Rosyth, is likely to be subject to a combination of minor and moderate adverse impacts from the new road alignments on scheme opening and at future assessment year. However, there are no noise-sensitive receptors in this area. This is considered in Chapters 10 (Terrestrial and Freshwater Ecology) and 11 (Estuarine Ecology).
- The Careshare Nursery, Dunfermline, beyond 600m but within 2km, would be subject to negligible impacts at both opening and future assessment years.
- Inverkeithing High School, Inverkeithing Primary School and Inverkeithing Nursery would be subject to negligible impacts at both opening and future assessment years.

16.4.29 DMRB requires that an analysis of affected routes which are outside the detailed calculation area (i.e. the noise study area) should be carried out using the Basic Noise Level (BNL) as defined in CRTN, along with a count of dwellings within 50m of the routes. There is only one affected route which lies outside of the noise study area north of the Firth of Forth:

- A very small section of the B981 classed as an affected route falls outside the noise study area. However, there are no residences within 50m of this section of road. A BNL analysis has therefore not been carried out for this road link.

Firth of Forth

16.4.30 On the river, the area between the Main Crossing and the Forth Road Bridge would be predominantly subject to negligible and minor impacts. To the east of the Forth Road Bridge, impacts would be predominantly minor beneficial. To the west of the Main Crossing, impacts would vary from minor adverse to moderate adverse, with some small areas of major adverse near to where the Main Crossing makes landfall. However, given the elevation of the noise source on the Main Crossing, even in the locations where there are moderate and major noise change impacts identified, the absolute noise levels on the river are less than 55dBL_{Aeq}. The Firth of Forth is an active waterway. The ambient noise survey undertaken at Port Edgar (Appendix A16.3) shows that there are a range of other noise sources that influence ambient noise on the river and hence the existing levels are already higher than 55 dBL_{Aeq}. Hence the operation of the Main Crossing is not considered to give rise to a significant noise effect on the Firth of Forth.

16.4.31 The bridge structures have two effects. Firstly road decks will act as noise screens for airborne traffic generated noise at any point on the Firth of Forth under or immediately either side of the bridge, although the screening benefits may not be as great as predicted (refer to Section 16.2). Secondly, especially around expansion joints the bridge structure itself can radiate low frequency noise. It is important to note that CRTN only predicts airborne noise from road traffic and does not predict radiated noise from the underside of bridge decks or expansion joints. The potential issue of expansion joint noise is addressed in Section 16.2.

16.4.32 Due to the fact that the CRTN-based noise calculations only predict direct airborne noise from traffic, there are some noise decreases predicted on the Firth of Forth near to the Main Crossing and some noise increases predicted on the Firth of Forth near to the Forth Road Bridge. These effects are most easily explained by considering two example noise receptors on the Firth of Forth.

- A receptor just to the west of the Forth Road Bridge would, in the Do-Minimum scenario, experience significant shielding from the road traffic on the Forth Road Bridge, leading to relatively low noise levels. In the Do-Something scenario, the same receptor would, whilst further away from the Main Crossing, have a clear line-of-sight to the road traffic on the Main Crossing and would hence be subject to increased predicted noise levels. The noise level difference maps of the proposed scheme therefore show a predicted increase in noise at these locations (including Long Craig Island in the Forth Islands SPA as discussed in Chapter 11).

- A receptor just to the east of the Main Crossing would, in the Do-Minimum scenario, have a good line-of-sight to road traffic on the Forth Road Bridge, leading to relatively high noise levels. In the Do-Something scenario, the same receptor's new road traffic noise source (the Main Crossing) would be heavily shielded by the road deck of that bridge and noise levels would be relatively lower. Noise level difference maps of the proposed scheme therefore show a predicted decrease in noise at these locations.

16.4.33 Whilst these localised variations in noise change are real, the CRTN calculation method will tend to over-estimate the magnitude of any noise change observed on the river surface under and adjacent to the existing Forth Road Bridge and the new Main Crossing.

South of the Firth of Forth

Direct Impacts on Residential Receptors

16.4.34 The proposed route makes landfall on the south bank of the Firth of Forth and then passes through Echline fields, between Linn Mill and the main body of South Queensferry.

16.4.35 To the west of the proposed route, Inchgarvie House (a category C listed building), all dwellings on Linn Mill and other dwellings Butlaw Fisheries, The Weddles, The Square, The Rowans and Butlaw Cottages (approximately 30 properties in total) would, in the absence of mitigation (paragraph 16.4.1), be subject to major adverse impacts, and would remain subject to major adverse impacts at future assessment year. These properties are considered to form a community and hence collectively the impact on them is considered to constitute a significant adverse noise effect. Mitigation to reduce this significant effect is presented in Section 16.5.

16.4.36 To the east of the proposed route, a large number of dwellings on the northwestern corner of South Queensferry face onto the proposed route, including properties on Society Road, Clufflat Brae, Springfield Place, and Springfield Lea. Without mitigation (paragraph 16.4.1), these dwellings would be subject to major adverse impacts from the new road alignments on scheme opening, and would remain subject to major adverse impacts at future assessment year. Most other houses within 600m east of the proposed route and to the north of Bo'ness Road would be subject to minor adverse, moderate adverse or major adverse impacts from the new road alignments on scheme opening, and remain subject to minor adverse, moderate adverse or major adverse impacts at future assessment year. Collectively, given the number of properties subject to moderate or major adverse impacts (approximately 250 in total), which represents a substantial proportion of this part of the South Queensferry community, this is considered to be a significant adverse noise effect. Mitigation to reduce this effect is presented in Section 16.5.

16.4.37 Port Edgar is collectively classed as a category B listed site, and includes a number of (currently unoccupied) category B listed buildings (Port Edgar Barracks). Impacts from the new road alignments at Port Edgar will vary from major adverse at the west of the site (close to the Main Crossing), to minor beneficial at the eastern end of the site. This is considered to constitute a significant adverse effect.

16.4.38 The western half of the Echline Estate in the southwest of South Queensferry would benefit from noise screening provided by the engineering cutting required for the main carriage way to pass under the new South Queensferry Junction. Nonetheless, receptors in this area would be subject to minor adverse and moderate adverse impacts from the new road alignments on scheme opening. At future assessment year, the area would remain subject to minor and moderate adverse impacts from the new road alignments - although the relative proportion of moderate adverse impacts would have increased slightly. Collectively, given the number of properties in this area subject to moderate adverse impacts (approximately 100) and that these represent a substantial proportion of this part of the South Queensferry community, this is considered to be a significant adverse noise effect. Mitigation is discussed in Section 16.5.

16.4.39 In the absence of mitigation (paragraph 16.4.1), Dundas Castle would be subject to moderate adverse impacts on scheme opening and in future assessment year. Properties around Dundas Castle (Greenacre, Blue Acre and the Clock House) would be subject to major adverse impacts on scheme opening and in future assessment year. Given that these properties form a community group and are all subject to moderate or major adverse impacts, this has been rated as a significant noise effect. Mitigation to reduce or remove this effect is presented in Section 16.5.

16.4.40 The dwellings at Dundas Mains (which features a category B listed building) would be subject to moderate to major adverse impacts on scheme opening, and remain subject to moderate and major adverse impacts by future assessment year. Given that these properties form a community group and are all subject to moderate or major adverse impacts, this has been rated as a significant noise effect. Mitigation to reduce or remove this effect is presented in Section 16.5.

16.4.41 For the dwellings at the eastern end of the Dundas Home Farm community (including Dundas North Lodge and Newbigging Lodge), the reduction in traffic on the A8000 and its slight realignment to the east would counterbalance the impact of the new alignments. They would be subject to negligible impacts and minor beneficial impacts on scheme opening, remaining as negligible impacts and minor adverse impacts by future assessment year.

16.4.42 Despite the noise-reducing effects of the base scheme earthworks in this area (in the form of earth bunds), a number of other properties at Dundas Home Farm would be subject to noise impact. Within the main cluster of buildings, the easternmost two dwellings would be subject to minor adverse impacts from the new road alignments on scheme opening and at future assessment year. The westernmost three dwellings would be subject to major adverse impacts from the new road alignments on scheme opening and at future assessment year. This is because these properties are further away from the main existing noise source (the A8000) and hence the baseline noise levels in this location are lower. The remaining dwellings in the centre of the complex would be subject to moderate adverse impacts from the new road alignments at scheme opening and future assessment year. Due to the proportion of the community group that this represents, this has been rated as a significant effect. Mitigation to reduce or remove this remaining effect is presented in Section 16.5.

16.4.43 Those areas of Kirkliston whose noise climate is dominated by the M9 or the M9 Spur would be subject to negligible and minor adverse impacts from the new road alignments on scheme opening. These impacts would be predominantly minor adverse, with small areas of negligible impact, by future assessment year. This is not significant.

16.4.44 The small cluster of dwellings to the southwest of M9 Junction 1A, which includes Overton Cottages, would be subject to negligible impacts from the new road alignments at scheme opening and at future assessment year.

16.4.45 Many properties in the southwest of Kirkliston adjacent to the M9 (some of those on Cotlaws and King Edwards Way) are currently subject to very high levels of road traffic noise. Calculations show that whilst noise increases would be less than 3dB(A) these properties may qualify for noise insulation under the NISR. Given that this is a demonstrable change in noise (greater than 1dB(A) change) at a large number of properties that form a community area, and that these properties are already exposed to very high levels of noise this is considered to constitute a significant adverse noise effect. Mitigation to reduce or remove this effect is presented in Section 16.5.

16.4.46 Muriehall House is situated to the east of Winchburgh adjacent to the M9. It would be subject to negligible impacts on scheme opening and minor adverse impacts by future assessment year. Due to its close proximity to a section of the M9 proposed to be altered as part of the proposed scheme, it may potentially qualify for noise insulation under the NISR. However, because only one property within a much larger community is exposed to these noise levels it considered not to constitute a significant effect.

Direct Impacts on Non-residential Receptors

16.4.47 The following non-residential noise sensitive receptors were identified in the south of the study area. The locations of these receptors are shown in Figure 16.1:

- Echline Primary School in South Queensferry.
  i. On scheme opening, this would be subject to negligible and minor adverse impacts arising from the new road alignments on all façades except the western façade. The southern end of the western façade is currently shielded from its main noise source, Bo'Ness Road. At this part of the facade, the introduction of the base scheme would result in an increase in noise levels at future assessment year. This would constitute a major adverse impact at scheme opening and at future assessment year.
  ii. It is understood that that Echline Primary School generally uses natural means of ventilation (i.e. openable windows). Based on the Local Authority's guidance which draws on Building Bulletin 93 (Department for Education and Skills, 1993), free-field noise levels above 53dBL_{Aeq} outside a classroom window would have the potential to start to cause disturbance within classrooms. The northern façade of the school is already subject to noise levels in excess of this threshold value. The base scheme would cause the northern part of the western façade to also exceed this threshold value, although a site visit has identified that there are no windows in this affected section of building. The remainder of the façades would remain below the threshold value and hence even with the noise increase, windows could be opened to ventilate classrooms whilst still maintaining noise levels inside the classrooms consistent with good teaching environments. It is therefore concluded that Echline Primary School will not be subject to a significant noise effect from the scheme.
- Queensferry Primary School in South Queensferry would be subject to negligible impacts arising from the new road alignments on scheme opening, and remain subject to negligible impacts at future assessment year.
- The Queensferry Churches Care in the Community Project would be subject to negligible impacts arising from the new road alignments on scheme opening, and would remain subject to negligible impacts at future assessment year.
- St. Margaret's RC Primary School would be subject to impacts ranging from negligible to minor beneficial on scheme opening. At future assessment year, the Primary School would be subject to negligible and minor beneficial impacts.
- Dalmeny Primary School would be subject to negligible beneficial impacts on scheme opening, and remain subject to negligible beneficial impacts at future assessment year.
- Leonard Cheshire Home in Kirkliston would be subject to negligible impacts arising from the new road alignments on scheme opening, rising to minor adverse impacts (not significant) by future assessment year.
- Kirkliston Primary School would be subject to negligible impacts from the new road alignments on scheme opening, rising to minor adverse impacts by future assessment year.

Direct Impacts outside Noise Study Area but within two km of the Proposed Scheme

16.4.48 South of the Firth of Forth, areas within two km of the proposed scheme which are not covered by the noise study area occur in the following areas:

- The southern bank of the Firth of Forth between 600m and two km from the Main Crossing:
  i. West of the Main Crossing: The eastern part of this area would be likely to be subject to major adverse impacts arising from the new road alignments, whilst the western part would be likely to be subject to moderate adverse impacts, on scheme opening and at future assessment year. Absolute noise levels in the design year are forecast to be less than 55dBL_{Aeq} levels that the Word Health Organisation advises few people are seriously

annoyed. The effect of these noise changes on ecological receptors is discussed in Chapters 10 and 11.

ii. East of the Main Crossing: This area would be likely to be subject to negligible to minor beneficial impacts arising from the new road alignments. Absolute noise levels in the design year are forecast to be less than 50dBL_{Aeq}, levels that the World Health Organisation (WHO) advises few people a moderately annoyed. This is not considered to be a significant. The effect on ecological receptors is discussed in Chapters 10 and 11.

- To the north-west of Dundas, Duddingston Wood would be likely to be subject to moderate adverse impacts arising from the new road alignments at future assessment year. Absolute noise levels in the design year are forecast to be around 50dB$L_{Aeq,}$ levels that the Word Health Organisation advises few people a seriously annoyed. The noise effect of the scheme in this area is not considered to be a significant.
- The majority of the Dundas Estate, generally to the south of Dundas Castle, would be likely to be subject to minor adverse impacts arising from the scheme, increasing to moderate adverse noise impacts towards the north, which the closest point to the new link road. However, even without mitigation (paragraph 16.4.1), the absolute noise levels with the scheme in place, in the future assessment year, are predicted to be less than 50dBL_{Aeq} for the majority of Dundas Estate. The WHO Guidance notes that at levels below 50dBL_{Aeq} few people will be moderately annoyed and hence the noise effect of the scheme in this area is not considered to be a significant.

Indirect Impacts within the Noise Study Area

16.4.49 Houses along the southern edge of the Echline Estate, at the southern edge of South Queensferry, which face directly onto the A904 (including the category B listed buildings of Echline Farm House and Echline Cottages) would be subject to a mixture of major beneficial and moderate beneficial impacts on scheme opening, due to the reduction in traffic along this road. By future assessment year, these properties would be principally subject to moderate beneficial impacts. Due to the number of properties subject to moderate or better beneficial impacts, and the substantial proportion of the community affected, this is considered to be a significant beneficial noise effect.

16.4.50 To the west of the approach road to the Forth Road Bridge, the houses within approximately 300m of the base scheme (this includes the eastern half of the Echline Estate) would be subject to beneficial impacts due to the sharp reduction in traffic using the Forth Road Bridge. On scheme opening, these impacts would range from major beneficial close to the road, to moderate beneficial and minor beneficial further from the Forth Road Bridge approach road; and would remain as major beneficial close to the road, to moderate beneficial and minor beneficial further from the Forth Road Bridge approach road by future assessment year. Due to the number of properties subject to moderate or better beneficial impacts, this is considered to be a significant beneficial noise effect.

16.4.51 The area to the east of the Forth Road Bridge approach road, bounded by the B924, the B907 and the A8000, would be subject to beneficial impacts on scheme opening, ranging from major beneficial and moderate beneficial impacts close to the approach road, to minor beneficial and negligible impacts further away. By future assessment year, these impacts would remain as major beneficial and moderate beneficial close to the approach road, to minor beneficial and negligible further away. Due to the number of properties subject to moderate or better beneficial impacts, this is considered to be a significant beneficial noise effect.

16.4.52 On scheme opening, the area to the east of the B907 would be subject to negligible impacts. These impacts would remain as negligible by future assessment year.

16.4.53 From the junction of the existing A90 and A8000, as far south as the northern outskirts of Kirkliston, impacts would be negligible on scheme opening, and negligible or minor adverse at future assessment year. There are very few residential dwellings in this section of the study area.

16.4.54 Those dwellings in Kirkliston which face directly onto the B9080 would be subject to minor beneficial impacts on scheme opening due to the projected reduction in traffic along this route. By future assessment year, these dwellings would be subject to minor adverse impacts, with a small number of moderate adverse impacts. However, due to the fact that the noise level increase for these properties is due to natural traffic growth i.e. would occur in the absence of the proposed scheme, this effect has not been rated as a significant effect of the proposed scheme.

16.4.55 A small area of the suburb of Newbridge falls within the noise study area. Dwellings in this area would be subject to negligible impacts arising from the new road alignments on opening. At the future assessment year, these same properties would be principally subject to minor adverse impacts, with some properties subject to negligible impacts.

16.4.56 The area of Winchburgh which lies to the east of the Edinburgh to Falkirk Union Canal falls into the noise study area. The residential dwellings in this area would be predominantly subject to negligible and minor adverse impacts on scheme opening, rising to minor adverse impacts with a small number of moderate adverse impacts by future assessment year. However, due to the fact that the noise level increase for these properties is predominantly due to natural traffic growth due to other development allocations (i.e. most of the noise increase would occur in the absence of the proposed scheme) this has not been rated as a significant effect arising from the proposed scheme.

16.4.57 Dwellings facing onto the B8020 between the B9080 and the A904 would be subject to minor adverse impacts on scheme opening, rising to moderate adverse impacts by future assessment year. However, due to the fact that the noise level increase for these properties is predominantly due to natural traffic growth due to other development allocations (i.e. most of the noise increase would occur in the absence of the proposed scheme) this has not been rated as a significant effect.

Indirect Impacts Outside Noise Study Area but within 2km of the Proposed Scheme

16.4.58 South of the Firth of Forth, areas within 2km of the proposed scheme which are not covered by the noise study area would be subject to noise impacts in the following areas:

- The western half of Winchburgh would be likely to be subject to negligible adverse impacts on scheme opening and to minor adverse impacts at future assessment year.
- To the east of South Queensferry, impacts will be a combination of negligible and minor beneficial on scheme opening and at future assessment year.
- The majority of the rest of areas between 600m and 2km in the south of the study area are sparsely populated. They will predominantly be subject to negligible impacts from the new road alignments on scheme opening and minor adverse impacts at future assessment year.
- South Queensferry High School is likely to be subject to negligible or minor beneficial impacts. This is not significant.

Analysis of Affected Routes outside the noise calculation area

16.4.59 As described earlier, DMRB requires that an analysis of affected routes which lie outside the detailed calculation area (i.e. the noise study area) should be carried out using the Basic Noise Level (BNL) as defined in CRTN, along with a count of dwellings within 50m of the routes. There are very few affected routes outside the noise study area south of the Firth of Forth. For example, the road connecting the B8020 and the A904 is a very minor road with a flow well below that of the valid range of CRTN i.e. 1000 vehicles per day. For this reason, an analysis based on BNLs was not considered to be appropriate. There are six properties within 50m of this road link. Potential traffic changes on these roads are considered highly unlikely to give rise to significant noise effects.

16.4.60 Several other very minor side roads to the east of the M9 Spur and to the east of South Queensferry were not considered for BNL analysis due to having predicted flows well below 1000

vehicle per day that is below the valid traffic flow range for CRTN. Potential traffic changes on these roads are considered highly unlikely to give rise to significant noise effects.

Main Crossing – Potential for Wind Generated Noise

16.4.61 Appropriate design standards will be adhered to for these structures and as discussed in Section 16.2, projects designed to these standards do not exhibit wind noise and hence it is considered highly unlikely that wind generated noise would give rise to significant noise effects.

Main Crossing – Potential for Noise from Expansion Joints

16.4.62 Section 16.2 sets out the design features of the base scheme which will control noise from the expansion joints at either end of the Main Crossing.

16.4.63 It is still possible that noise from vehicles passing over the joints might be audible to some degree over the general road traffic at locations close to the Main Crossing abutments. However, it is likely that impulsive noise from the joints will quickly become inaudible over the road traffic noise with increasing distance from the abutment. It is considered highly unlikely that noise generated by vehicles passing over the expansion joints at both the north and south abutments would give rise to significant noise effects.

Analysis of Potential Noise Nuisance

16.4.64 As part of the DMRB (2008) Detailed Assessment, Assessment Summary Tables (ASTs) displaying changes in noise level and noise nuisance must be presented. The first table required presents the projected change in nuisance in the absence of the proposed scheme (by comparing the Do-Minimum scenario in the future assessment year with the Do-Minimum scenario in the proposed scheme opening year). A second table is required showing the projected change in nuisance if the proposed scheme goes ahead (by comparing the Do-Something scenario in the future assessment year with the Do-Minimum scenario in the proposed scheme opening year).

16.4.65 Both of these tables (Tables 16.3 and 16.4) are presented for the proposed scheme as part of this report. The assessment is then carried out by reporting the difference in numbers of dwellings falling into each category. For example, if there were 100 dwellings in the 1-2.9dB noise increase category in the Do-Minimum table and 110 in the Do-Something table, an increase of 10 dwellings in this category would be reported.

16.4.66 In this way, the impact of the Do-Something scenario in 2032 is compared with the Do-Minimum scenario in 2032; that is, what difference there would be in noise and nuisance terms in the future assessment year if the scheme went ahead compared with if it did not.

16.4.67 Two methods of calculating nuisance change are set out within DMRB (2008) guidance: one based on assessing the ‘steady-state’ nuisance due to noise from an existing road, and the second specifically related to ‘step’ changes in noise level. For the first table (the Do-Minimum comparison), only natural traffic growth is being assessed and so no ‘step-change’ occurs. Therefore, the ‘steady-state’ nuisance method applies, with the result that relatively small increases in nuisance are predicted.

16.4.68 The comparison of Do-Minimum scenarios between the opening year and the future assessment year (Table 16.3) shows low predicted rises in noise nuisance. Natural traffic growth results in overall noise level increases of <3dB(A) for the majority of dwellings within the noise study area (just under 9,500 out of approximately 9,600 dwellings).

16.4.69 In terms of nuisance, comparing the Do-Minimum scenario in the two assessment years the majority of dwellings would be subject to projected nuisance increases of less than 10 percentage points over the 15 years from 2017 to 2032. Much smaller numbers would be subject to nuisance rises of 10<20 percentage points and decreases of <10 percentage points. These nuisance

changes are assessed with the 'steady-state' relationship, as no step-change in noise level due to a new scheme occurs.

16.4.70 For the second table (the Do-Something comparison), a step noise change takes place at scheme opening. In this case, therefore, the steeper 'step-change' relationship is used to calculate noise nuisance increases, with the result that much higher levels of nuisance are predicted. Over time, levels of noise nuisance gradually revert to the lower 'steady-state' scenario. However, under DMRB (2008) the highest levels of nuisance in the first 15 years after opening are to be reported.

16.4.71 Analysing the differences between the Do-Minimum table and the Do-Something table, the following conclusions can be drawn. With the proposed scheme, 1430 fewer dwellings would be subject to noise level increases of <3dB(A) than without it; 490 more would be subject to noise increases of 3-5dB(A) than without it; and 520 more dwellings would be subject to noise increases of >5dB(A) than without the scheme. 350 more dwellings would be subject to noise decreases of <3dB(A) with the scheme than without it; 60 more dwellings would be subject to decreases of 3-5dB(A) with the scheme than without it; and 10 more dwellings would be subject to decreases of >5dB(A).

16.4.72 In terms of noise nuisance: with the proposed scheme, 7900 fewer dwellings would be subject to increases in nuisance of <10 percentage points than without it; 4740 more would be subject to an increase in nuisance of 10<20 percentage points than without it; 1890 more dwellings would be subject to an increase in nuisance of 20<30 percentage points; 620 more subject to an increase in nuisance of 30<40 percentage points and 240 more subject to an increase in nuisance of ≥40 percentage points. With the proposed scheme, 400 more dwellings would be subject to a decrease in nuisance of <10 percentage points than without it.

16.4.73 There are some intricacies of the nuisance calculation methodology required by DMRB (2008) which are useful to consider when interpreting the assessment results especially for a scheme such as the proposed scheme where community areas may be affected by both adverse effects from a new road and beneficial effects from an existing road that becomes substantially de-trafficked as a consequence of the scheme.

16.4.74 Firstly, when assessing noise decreases, the steady state relationship is used as it is the long term decrease that will result in the highest level of nuisance (which must be reported) rather than the short-term decrease. For a comparable magnitude of noise level increase and decrease, therefore, the predicted noise nuisance increase would be of much greater magnitude than the predicted noise nuisance decrease.

16.4.75 Secondly, the analysis methodology involves assessing the nuisance change for each façade of a building, then taking the worst-case nuisance change and assigning it to each dwelling within that building. This method applies to all properties reported in the ASTs.

16.4.76 Thirdly, DMRB (2008) states that the research from which the nuisance assessment methodologies are derived were based on noise surveys at which the noise exposures were >65dB$L_{A10,18h}$ and the dwellings were up to 18m from the kerb. Predictions of nuisance in the higher absolute noise bands and closer to the roads would therefore be expected to be more reliable, although in the absence of further data, the same nuisance assessment methodology is applied to every property.

16.4.77 Individually and in combination these method steps, give a very worst case view of potential changes in nuisance from road traffic noise. The following section therefore provides supplementary ASTs that identify the effect of the above method steps in the context of the proposed scheme.

Table 16.3: Detailed Assessment Summary Table: Do-Minimum Comparison

Change in noise/nuisance level		Number of dwellings (by façade level noise band LA10,18h dB(A)). NB all values are rounded to the nearest 10														
		Total	< 47.5	47.5 - 50.4	50.5 - 53.4	53.5 – 56.4	56.5 - 59.4	59.5 - 62.4	62.5 - 65.4	65.5 - 68.4	68.5 - 71.4	71.5 - 74.4	74.5 - 77.4	77.5 - 80.4	80.5 - 83.4	>= 83.5
Increase in noise level, LA10,18h dB(A)	0-0.1	80	20	10	20	20	10									
	0.1-0.9	6920	1190	1450	1450	1040	600	390	220	320	200	60				
	1-2.9	2360	220	590	570	320	210	90	80	90	70	60	60			
	3-4.9	120			10	10	10	10	20	10	40	10				
	5+															
Decrease in noise level, LA10,18h dB(A)	0-0.1															
	0.1-0.9	80	40	30	10											
	1-2.9	20			10	10										
	3-4.9															
	5+															
Increase in nuisance level, percentage points	< 10	9460	1420	2060	2040	1390	830	490	320	420	290	140	60			
	10 < 20	20									20					
	20 < 30															
	30 < 40															
	≥ 40															
Decrease in nuisance level, percentage points	< 10	110	50	30	10	10	10									
	10 < 20															
	20 < 30															
	30 < 40															
	≥40															

Table 16.4: Detailed Assessment Table: Do-Something (Base Scheme) Comparison

Change in noise/nuisance level		Number of dwellings (by façade level noise band LA10,18h dB(A)). NB all values are rounded to the nearest 10														
		Total	< 47.5	47.5 - 50.4	50.5 - 53.4	53.5 - 56.4	56.5 - 59.4	59.5 - 62.4	62.5 - 65.4	65.5 - 68.4	68.5 - 71.4	71.5 - 74.4	74.5 - 77.4	77.5 - 80.4	80.5 - 83.4	>= 83.5
Increase in noise level, LA10,18h dB(A)	0-0.1	100	20	30	20	10			10							
	0.1-0.9	3470	420	970	1000	500	230	110	90	60	80	30				
	1-2.9	4360	830	780	1110	710	350	210	110	80	100	30	30	20		
	3-4.9	610	10	50	240	150	80	40	10	10	10	10				
	5+	520		10	160	170	110	60	10							
Decrease in noise level, LA10,18h dB(A)	0-0.1	10														
	0.1-0.9	260	80	90	60	20	10	10								
	1-2.9	180	40	40	70	10	10	10	10							
	3-4.9	60	10	20	20	10										
	5+	10				10										
Increase in nuisance level, percentage points	< 10	1560	150	310	390	240	110	60	70	70	100	40	20	10		
	10 < 20	4760	910	1170	1310	730	280	140	80	60	80	10				
	20 < 30	1890	220	330	510	320	230	140	60	30	20	20	10	10		
	30 < 40	620	10	40	300	180	60	20	10							
	>= 40	240			40	70	80	50								
Decrease in nuisance level, percentage points	< 10	510	130	150	150	50	20	10	10							
	10 < 20															
	20 < 30															
	30 < 40															
	>= 40															

Supplementary Nuisance Analysis

16.4.78 As discussed above, the nuisance assessment analysis methodology set out in DMRB (2008) contains a number of procedures which direct the Summary Table outputs towards a conservative 'worst case' assessment of the noise level and nuisance changes.

16.4.79 Under the DMRB (2008) methodology, as explained in paragraph 16.4.77, the worst-case façade noise nuisance change is reported for each dwelling. This means if a dwelling is subject to a small noise increase on one façade and a large beneficial impact on another, data from the façade subject to the small increase would be used to categorise that dwelling in the assessment table. This could lead to an underestimation of the potential beneficial impacts of a proposed scheme.

16.4.80 Furthermore, the effects detailed in paragraphs 16.4.73 and 16.4.74 produce a far higher rating of nuisance change for noise increases as opposed to decreases, again potentially underestimating the potential beneficial impacts of the proposed scheme.

16.4.81 To place the worst case assessment into context, a pair of supplementary nuisance analysis tables is presented below. These tables are populated using façade data for each dwelling displaying the greatest magnitude of noise level change at that dwelling – be it positive or negative.

16.4.82 For example, a dwelling subject to noise level change of 0dB(A) at one façade and -5dB(A) change at another façade is categorised according to the 0dB(A) façade under DMRB (2008) methodology, despite another façade seeing a significant decrease in noise level. Under the supplementary nuisance analysis method, the -5dB(A) façade's result is used to categorise the change in nuisance at the dwelling.

16.4.83 The supplementary nuisance analysis tables also display nuisance in all cases as calculated using the 'steady-state' nuisance, to provide a more balanced comparison of adverse and beneficial impacts. The results are shown in Table 16.5 and Table 16.6.

16.4.84 Under the Do-Something supplementary nuisance analysis, with the proposed scheme, 2180 fewer dwellings would be subject to noise level increases of <3dB(A) than without it; 470 more would be subject to noise increases of 3-5dB(A) than without it; and 520 more dwellings would be subject to noise increases of >5dB(A) than without the scheme. Five hundred and sixty more dwellings would be subject to noise decreases of <3dB(A) with the scheme than without it; 410 more dwellings would be subject to decreases of 3-5dB(A) with the scheme than without it; and 220 more dwellings would be subject to decreases of >5dB(A).

16.4.85 In terms of noise nuisance: with the proposed scheme, 1210 fewer dwellings would be subject to increases in nuisance of <10 percentage points than without it; 30 more would be subject to an increase in nuisance of 10<20 percentage points than without it. A total of 1090 more dwellings would be subject to a decrease in nuisance of <10 percentage points; 70 more dwellings subject to a decrease in nuisance of 10<20 percentage points and 30 more dwellings subject to a decrease in nuisance of 20<30 percentage points.

16.4.86 This analysis demonstrates that whilst the base scheme (which includes some noise-reducing design features as described at Section 16.2) would give rise to an increase in noise nuisance across many properties there is also a significant reduction in nuisance at a large number of properties.

Table 16.5: Supplementary Detailed Assessment Table: Do-Minimum Comparison

Change in noise/nuisance level		Number of dwellings (façade level noise band LA10,18h dB(A) for Do-Minimum scenario in the baseline year) NB all values rounded to nearest 10														
		Total	< 47.5	47.5 - 50.4	50.5 - 53.4	53.5 - 56.4	56.5 - 59.4	59.5 - 62.4	62.5 - 65.4	65.5 - 68.4	68.5 - 71.4	71.5 - 74.4	74.5 - 77.4	77.5 - 80.4	80.5 - 83.4	>= 83.5
Increase in noise level, LA10,18h dB(A)	0-0.1	160	20	10	40	50	20				10					
	0.1-0.9	6790	1900	1660	1230	850	450	260	130	170	100	40				
	1-2.9	2110	400	680	530	170	100	60	50	60	30	30	20			
	3-4.9	130			10	10	20	20	20	20	30	10				
	5+															
Decrease in noise level, LA10,18h dB(A)	0-0.1															
	0.1-0.9	130	40	30	30	10				10						
	1-2.9	270		10	40	30	20	40	90	20	30					
	3-4.9															
	5 +															
Increase in nuisance level, percentage points	< 10	9170	2310	2350	1810	1080	600	340	190	240	160	70	20			
	10 < 20	10									10					
	20 < 30															
	30 < 40															
	>= 40															
Decrease in nuisance level, percentage points	< 10	400	40	40	70	30	30	40	90	20	30					
	10 < 20															
	20 < 30															
	30 < 40															
	>= 40															

Table 16.6: Supplementary Detailed Assessment Table: Do-Something (Base Scheme) Comparison

Change in noise/nuisance level		Number of dwellings (façade level noise band LA10,18h dB(A) for Do-Minimum scenario in the baseline year) NB all values rounded to nearest 10														
		Total	< 47.5	47.5 - 50.4	50.5 - 53.4	53.5 - 56.4	56.5 - 59.4	59.5 - 62.4	62.5 - 65.4	65.5 - 68.4	68.5 - 71.4	71.5 - 74.4	74.5 - 77.4	77.5 - 80.4	80.5 - 83.4	>= 83.5
Increase in noise level, LA10,18h dB(A)	0-0.1															
	0.1-0.9	2570	370	730	640	360	160	100	50	80	60	30				
	1-2.9	4310	1350	970	860	430	250	140	80	130	50	30	10			
	3-4.9	600	100	250	100	80	30	10	10	10	10					
	5+	520	290	180	30	10	10									
Decrease in noise level, LA10,18h dB(A)	0-0.1															
	0.1-0.9	220	40	60	40	20	20		10	10	10	10				
	1-2.9	740	200	190	130	90	50	30	40	10						
	3-4.9	410	10	20	60	90	40	40	70	20	40	10				
	5+	220			20	40	50	50	20	10	20					
Increase in nuisance level, percentage points	< 10	7960	2090	2120	1630	870	450	260	150	210	120	60	10			
	10 < 20	40	20	10							10					
	20 < 30															
	30 < 40															
	>= 40															
Decrease in nuisance level, percentage points	< 10	1490	250	270	240	240	170	120	120	40	40	10				
	10 < 20	70						10	20	10	20	10				
	20 < 30	30								10	20					
	30 < 40															
	>= 40															

16.5 Mitigation

16.5.1 This section describes the specific mitigation, by way of roadside noise barriers, proposed for those areas where significant adverse effects have been forecast for the base scheme as described in Section 16.4. The screening extents and heights have been specified using the noise model to predict the attenuation afforded by a range of screening options. The screening solutions proposed represent a practicable mitigation plan with the objective of controlling noise increases to prevent significant residual effects; or where this is not practicable, to minimise the noise increases. It should be noted that noise screening requirements have been balanced against other environmental considerations such as visual intrusion, engineering considerations and cost-benefit. The optimised mitigation solution has been developed on a multi-disciplinary basis within the project team.

Description of Mitigation

16.5.2 The following sets out the noise barriers as currently envisaged and this section should be read with reference to Figure 16.10 and Table 16.7.

16.5.3 Noise mitigation will be finalised during detailed design in accordance with the Noise and Vibration Policy and DMRB (2008) requirements for highway noise screening.

South Queensferry Barrier (Mitigation Items N1-N4)

16.5.4 The proposed barrier is located to the eastern side of the new mainline route. The barrier height changes from 2.8m on the approach viaduct to 4m (potentially a 2m earth bund and 2m noise barrier) as it comes off the Main Crossing and then reduces to 3m (potentially a 2m earth bund and 1m noise barrier) as it runs further south and augments the significant noise screening provided by the cutting approach to the proposed Queensferry Junction. Predictions show that there is a 1-3dB(A) reduction with the proposed mitigation to the closest properties to the proposed scheme on the western edge of South Queensferry. A large number of residential receptors would be mitigated by this screen. However, it is not reasonably practicable to provide any greater level of noise mitigation within the requirements of the engineering design (wind turbulence effects on road traffic over the Main Crossing and constraints on engineering design of false cuttings on the approach to the Main Crossing), and the landscape design for the area (to mitigate the scheme's landscape impact). Most importantly noise barriers provide maximum benefit close to the barrier and the benefit reduces with increasing distance from the source and barrier. The receptors at South Queensferry are at significant distance from at the new road and the wayside barriers and hence the noise reduction provided by any barrier will be modest.

Linn Mill Barrier (Mitigation Items N5-N6)

16.5.5 The proposed barrier runs for approximately 140m at 2.8m high on the western side of the approach viaduct. The barrier then increases to 4m high (potentially a 2m earth bund and 2m noise barrier) when leaving the approach viaduct extending 309m to the south. The predicted benefits are 3-4dB(A) for Inchgarvie House and 1-2dB(A) for properties at Linn Mill. It is not considered reasonably practicable to provide any greater level of noise mitigation within the requirements of the engineering design of the Main Crossing, and the landscape design for the area. The majority of the receptors Linn Mill are at significant distance from the new road and the wayside barriers and hence the noise reduction provided by any higher barrier will be modest.

West Dundas Barrier (Mitigation Item N7)

16.5.6 The proposed barrier is 4m high (potentially a 2m earth bund and 2m noise barrier) and runs for approximately 545m. It is predicted to attenuate traffic noise levels by 2-3dB(A) at receptors in Dundas Mains and around Dundas Castle.

16.5.7 It is not considered reasonably practicable to provide any greater level of noise mitigation within the requirements of the engineering design of the highway, and the landscape design for the area. The majority of the receptors are at significant distance from at the new road and the wayside barriers and hence the noise reduction provided by any barrier will be modest.

East Dundas Barrier (Mitigation Item N8)

16.5.8 The proposed 4m high barrier (potentially a 2m earth bund and 2m noise barrier) is predicted to attenuate traffic noise levels by 2-5dB(A).

16.5.9 It is not considered reasonably practicable to provide any greater level of noise mitigation within the requirements of the engineering design of the highway, and the landscape design for the area. As above the majority of the receptors are at significant distance from at the new road and the wayside barriers and hence the noise reduction provided by any barrier will be modest.

Kirkliston Barrier (Mitigation Item N9-N10)

16.5.10 The majority of the proposed barrier consists of a timber fence 2.5m high, extending approximately 245m from approximately 70m south of the where Niddry Burn runs underneath the M9, to as far north as the most north-westerly properties on Cotlaws. A further contiguous barrier of approximately 30m in length and 2m height then extends further north-west. The barrier is predicted to prevent noise levels at the south western corner of Kirkliston, close to the M9, from exceeding the threshold at which noise levels would be considered unacceptable. This threshold represents the qualifying criteria for the NISR. Additionally, the barrier is predicted to provide attenuation of between 2 and 5dB to the facades of those properties closest to the M9.

Table 16.7: Proposed Noise Mitigation Scheme

Barrier	ID Code	Indicative Chainage	Barrier Length	Total Barrier Height	Comments
South Queensferry	C-B2 rev A	ch4310 – 4515	~180m on viaduct ~25m on road	2.8m	180m. There is also a wind barrier in this location.
		ch4260 – 4310	~50m	4m	Integrated into landscape design.
		ch4110 – 4260	~150m	3m	
		ch4030 – 4110	~80m	3m	
			Total Length: ~485m		
Linn Mill	A-B3	ch4310 - 4450	~115m on viaduct ~25m on road	2.8m	Integrated into landscape design.
		ch4000 – 4310	~310m	4m	
			Total Length: ~450m		
West Dundas	A-B4	ch2550 – 3095	~545m	4m	Integrated into landscape design.
East Dundas	B-B5	ch1860- 2365	~505m	4m	Integrated into landscape design.
Kirkliston	A-SWK	M9 ch1015 – 1260	~245m	2.5m	Typical highway noise barrier (fence).
		M9 ch1260 – 1290	~30m	2m	Typical highway noise barrier (fence).

16.6 Residual Impacts

16.6.1 Following inclusion of the noise mitigation described in Section 16.5, this section re-examines the areas where likely significant effects would occur. As described in Section 16.5, mitigation is proposed to address the significant adverse noise effects predicted for the base scheme. It should be noted that in many cases it is not possible to remove adverse effects although they may be

significantly reduced by the provision of mitigation. In such cases the combined noise-reducing base scheme design features (described in Section 16.2) and any mitigation as described above in Section 16.5 are intended to minimise the adverse noise effects as far as is reasonably practicable.

16.6.2 The base scheme noise model was revised to include the mitigation described in the previous section. Noise levels were then re-calculated. Noise maps showing the mitigated noise levels at opening and future assessment years are presented in Figures 16.11 and 16.12 respectively. Figures 16.13 and 16.14 (noise difference maps) show the mitigated scheme impacts at opening and future assessment year respectively.

16.6.3 Figure 16.15 shows the difference between the base scheme and the scheme with mitigation - i.e. the benefits provided by the barriers relative to the base scheme.

North of the Firth of Forth

16.6.4 There is no mitigation proposed to the north of the Firth of Forth. Impacts at dwellings therefore would remain as reported in Section 16.4.

South of the Firth of Forth

16.6.5 South Queensferry Barrier provides a small benefit to a large number of dwellings in the north-western corner of South Queensferry referred to in paragraph 16.4.36. Impacts at these dwellings would remain as major adverse at opening and future assessment year (significant effect), but the proposed mitigation means noise levels would be 1-3 dB(A) lower than would be the case in the absence of mitigation. It should be noted that noise levels in this area would already be reduced through the base scheme design features. The total noise screening is therefore greater than 1-3 dB(A).

16.6.6 South Queensferry Barrier therefore reduces, but does not remove, the significant adverse effect predicted on the west side of South Queensferry. Extensive barriers are proposed in addition to the earth bunding of the base scheme and it is not practicable to increase the height of this mitigation further. A significant residual adverse noise effect is therefore unavoidable.

16.6.7 Relative to the base scheme, Linn Mill Barrier would provide benefits of approximately 1-2dB(A) for the first row of dwellings on Linn Mill; approximately 1dB(A) for the second row dwellings on Linn Mill; and between 3-4dB(A) for the multiple residences at Inchgarvie House. Noise impacts at all of these dwellings would, however, remain as major adverse on opening and at future assessment year.

16.6.8 Linn Mill Barrier therefore reduces, but does not remove, the significant adverse effect predicted on Linn Mill/Inchgarvie community. The barriers proposed are 4m in height and it is not practicable to increase the height further. The residual effect remains significant.

16.6.9 Relative to the base scheme, West Dundas Barrier would provide benefits of 2-3 dB(A) at Dundas Castle and the surround residential property. This results in residual impacts of moderate adverse magnitude at all properties except Dundas Castle, with minor adverse magnitude at Dundas Castle itself (all at future assessment year). Whilst moderate adverse impacts are still present at most of these receptors, the proposed barrier reduces absolute traffic noise levels in the future assessment year to less than 50dBL_{Aeq}. The WHO guidance notes '*few people…are moderately annoyed at LAeq levels below 50dB*'. Furthermore, the advice in DMRB relating road traffic noise to noise nuisance predicts that only approximately 5% of people would be '*bothered very much or quite a lot*' by traffic noise at this level. For these reasons, the residual effect is not considered to be significant.

16.6.10 West Dundas Barrier would provide relative benefits of approximately 2-3dB(A) at Dundas Mains, although the magnitude of impact would remain as moderate adverse at future assessment year. However, again the mitigation reduces absolute traffic noise levels in the future assessment year

these properties to levels less than 50dBL_{Aeq}. Therefore, for the same reasons as those detailed above for the Dundas Castle, the residual noise effect on this community has not been rated as significant.

16.6.11 West Dundas Barrier therefore removes the significant effects at Dundas Castle residential community and at Dundas Mains.

16.6.12 Relative to the base scheme, East Dundas Barrier would provide benefits of approximately between 2-5dB(A) for the main cluster of dwellings at Dundas Home Farm. This relative benefit would generally reduce the severity of impacts by one impact magnitude category for all dwellings at Dundas Home Farm.

16.6.13 At the westernmost dwellings, impacts would be limited to moderate adverse at opening and future assessment years. The impact of the base scheme at this location was major adverse at the future assessment year. The main central cluster would see impacts limited to minor adverse at opening and future assessment years. The impact of the base scheme at this location was moderate adverse at future assessment year. The easternmost dwellings would be limited to negligible or minor adverse impacts at future assessment year. The impact of the base scheme at this location was minor adverse at future assessment year.

16.6.14 East Dundas Barrier reduces the predicted impacts at Dundas Home Farm such that a very small proportion of the community would be subject to moderate adverse impacts. For this reason, the mitigated scheme is not considered to result in a significant residual adverse effect.

16.6.15 Due to the high predicted absolute noise levels at the buildings close to the M9 in southwest Kirkliston, many of these dwellings would be eligible for noise insulation under NISR. This is because the façade noise levels would exceed 68dB$L_{A10,\ 18h}$ and noise levels would increase by 1dB(A) or more due to the proposed scheme. The proposed barrier design would prevent traffic noise exceeding the noise insulation threshold In addition, relative to the base scheme, Kirkliston Barrier would provide benefits of approximately between 1.5-5dB(A) of attenuation for residences close to the M9.

16.6.16 The Kirkliston Barrier therefore removes the predicted adverse effect of the scheme at properties in southwest Kirkliston.

16.6.17 Other areas of impact rated as significant will remain as described in Section 16.4. The significant effects are represented below for ease of reference.

16.6.18 Dwellings along the southern edge of the Echline Estate which face directly onto the A904 would still, under the mitigated scheme, be subject to a mixture of major beneficial and moderate beneficial impacts on scheme opening, due to the reduction in traffic along this road. By future assessment year, these impacts would remain as major beneficial and moderate beneficial, although the relative proportion of moderate beneficial impacts would have increased slightly. This is considered to be a residual significant beneficial effect.

16.6.19 To the west of the Forth Road Bridge approach road, the dwellings within approximately 300m of the existing approach road (this includes the eastern half of the Echline Estate) would be subject to beneficial impacts. On scheme opening, these impacts would range from major beneficial close to the road, to moderate beneficial and minor beneficial further from the Forth Road Bridge approach road; impacts would remain as major beneficial close to the road, to moderate beneficial and minor beneficial further from the Forth Road Bridge approach road at future assessment year. Overall this is considered to be a residual significant beneficial effect.

16.6.20 The area to the east of the Forth Road Bridge approach road, bounded by the B924, the B907 and the A8000, would be subject to beneficial impacts on scheme opening, ranging from major beneficial and moderate beneficial impacts close to the approach road, to minor beneficial and negligible impacts further away. At future assessment year, these impacts would remain as major

beneficial and moderate beneficial close to the approach road, to minor beneficial (not significant) and negligible further away. Overall this is considered to be a residual significant beneficial effect.

16.6.21 The western half of the Echline Estate in the southwest of South Queensferry would be subject to minor adverse and moderate adverse impacts from the new road alignments on scheme opening. At future assessment year, the area would remain subject to minor adverse impacts and moderate adverse impacts from the new road alignments - although the relative proportion of moderate adverse impacts would have increased slightly. The fact that the proposed new alignments are already shielded from the Echline Estate through being in cutting substantially limits the potential effectiveness of noise barriers to address these impacts. Collectively, therefore, given the number of properties in this area subject to moderate adverse impacts (approximately 100), this is considered to be a residual significant adverse effect of the proposed scheme.

Analysis of Residual Noise Nuisance

16.6.22 The scheme with mitigation shows a reduction in the number of dwellings subject to noise nuisance increases as compared with the base scheme.

16.6.23 The proposed mitigation has only a limited effect in terms of overall noise nuisance associated with the base scheme. This is due to a combination of factors relating to the nuisance assessment methodology and presentation of the noise impacts. The two main reasons are as follows:

- DMRB (2008) methodology states that each façade of each building must be evaluated separately. In some cases, therefore, even if a barrier has had a beneficial effect on one façade of a building, it may have little effect on other façades. It is the worst-case nuisance change (i.e. increase in nuisance) that is reported. Hence, the change in noise nuisance at that dwelling may remain unchanged from that reported for the base scheme.
- Some of the proposed noise barriers, for example South Queensferry Barrier and Linn Mill Barrier, provide mitigation to dwellings which would be subject to very large potential impacts. For this reason, despite the noise levels being reduced by appreciable amounts, dwellings' noise and nuisance change categories may not register any change. For example, a reduction in noise level increase on scheme opening from 12dB(A) to 8dB(A) at a particular dwelling would not lead to a change in its categorisations in the table.

16.6.24 By analysing the difference between the Do-Minimum table and the Do-Something table, the following conclusions are drawn: With the proposed mitigated scheme, 1410 fewer dwellings would be subject to noise level increases of <3dB(A) than without it; 490 more would be subject to noise increases of 3-5dB(A) than without it; and 530 more dwellings would be subject to noise increases of >5dB(A) than without the scheme. Three hundred and thirty more dwellings would be subject to noise decreases of <3dB(A) with the scheme than without it; 60 more dwellings would be subject to decreases of 3-5dB(A) with the scheme than without it; and 20 more dwellings would be subject to decreases of >5dB(A).

16.6.25 In terms of noise nuisance: with the proposed mitigated scheme, 7880 fewer dwellings would be subject to increases in nuisance of <10 percentage points than without it; 4850 more would be subject to an increase in nuisance of 10<20 percentage points than without it; 1770 more dwellings would be subject to an increase in nuisance of 20<30 percentage points; 650 more subject to an increase in nuisance of 30<40 percentage points and 230 more subject to an increase in nuisance of □40 percentage points. With the proposed mitigated scheme, 370 more dwellings would be subject to a decrease in nuisance of <10 percentage points than without it.

16.6.26 Reported numbers of dwellings subject to noise and nuisance changes have been rounded to the nearest 10 dwellings.

Table 16.8: Detailed Assessment Table: Do-Minimum

Change in noise/nuisance level		Number of dwellings (façade level noise band LA10,18h dB(A)). NB all values are rounded to the nearest 10														
		Total	< 47.5	47.5 - 50.4	50.5 - 53.4	53.5 - 56.4	56.5 - 59.4	59.5 - 62.4	62.5 - 65.4	65.5 - 68.4	68.5 - 71.4	71.5 - 74.4	74.5 - 77.4	77.5 - 80.4	80.5 - 83.4	>= 83.5
Increase in noise level, LA10,18h dB(A)	0-0.1	80	20	10	20	20	10									
	0.1-0.9	6920	1190	1450	1450	1040	600	390	220	320	200	60				
	1-2.9	2360	220	590	570	320	210	90	80	90	70	60	60			
	3-4.9	120			10	10	10	10	20	10	40	10				
	5+															
Decrease in noise level, LA10,18h dB(A)	0-0.1															
	0.1-0.9	80	40	30	10											
	1-2.9	20			10	10										
	3-4.9															
	5+															
Increase in nuisance level, percentage points	< 10	9460	1420	2060	2040	1390	830	490	320	420	290	140	60			
	10 < 20	20									20					
	20 < 30															
	30 < 40															
	>= 40															
Decrease in nuisance level, percentage points	< 10	110	50	30	10	10	10									
	10 < 20															
	20 < 30															
	30 < 40															
	>= 40															

Table 16.9: Detailed Assessment Table: Do-Something (With Mitigation)

Change in noise/nuisance level		Number of dwellings (façade level noise band LA10,18h dB(A)) NB all values are rounded to the nearest 10.														
		Total	< 47.5	47.5 - 50.4	50.5 - 53.4	53.5 - 56.4	56.5 - 59.4	59.5 - 62.4	62.5 - 65.4	65.5 - 68.4	68.5 - 71.4	71.5 - 74.4	74.5 - 77.4	77.5 - 80.4	80.5 - 83.4	>= 83.5
Increase in noise level, LA10,18h dB(A)	0-0.1	90	20	30	20	10			10							
	0.1-0.9	3470	390	960	960	520	250	110	100	60	80	40				
	1-2.9	4390	830	780	1140	740	350	200	110	70	100	20	30	20		
	3-4.9	610	20	50	240	160	70	30	10	10	10					
	5+	530		10	170	180	110	40	10							
Decrease in noise level, LA10,18h dB(A)	0-0.1	10		10												
	0.1-0.9	240	70	70	50	20	10	10								
	1-2.9	180	40	40	60	10	10	10	10							
	3-4.9	60	10	20	20	10										
	5+	20				10										
Increase in nuisance level, percentage points	< 10	1580	130	310	370	260	130	70	80	70	100	50	20	10		
	10 < 20	4870	900	1170	1330	770	310	160	100	60	80	10				
	20 < 30	1770	220	330	500	310	210	110	50	20	10	10	10	10		
	30 < 40	650	10	40	290	210	60	20	10							
	>= 40	230			40	70	90	30								
Decrease in nuisance level, percentage points	< 10	480	120	130	140	40	20	10	10							
	10 < 20															
	20 < 30															
	30 < 40															
	>= 40															

Supplementary Nuisance Analysis

16.6.27 Under the Do-Something mitigated supplementary nuisance analysis, with the proposed scheme, 2210 fewer dwellings would be subject to noise level increases of <3dB(A) than without it; 480 more would be subject to noise increases of 3-5dB(A) than without it; and 520 more dwellings would be subject to noise increases of >5dB(A) than without the scheme. Five hundred and seventy more dwellings would be subject to noise decreases of <3dB(A) with the scheme than without it; 410 more dwellings would be subject to decreases of 3-5dB(A) with the scheme than without it; and 220 more dwellings would be subject to decreases of >5dB(A).

16.6.28 In terms of noise nuisance: with the proposed mitigated scheme, 1210 fewer dwellings would be subject to increases in nuisance of <10 percentage points than without it; 20 more would be subject to an increase in nuisance of 10<20 percentage points than without it. One thousand one hundred and ten more dwellings would be subject to a decrease in nuisance of <10 percentage points; 70 more dwellings subject to a decrease in nuisance of 10<20 percentage points and 30 more dwellings subject to a decrease in nuisance of 20<30 percentage points.

Table 16.10: Supplementary Detailed Assessment Table: Do-Minimum

Change in noise/nuisance level		Number of dwellings (façade level noise band LA10,18h dB(A) for Do-Minimum scenario in the baseline year) NB all values are rounded to the nearest 10														
		Total	< 47.5	47.5 - 50.4	50.5 - 53.4	53.5 - 56.4	56.5 - 59.4	59.5 - 62.4	62.5 - 65.4	65.5 - 68.4	68.5 - 71.4	71.5 - 74.4	74.5 - 77.4	77.5 - 80.4	80.5 - 83.4	>= 83.5
Increase in noise level, LA10,18h dB(A)	0-0.1	160	20	10	40	50	20				10					
	0.1-0.9	6790	1900	1660	1230	850	450	260	130	170	100	40				
	1-2.9	2110	400	680	530	170	100	60	50	60	30	30	20			
	3-4.9	130			10	10	20	20	20	20	30	10				
	5+															
Decrease in noise level, LA10,18h dB(A)	0-0.1															
	0.1-0.9	130	40	30	30	10				10						
	1-2.9	270		10	40	30	20	40	90	20	30					
	3-4.9															
	5+															
Increase in nuisance level, percentage points	< 10	9170	2310	2350	1810	1080	600	340	190	240	160	70	20			
	10 < 20	10									10					
	20 < 30															
	30 < 40															
	>= 40															
Decrease in nuisance level, percentage points	< 10	400	40	40	70	30	30	40	90	20	30					
	10 < 20															
	20 < 30															
	30 < 40															
	>= 40															

Table 16.11: Supplementary Detailed Assessment Table: Do-Something (With Mitigation)

Change in noise/nuisance level		Number of dwellings (façade level noise band LA10,18h dB(A) for Do-Minimum scenario in the baseline year) NB all values are rounded to the nearest 10														
		Total	< 47.5	47.5 - 50.4	50.5 - 53.4	53.5 - 56.4	56.5 - 59.4	59.5 - 62.4	62.5 - 65.4	65.5 - 68.4	68.5 - 71.4	71.5 - 74.4	74.5 - 77.4	77.5 - 80.4	80.5 - 83.4	>= 83.5
Increase in noise level, LA10,18h dB(A)	0-0.1															
	0.1-0.9	2570	360	720	640	360	160	110	60	70	60	30				
	1-2.9	4280	1350	970	870	430	250	140	80	120	40	30	10			
	3-4.9	610	100	260	100	70	30	10	10	10	10					
	5+	520	290	180	30	10	10									
Decrease in noise level, LA10,18h dB(A)	0-0.1															
	0.1-0.9	250	50	70	40	30	20	10	10	10	10	10				
	1-2.9	720	190	180	120	90	50	30	40	20	10					
	3-4.9	410	10	20	70	90	40	40	70	20	40	10				
	5+	220			10	40	60	50	20	10	20					
Increase in nuisance level, percentage points	< 10	7960	2100	2120	1630	870	450	260	150	200	110	60	10			
	10 < 20	30	10	10							10					
	20 < 30															
	30 < 40															
	>= 40															
Decrease in nuisance level, percentage points	< 10	1510	250	270	240	240	170	120	120	50	40	10				
	10 < 20	70						10	20	10	20	10				
	20 < 30	30									20					
	30 < 40															
	>= 40															

Remaining Properties Potentially Qualifying under NISR

16.6.29 The mitigation of significant impacts includes reduction of noise levels at as many dwellings as reasonably practicable such that noise levels would be prevented from exceeding the NISR eligibility criteria. This objective has been met for 23 properties, reducing the number of properties exceeding the 68dB$L_{A10,18h}$ threshold from 26 to three, and has also resulted in associated noise reductions at other properties already below the threshold. However, three properties have been identified where it would not be practicable to limit noise levels below the threshold. The circumstances in which other constraints prevented mitigation of noise levels below the threshold are discussed in the preceding sections.

16.6.30 The remaining dwellings that would potentially qualify for noise insulation under the NISR are listed below:

- 9 Mucklehill Park, Inverkeithing, KY11 1BX.
- St Margaret's Hope Lodge, North Queensferry, KY11 1HP.
- Muriehall House, Winchburgh, EH52 6QN.

16.7 References

British Standards Institution (1993). BS 7385-2 Evaluation and Measurement for Vibration in Buildings – Guide to Damage Levels from Groundborne Vibration, British Standards Institution

British Standards Institution (2009). BS 5228 Noise and Vibration Control on Construction and Open Sites, British Standards Institution

British Standards Institution (2008). BS 6472 Guide to Evaluation of Human Exposure to Vibration in Buildings, British Standards Institution

Department of Environment (1976). Advisory Leaflet (AL) 72 (1976), Noise control on Building Sites, HMSO

Department of Transport Welsh Office (1988). Calculation of Road Traffic Noise, HMSO

Department for Education and Skills (1993). Building Bulletin 93: Acoustic Design of Schools – A Design Guide, The Stationery Office

Highways Agency et al., (2008). Design Manual for Roads and Bridges (DMRB) HA 213/08, Volume 11, Part 7. The Highways Agency, Scottish Government, Welsh Assembly Government, The Department for Regional Development Northern Ireland.

HMSO (1974). Control of Pollution Act, HMSO

HMSO (1975). Noise Insulation (Scotland) Regulations (1975 SSI No.0460 (s.60)), HMSO

HMSO (1990). Environmental Protection Act, HMSO

HMSO (1974). Noise in the Next Ten Years, Noise Advisory Council

IOA/IEMA (2002). Guidelines for Noise Impact Assessment produced by the joint working party of the Institute of Acoustics (IOA) and the Institute of Environmental Management and Assessment (IEMA)

Jacobs Arup (2009). Forth Replacement Crossing – DMRB Stage 3 Scheme Assessment Report.

Scottish Office (1999) PAN 56: Planning and Noise. The Scottish Office Development Department.

The Stationery Office (1999). Environmental Impact Assessment (Scotland) Regulations

Transport Scotland (2007). Forth Replacement Crossing Study - Strategic Environmental Assessment, Scottish Executive

Watts G R (1990). Traffic Induced Vibration in Buildings. Transport and Road Research Laboratory, Research Report 246

World Health Organisation (1999). Guidelines for Community Noise, World Health Organisation