STAG Technical Database Section 7

Environment

April 2015

Transport Scotland

Version History

Changes since STAG Refresh, May 2008

Change number	Section updated	Date
1	New Section 7.4.11 Physical Fitness	April 2009
2	Section 7.4.2.4 Global air quality methods project level	April 2009
3	7.4.2.7 Embodied Carbon	December 2009
4	7.4.2 Global air Quality - Updated Carbon Values	April 2012
5	Updated base year for appraisal (2010)	November 2012
6	7.4 The Appraisal Sub-Criteria - Updated references	December 2013
7	Tables 7.3 and 7.4 Updated 7.4.3 Local Air Quality – updated to provide guidance on monetising impacts 7.4.11 Physical fitness added (had been removed in error)	May 2014
8	Updating the Non-Traded Values, £ per Tonne of CO2 Equivalent. Enhancing guidance on Appraisal of Active and Sustainable travel interventions.	April 2015

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7. Environment

The detailed STAG Part 2 Appraisal against the Environment criterion provides a more in-depth environmental assessment of those options which have passed through the Part 1 successfully, including the identification of appropriate mitigation measures. The outcome is summarised in a Part 2 Appraisal Summary Table.

7.1 Introduction

This section provides guidance on assessing the environmental impacts of a transport option, whether this comprises a strategy, plan, programme or specific project. It provides guidance on the general process to be adopted in the Part 2 Appraisal and outlines the issues and methodologies relating to different topic areas. Environmental assessment is conducted to contribute to the appraisal of the transport option within the terms of the Environment Criteria.

The Part 2 Appraisal requires an assessment of the environmental impact of an option against a number of Environmental sub-criteria. It should be noted that these issues classified as sub-criterion will not necessarily be common to all assessments.

The Environmental sub-criteria considered in detail during Part 2 Appraisal, include:

- Noise and vibration;
- Global air quality – carbon dioxide (CO_2)
- Local air quality – particulates (PM_{10}) and nitrogen dioxide (NO_2);
- Water quality, drainage and flood defence;
- Geology;
- Biodiversity and habitats;
- Landscape;
- Visual amenity;
- Agriculture and soils; and
- Cultural heritage;

The scoping exercise undertaken during Part 1 Appraisal should identify the relevance of each sub-criterion to a particular option and whether any additional topics need to be covered. The Part 1 Appraisal will also determine the scope and level of detail required for the appraisal against each sub-criterion at Part 2.

The underlying fundamental principles are that practitioners should concentrate on significant impacts and that both qualitative and quantitative measures should be used to determine significance, provided that these measures are understandable and robust.

Significant impacts may be defined as those which should be given due consideration in decision-making. Where an impact on a particular sub-criterion is unlikely to be significant, the detailed assessment as reported in Part 2 Appraisal may not be necessary. On the other hand if the scope of the assessment is too narrowly defined, significant issues may not be identified at the outset of the study and subsequent data collection and analysis may be inadequate. Issues which are significant at the specific option level (such as land take from a particular habitat of ecological value) may not be significant at the more strategic level.

The process of assessing environmental impacts should be fully integrated with the development of the option and should therefore be applied at the strategic level, during option formulation and appraisal, and at the detailed project level. Early consideration of environmental issues should result in the development of options that avoid environmental constraints, or result in a reduced environmental impact and a lesser need for mitigation measures and their associated costs. It should also inform the consideration of alternatives and the choice between them.

Additional Environmental Assessment Requirements

Before substantive work is undertaken the need for a Strategic Environmental Assessment (SEA) or an Environmental Impact Assessment (EIA) should be considered carefully.

There is a certain level of overlap between the STAG Process and both SEA and EIA. However, duplication of effort can be avoided if the available guidance on SEA and EIA is reviewed prior to undertaking the STAG Process to ensure appropriate methodology and approach.

In summary, if a SEA or EIA is undertaken as part of the STAG Process, the focus should be on:

- Collection of baseline information and identification if environmental problems;
- Prediction of significant environmental effects;
- Identification of mitigation measures;
- Identification of alternatives and the effects of such alternatives;
- Consultation with the public and authorities with environmental responsibilities;
- Reporting on the results of the SEA/EIA assessment and how consultation responses have been taken into account;
- Non-technical summary; and
- Monitoring of the actual environmental effects during implementation.

Strategic Environmental Assessment (SEA):
When considering the environmental impact of options a Strategic Environmental Assessment (SEA) may also be required of the transport plan, programme or strategy. Similarly, a transport project may also require an Environmental Impact Assessment (EIA) to be undertaken in addition to the STAG study.

Project Environmental Impact Assessment (EIA):
The Environmental Impact Assessment (EIA) process provides a means of drawing together, in a systematic way, an assessment of a project's likely significant environmental effects. This helps to ensure that the importance of the predicted effects, and the scope for reducing them, are properly understood by relevant stakeholders prior to any decision being made.

A transport plan or programme requiring a STAG assessment may also require a SEA, within the terms of the Environmental Assessment (Scotland) Act 2005. Similarly, a transport project may require a STAG and also require EIA to be undertaken within the terms of the EIA Regulations. Practitioners should refer to the relevant legislation and Scottish Government Circulars for guidance on legislative requirements for assessment.

Until recently, EIAs of transport options tend to have been conducted on projects which have been fairly well defined (either at the outline planning stage or where detailed designs have been available). Examples have included road schemes, a rail freight terminal, a causeway and jetty improvements. This means that consideration of alternatives has been limited to, for example, variations in alignment or design rather than considering different modal solutions to address the particular transport problem.

The EC Directive 97/11/EC has increased the emphasis on the consideration of alternatives and on the reason for the choice of preferred option. The approach to the environmental assessment of transport options, including, at the strategic level, plans, programmes and transport corridor studies, needs to reflect this by incorporating the consideration of environmental issues at the option appraisal stage, early in the decision making process. Such strategic assessments will increasingly be used to select transport options for further development and implementation.

7.1.1 Process

The assessment of environmental impacts within a STAG Appraisal should follow the process outlined below:

- Baseline information - collection of relevant background information;
- STAG Part 1 — to filter out unsuitable options by identifying any major adverse environmental impacts. The outcome is summarised in the Part 1 AST;
- STAG Part 2 — a more in-depth environmental assessment of those options which have passed through the Part 1 successfully, including the identification of appropriate mitigation measures. The outcome is summarised in the Part 2 AST.

Each stage in the process should be carefully documented. The AST is intended as a summary of the assessment which can aid decision making. In order to provide confidence about the objectivity of the assessment underlying this summary, worksheets or working papers should be prepared for each relevant topic.

7.1.2 Baseline Information

Environmental baseline data are needed principally to assess the vulnerability of the study area to likely changes associated with transport or other options. Baseline data are required to inform both the Part 1 and Part 2 STAG Appraisals (baseline data collected for Part 1 will be generally limited to readily available existing information).

Impact assessment relies on reliable and readily available baseline information to give an indication of the significance of impacts. The topics for which more in-depth data are to be collected should be agreed between relevant parties following the Part 1 process, based on the scope of the assessment.

The baseline information will not necessarily relate to the existing situation - in fact, when dealing with strategy-level options, a long lead time to implementation is normal and the baseline might therefore relate to a situation several years hence. There will therefore be a requirement to project the existing situation, against which impacts can then be assessed.

Collecting the information may involve, in the first instance, desk studies of existing records. Where information does not exist or is inadequate for the purposes of making accurate predictions about potential impacts, additional field surveys may need to be undertaken. Field surveys are less likely to be required where environmental assessment is being undertaken on a strategy, plan or programme rather than at project level, as the emphasis is likely to be on identification of relevant environmental issues and the broad scale of potential impacts rather than on accurate predictions.

The data collected should include that which relates to the indicators selected for the Appraisal Summary Table.

Baseline data should, as far as possible, be adequately documented and of known quality and updated at regular intervals in accordance with reliable procedures. Gaps and uncertainties in data should be identified.

The level of detail and quantification in which the baseline environment can be described will also vary depending on the nature of the option. Environmental descriptions for environmental assessments of strategies, plans and programmes will be less detailed than those for project-based assessments. The nature of the option and the sensitivity of the environment will determine the methods and level of survey.

The key environmental attributes of the study area should be summarised on the Background Information section of the Part 1 AST and updated for the Part 2 AST. This should draw attention to the particular qualities of the area, making reference to specially designated parts of the area and to known options for change. The AST also allows environmental problems to be identified, which could include, for example, references to areas of dereliction or locations suffering poor air quality.

7.2 Environmental Impact Assessment

The European Commission Directive on Environmental Assessment (85/337/EEC) (1985) has subsequently been amended by Directive 97/11/EC and also Article 3 of Directive 2003/35/EC. The Directives set out a framework for environmental impact assessment which has been enacted in Scotland principally by means of the Environmental Impact Assessment (Scotland) Regulations 1999 as amended. These regulations are applicable to specific development projects rather than strategies, plans or programmes.

An EIA draws together, in a systematic way, an assessment of a project's likely significant environmental effects. This helps to ensure that the importance of the predicted effects, and the scope for reducing such effects, are understood by relevant stakeholders, the public and decision makers prior to any decision being made.

When considering the environmental impact of options a Strategic Environmental Assessment (SEA) may also be required of the transport plan, programme or strategy. Similarly, a transport project may also require an Environmental Impact Assessment (EIA) to be undertaken in addition to the STAG study.

The level of detail at which the assessment is conducted should be appropriate for the stage and type of option.

Various techniques may be employed to identify potential environmental impacts/issues:

- Use of environmental objectives - early identification of environmental objectives may allow particular topics to be identified to provide a focus for consideration of impacts. Such objectives (established policy directives, using the terminology introduced in Section 3) may be found in Development Plans or strategies prepared by planning authorities or other agencies and will generally be applicable at a wide area level. An option’s planning objectives may include one or more which are focussed on environmental concerns;
- Involvement of experts - experts on the assessment team should set out their independent view of potential impacts based on their own knowledge and experience;
- The use of standard checklists - standard topic lists can be defined which set out, for each topic area, a description of the potential impacts, the geographical level of importance of the impact, the magnitude of the impact and the nature of the impact (e.g. short/long term, reversible/irreversible etc);
- Desk studies - a rapid search of published information (such as Development Plans and agency websites) can identify areas of sensitivity and issues of environmental concern. Development Plans can also assist in identifying potential land-use change and predicting future environmental conditions;
- Preliminary consultation with statutory, transport and land-use planners/practitioners and official bodies with an interest in the likely environmental effects who may have specific knowledge of the locality or experience of considering the impacts of particular types of option on their area of expertise;
- Comparison with the impacts of other similar options, which may be revealed through literature surveys; and
- Network analysis involving monitoring data, mathematical models, GIS, other mapping matrices and expert judgement.

At the strategic level, a useful approach will be to draw upon the above sources to identify environmental constraints and objectives affecting the study area. This can be used to set the scope for the initial stages of assessment and to guide development of the option. As more information becomes available about the emerging transport options, the scope of the assessment may need to be revisited — the nature of the option will be a key factor governing the range of potential effects on the environment.

Selected indicators used at the option development stage should also be capable of use in monitoring the performance of options following implementation.

Indicators that have been used to describe the baseline environment and objectives of a plan, or programme can often be used for monitoring as part of the SEA process.

7.2.1 Impact Assessment Methodology

Environmental impacts may be classified in several ways. Normally this would be by topic and by the nature of the impact. It is also possible to classify impacts as large scale (regional, national or even global) or local. Effects upon global and national issues and objectives are difficult to assess by using conventional EIA techniques at individual project level, but at a strategic level the use of more qualitative assessment techniques may be more appropriate; however, hard data may be available to make detailed quantitative predictions and can be particularly useful where an option's effects are uncertain, close to a threshold, or cumulative. But quantification is not always practicable, and broad-based and qualitative predictions can be equally valid and appropriate.

The list below illustrates different scales of geographical impact, though it should be noted that some effects often apply at several different levels — for example, air quality can be an issue at all levels:

- Trans-national (climate change, greenhouse effect, ozone depletion, cross-border effects);
- National (non-renewable energy, air quality, biodiversity, cultural heritage, material assets);
- Regional (natural resources, landscape, water resources, ecology, waste, human health);
- Corridor (noise, pollution, soils and geology, flora and fauna, habitats, land-use); and
- Local (construction, severance, community, visual, noise).

For each topic, the area to be considered will have to be defined. The extent of this area will depend on a number of factors, including:

- The nature of the study (for example a multi-modal study may cover a sub-region or may cross regional or national boundaries);
- The form of the development (an airport study may be required to cover a large area to take account of the aircraft noise footprint);
- The topic being considered (water quality effects may be extensive whereas impacts on agricultural land would relate to immediate land take);
- The existence of neighbouring plans and/or plans for different sectors in the same area; and
- The spatial level of appraisal will, therefore, vary depending on the scale of the option and the topics being considered; this reflects the fact that the spatial extent of the effects being assessed can vary substantially, as discussed above.

The key areas of environmental effects to be considered in the appraisal of transport options include:

- Noise and vibration;
- Global air quality — carbon dioxide (CO_2);

- Local air quality - particulates (PM_{10});
- Local air quality — nitrogen dioxide (NO_2);
- Water quality, drainage and flood defence;
- Geology;
- Biodiversity and habitats;
- Landscape;
- Visual amenity;
- Agriculture and soils; and
- Cultural heritage.

In general, these will apply to all transport options, though it is the role of the scoping exercise undertaken at Part 1 to identify their relevance to a particular option and to identify whether fewer or additional topics need to be covered. For example, a transport option to construct harbours or jetties or crossings of coastal inlets would be likely to require an assessment of impact on coastal processes, including changes to tidal activity, sedimentation and geomorphology as well as the impact on marine ecosystems. On the other hand, land take issues may be less important when STAG is being undertaken on a policy, plan or programme.

Note that for options requiring a SEA, the topics addressed must meet the statutory requirements set out in SEA legislation.

Each sub-criterion may have a number of characteristics. For example, under the water quality sub-criterion, one might have to consider chemical and biological water quality. Each characteristic will then have one or more criteria that can be assigned to it for measuring the effects of transport options. A criterion may be defined as a measurable quantity or quality and is usually related to an objective. For example, if one of the planning objectives is to protect existing woodlands, then a criterion might be used which measures the scale of woodland loss. At the project level this could be related to actual land take, whereas for a policy, plan or programme the criterion might need to be stated in terms of the overall quality of the woodland resource which may be affected. The key criteria and the measured effect upon them are to be reported and summarised in the AST.

Methods for predicting environmental effects and their magnitude are specific to the individual environmental topic and are a matter for expert consultants. For some topics, such as the assessment of impact on landscape character, qualitative techniques will be most appropriate. In other cases, such as the dispersion of emissions, the use of quantitative techniques will be possible. The use of quantitative techniques may offer a greater degree of consistency, but are not always available or appropriate. It is recognised however, that at the strategic level, qualitative techniques will be more appropriate because, for example, options will lack physical definition. Where qualitative techniques are used, the basis of terms employed must be explained and categorisations applied consistently. Numerical scoring or weighting of qualitative indicators should be avoided as it is inaccurate and misleading.

In considering the nature of impacts, the assessment will need to consider whether each is:

- Direct - arising as a result of the option itself (e.g. changes in traffic volumes leading to changes in emissions affecting properties adjacent to a new or improved road or rail link, or land take to construct new transport infrastructure);
- Indirect - arising from effects associated with measures required to accommodate the option (e.g. land take for planting required to screen a new transport facility);

- Secondary/induced - arising from development induced by the option (e.g. additional traffic generated by new development attracted by improved transport infrastructure);
- Short, medium or long term - the duration of effects where short term may be less than one year, medium term one to five years and long term over five years;
- Permanent or temporary - whether or not change is reversible or irreversible, given mitigation measures, or whether the effect is for a limited duration;
- Positive or negative - whether the effects are beneficial or detrimental to resources or receptors;
- Cumulative - arising from the combined effect of a number of effects (e.g. loss of woodland over the length of route of a new railway, impact of land loss, noise and visual intrusion on a property), or from the combined effects of a plan or project with other plans or projects;
- Synergistic - a form of cumulative effect where the combined impact of several options may exceed the sum of their individual effects (e.g. several options which each encroach minimally on a wildlife site may together affect the site so much that its habitat value is lost).

The effects may relate to the construction phase, to the permanent physical changes resulting from the development, or to and from the presence of the option once implemented. In relation to plans, impacts may occur in advance of the project construction e.g. blight. The assessment of effects should be made assuming that stated mitigation measures (see section 7.2.3) are in place, if appropriate.

Climate, pollution and energy effects are normally deduced from traffic forecasts and measurements, whilst most remaining sub-criteria are impacted by physical modification of the environment (e.g. land take).

Environmental assessments of road options have considered the impacts of the option during construction and at year 1 and year 15 after construction. Year 15 is normally taken as the assessment year and the effects of the do-minimum and do-something scenarios are compared for that year. With the emphasis moving towards other modes of transport and strategic studies, it may not be appropriate to adopt such a rigid approach to operational impacts. Rather the assessors should consider:

- The nature of the option and its components;
- Those operational factors which influence the magnitude of environmental impacts and the point at which the greatest impacts are likely to occur;
- Whether timescales should relate to other key events or programmes such as the end date of a national/regional strategy or land-use plan.

The level of accuracy of predicted impacts will reduce (and uncertainties increase) as the assessment looks further into the future. It will seldom be appropriate to consider impacts more than 20 years hence. Whichever year is adopted as the assessment year, it must be clearly stated and used consistently when assessing effects across the range of topic areas.

The guidance on the assessment of particular topics set out in later sections is intended to direct the reader to source material from which appropriate techniques may be selected, rather than to specify particular techniques in detail. This is because the selection of technique will need to take into account the nature of the plan, programme or project being assessed and the level of detail available for assessment purposes, particularly on the nature of outputs from any transport model which may be employed.

7.2.2 Evaluation of Impact Significance

The basis for the evaluation of impact significance must be clearly set out for each topic in worksheets or supporting documentation. In most cases, impact significance is a function of the two variables, impact magnitude and receptor sensitivity. For example, a small-scale option in an area of unremarkable landscape may not be significant in terms of landscape quality whereas the same option in a National Scenic Area may be evaluated as having a major impact. Small increases in noise levels may not be significant where noise levels are already high, but could be significant in a quiet rural village. The AST allows for specific sensitivities to be recorded in the 'qualitative' column and more information about these should be provided in worksheets.

In line with the approach of the DfT, it is proposed that the seven point scale be adopted for assessing the predicted magnitude of impacts on each of the sub-criteria - the appropriate level should be recorded in a worksheet or in supporting documentation:

- Negative major;
- Negative moderate;
- Negative minor;
- Neutral;
- Positive minor;
- Positive moderate;
- Positive major.

At the strategic level, this assessment may need to be based entirely on qualitative information, with informed value judgements recorded in the 'qualitative' column of the AST. In some cases, the consideration of options will be informed by the results of traffic models. Such models would allow a quantitative approach to be adopted to the assessment of effects on noise and air quality. Where this information is available, it should be recorded in the 'quantitative' column of the AST. At the project level, both 'qualitative' and 'quantitative' columns should be completed. Those entries should provide a summary of the data included in worksheets and other supporting documentation.

Once the magnitudes of impacts have been identified, impacts must be evaluated so that their significance can be determined. It is proposed that significance should be recorded in the column carrying that heading in the AST, using a seven point scale as described in section 5.4.

- No impact;
- Minor impact (positive/negative);
- Moderate impact (positive/negative);
- Major impact (positive/negative).

The significance of impacts may be evaluated by means of expert judgement by individuals or panels, or may relate specifically to published standards and thresholds, for example in the case of air quality.

7.2.3 Mitigation Measures

Mitigation measures are those measures considered necessary to prevent, reduce and where possible remedy or offset any significant adverse impacts on the environment. They should not be an afterthought, but integrated in the final option(s) to ensure that the best environmental fit is achieved. Effects which cannot be mitigated should be acknowledged. Where an assessment identifies significant environmental impacts in the absence of mitigation, this suggests that an alternative option should be considered rather than seeking to mitigate an unacceptable option. At the strategic level, mitigation measures may have to be stated in generic terms which can then be used to guide the development of projects forming part of their implementation.

Mitigation measures can take many forms including:

Projects:
- Modal alternatives and measures to influence traffic flows (by means of policies such as road pricing or traffic control/management systems);
- Alternative indicative routes or sites (for nodal facilities);
- Alternative detailed design criteria for the source or receptor;
- Alternative construction methods; and
- Remedial or compensatory action such as noise insulation or relocation of species.

Strategies, Plans and Programmes:
- Changes to the wording of the plan or plan alternative;
- The removal of the plan alternatives that are unsustainable or do not promote the objectives;
- The addition of new plan alternatives;
- Devising new alternatives, possibly a combination of the best aspects of existing alternatives; and
- Identifying issues to be considered in environmental impact assessment of specific developments.

Where appropriate mitigation measures associated with a particular option can be identified, these should be stated and included as commitments in the assessment reporting. At the strategic level the potential for mitigation measures should be acknowledged and taken into account as far as possible. At the project level, the design of mitigation measures may need to be specified in some detail and a commitment made to their implementation.

If the assessment of effects is to be made assuming stated mitigation measures are in place, it follows that there must be confidence that any measures identified are capable of being delivered and that they have a real prospect of success.

More extensive information on project-related mitigation is contained in *Mitigation Measures in Environmental Statements* DETR 1997.

7.2.4 The Environmental Capital Approach

It may be useful to follow an environmental capital methodology for those areas that are not easily quantifiable. The main elements of this approach are:

- To describe sequentially the characteristic features;
- To appraise environmental capital - using a set of indicators, this is done by assessing
    - the importance of these characteristic features;
    - why they are important; and
    - their inter-relationships;
- To describe how options impact on features; and
- To produce an overall assessment score on a seven point scale.

7.3 Strategic Environmental Assessment

The Environmental Assessment (Scotland) Act 2005 introduces a requirement to undertake '**strategic'** environmental assessment of most strategies, plans and programmes.

SEA is a systematic method which extends the assessment of environmental impact beyond individual projects. The Environmental Assessment (Scotland) Act 2005 came into effect in February 2006 and extends the scope of SEA in Scotland beyond the provisions of the European Union Directive 2001/42/EC to include strategies as well as plans and programmes.

In September 2006 the Scottish Government launched the SEA toolkit. The aim of the toolkit is to provide advice on the requirements of the Environmental Assessment (Scotland) Act 2005. The toolkit gives guidance on when a SEA will be required, practical advice on how to do a SEA and templates for each stage of the report writing process.

Further information and guidance on the SEA process can be obtained from http://www.scotland.gov.uk/Topics/Environment/environmental-assessment/sea.

7.4 The Appraisal Sub-Criteria

In this section, each of the environment sub-criteria against which appraisal is required is discussed in turn. The following items are considered for each:

- Issues;
- Sources of Information;
- Methods, Part 1, Part 2 strategic level, Part 2 project level; and
- Appraisal Summary Table.

The difference between *project* and *strategic* level should be understood as follows: project level appraisal will be appropriate where an option is sufficiently specific (in terms of its location, extent and design) that detailed judgements can be made about its environmental effects. An example might be a preferred alignment for a railway or for a road improvement. Strategic level appraisal will be appropriate for options where only outline information is available about their location, extent and design, or where concepts or broad options are being tested. Examples might include strategies, plans or programmes, including multi-modal studies (where a strategic level assessment can help to inform the option selection process), and assessments of local or regional transport strategies (where broad corridors for transport infrastructure may be identified, but specific routes have yet to be determined).

A strategic level '*appraisal*' should not be confused with conducting an SEA. Guidance on the requirements for SEA is provided in the Scottish Government's SEA Toolkit, and ODPM: A Practical Guide to the Strategic Environmental Assessment Directive.

7.4.1 Noise and Vibration

In the different legislative environments of Scotland and England and Wales, the advice in this area offered by STAG has diverged from the approach taken by the Department for Transport. This situation is currently under review by Transport Scotland.

7.4.1.1 Issues

Transport is a major source of noise. Noise exposure can have an adverse impact on human health and the perceived quality of life. Nuisance arising from noise exposure varies greatly between individuals, but generally at the community level there is a reasonable correlation between physical measurements of noise and annoyance response. However, people react differently to noise from different modes of transport and at the strategic level effects will be more difficult to quantify because the relationship between the key variables of source and receiver will be unclear.

DfT have recently published new guidance on Noise, including a monetisation methodology. STAG has, at this time, not adopted this as guidance and so the process detailed in 7.4.1.2 and 7.4.1.3 should be followed.

7.4.1.2 Sources of Information

- Local authority Environmental Health Officers - existing noise levels and noise issues;
- Development Plans - noise constraint policies;
- Land-use maps - location of receptors especially sensitive to noise e.g. schools, hospitals, aged persons homes, laboratories using sensitive instruments, heritage buildings, outdoor areas for quiet recreation;
- Census of Population - resident population in defined zones may be determined by aggregating Small Area Statistics;
- Field survey - ambient noise levels;
- Calculation of Road Traffic Noise (CRTN) - Department of Transport 1988;
- Noise Insulation (Railways and Other Guided Transport Systems) Regulations (1996 as amended in 1998).;
- Scottish Government Planning Advice Note 1/2011 "Planning and Noise";
- Airport Master Plans
- Strategic Noise Maps
  http://www.scottishnoisemapping.org/default.aspx
  http://www.opsi.gov.uk/legislation/scotland/ssi2006/20060465.htm#4

7.4.1.3 Methods - General

Appraising the noise implications of multi-modal transport plans and strategies presents a particular challenge for two main reasons:

- People exhibit different responses to noise from different transport modes, making the determination of cumulative impact difficult; and
- Noise is a local impact which, together with the effect of non-acoustical factors (outwith the scope of a STAG assessment), is dependent upon the precise geometric relationship of source and receiver - while the geometric relationship will be easily ascertainable at the plan level of assessment, it is unlikely it will be at the strategic level. Variances in methodology are discussed below.

There is a body of knowledge developing in the UK and other countries in Europe (see https://www.gov.uk/government/organisations/department-for-environment-food-rural-affairs), through ongoing research studies, that addresses these difficulties. Much of that work has been initiated following the European Commission's green paper in 1996 on Future Noise Policy. The Commission's own work on the relationship between community annoyance and noise exposure level will be useful in seeking a European consensus.

The approach offered in STAG is based on the difference in the estimated population who are annoyed by noise, from alternative sources, between the do-minimum and do-something scenarios. Estimates of effects at the project level can be based on relatively precise data; indications at the strategic level will be comparatively broad brush.

It should be recognised that, in many situations, relatively large changes in traffic flows are required to bring about perceivable changes in noise levels (assuming all other traffic variables are constant). For freely flowing traffic, a difference of about 3dB(A) is required before there is a change, perceivable to the human ear, in the noise level for the steady state situation, i.e. a gradual increase in traffic noise. A 25% increase or 20% decrease in traffic flow, if speed and other factors remain unaltered, only results in a 1dB change. Where options, particularly of a more strategic nature and which increase traffic flows by less than 25% or decrease flows by less than 20%, are being appraised, the analyst will need to exercise judgement about whether the impact of the option on noise should be ignored, unless particular sensitivities are involved. This 'acoustic rule of thumb', however, should be supplemented with the evidence contained within DMRB Vol. 11, Section 3, Part 7 HD213/11 Noise and Vibration. The latter highlights that 'people are more sensitive to abrupt changes in the traffic noise associated with new road schemes than would be predicted from the steady state evidence. In the period following a change in traffic flow, people may experience benefits or disbenefits when the noise changes are as small as 1dB(A)'. Similarly, a 3dB(A) increase in noise levels might arise from a doubling of railway movements and this may well be perceivable. Care is also needed in assessing options, such as those to intensify rail freight movements, which may result in adverse noise impacts during the night. Whilst traffic levels and their resultant noise impacts are lower at night than during the day - by about 10dB on roads - people tend to be more sensitive to night-time noise (DMRB, Volume 11, Section 3, Part 7).

Community response to transport noise

It is known that individuals vary widely in their response to the same level of noise, even when it arises from the same source. However the average or community response from a large number of people exposed to the same source of noise is relatively stable and a community average degree of annoyance can be associated with long-term average noise exposure.

The concept of annoyance is generally recognised as a robust and well established measure for identifying the long term noise impacts from roads and railways. However, there is reason to believe that the same level of noise emitted by different sources provokes different responses, when measured as community annoyance.

Given these differing levels of annoyance for different transport modes, a simple summation of noise exposure levels, using a convenient noise metric, is not, therefore, a reliable indicator of noise impact for a multi-modal study.

One approach to overcoming the problem of mode-specific community noise response relationships is to apply different impact criteria to each mode. This allows estimates of numbers of people exposed to different noise levels to be made on each mode. However in comparing the noise impact of each mode there is a residual problem in weighing up the significance of the impact against the number of people exposed. This problem is also encountered in single mode assessments, in that it is difficult to compare an option which has a small noise impact for a large population with an option which has a large noise impact for a small population.

Annoyance response relationship

A solution to this problem when comparing the noise impacts of different road options, is to use the annoyance response relationship to estimate the numbers of people likely to be annoyed by each road option. The relationship shows the percentage of a population annoyed by road traffic noise in the longer term as a function of the noise level. The latter is measured in $L_{A10,\ 18\ hour}$, which is the noise unit used in the calculation of road traffic noise, as set out in the Calculation of Road Traffic Noise (DoT, 1988).

Given that the basis of the relationship is long term, it ignores the immediate impacts of any change. DMRB 11.3.7 presents the relationship in tabular and graphical form.

Unlike road traffic, railway noise levels are calculated in $L_{Aeq,18hour}$ (see Calculation of Railway Noise, DoT, 1995). In addition, there is no standard annoyance response relationship for railway noise. Probably the best guidance available on conversion between different units of measurement can be found in the CIRIA document Sound Control for Homes (first version). That states that $L_{A10,T}$ - 3 can be taken as an approximation for $L_{Aeq,T}$. Even when they are both measured using the $L_{Aeq,18hour}$ noise scale, there is reason to believe that people respond differently to road and rail noise. See, for example, the Mitchell Committee's report *Railway Noise and the Insulation of Dwellings* (DoT, 1991), which summarises research, undertaken up to 1991, on the question of the differential between road and rail noise annoyance response. Although the Committee found no clear consensus, they concluded that at levels of 60 to 70dB(A) most studies found a road/rail differential of between 4 and 9dB(A) and at levels of 50 to 60dB(A) this differential was small or zero. In reaching this conclusion, the Committee gave emphasis to UK studies, as it was recognised that social and cultural factors may have a strong influence on the differential. The Committee was also primarily concerned with daytime and evening noise, in order to be consistent with the road traffic.

Based on the results of the Mitchell Committee Report (1991) and other research, an annoyance response curve for rail traffic noise has been derived for use in the studies. The differential between road and rail noise annoyance has been taken as: 0 at 55dB $L_{Aeq,18hour}$; and 6dB at 70dB $L_{Aeq,18hour}$.

Annoyance response curve

The annoyance response curve for rail traffic noise derived on this basis is given in Table 7.1, together with the annoyance response curve for road traffic noise, taken from DMRB 11.3.7 The '% Annoyed' column shows the percentage of respondents who described themselves as 'bothered very much or quite a lot'.

Using these annoyance response relationships obviates the need for a decision taker to make the difficult trade-off described earlier, because the relationship implies that people are either annoyed or not annoyed by noise. The poorest performing option, in terms of noise, will be that with the largest increase in estimated population annoyed when comparing the do-something scenario with the do-minimum. However further research is needed to assess the annoyance response to: i) high speed rail, which produces a different quality of noise; ii) low frequency noise from light rail systems in urban areas; iii) noise from road traffic which is not free flowing; and iv) significant changes in the noise level in rural areas where the baseline level is very low. This needs to be taken into account in assessing the noise impact of options which involve these types of project. Very little is also known about the combined effect of noise from different sources, as one source of noise can mask another.

When using this method it is important to be aware that at low noise levels (over large distances) the annoyance response function is uncertain and prediction becomes inaccurate. Consequently, it is recommended that a cut-off noise level is introduced to the appraisal, below which only a small percentage of the population would be annoyed. In quantifying aircraft noise annoyance, a population annoyance of about 10% has been used. PAN 1/2011 and WHO suggest an onset of community noise impact at daytime 55dB $L_{Aeq,16hour}$. This corresponds to a population annoyed from road and rail traffic of about 10%. Therefore 55dB $L_{Aeq,16hour}$ (57dB $L_{A10,18hour}$) is the recommended cut-off level to use in estimating the total population annoyed.

The assessment of noise impacts from multi-modal plans and strategies should aim to inform the appraisal process by comparing the change in estimated population annoyed in the longer term for each option in relation to a do-minimum scenario. In reality, this is not necessarily straightforward and the approach should be seen as provisional at this point in time. The degree of uncertainty in the calculation of estimated population annoyed will depend on the quality and amount of detailed information available, including that for population distribution. It may be necessary to make simplifying assumptions to arrive at estimates of the change in population annoyed for each option.

However, the approximate nature of these estimates need not invalidate comparisons between options. The assessment should be carried out for the fifteenth year after opening, or the year in which traffic flows are expected to be greatest.

Table 7.1: Annoyance Response Curves for Road and Rail Traffic Annoyance.

Road noise L_{A1018h} dB	% annoyed	Rail noise L_{Aeq18h} dB	% annoyed
55	8	55	11
56	9	56	12
57	10	57	12
58	11	58	13
59	12	59	15
60	13	60	16
61	15	61	17
62	16	62	18
63	18	63	19
64	20	64	21
65	22	65	22
66	24	66	24
67	26	67	25
68	28	68	27
69	31	69	28
70	34	70	30
71	36	71	32
72	39	72	34
73	42	73	36
74	45	74	38
75	48	75	40
76	51	76	42
77	54	77	44
78	57	78	46
79	60	79	48
80	63	80	51

Important note: Road and rail noise are presented in different units in this table. To convert from one to the other, $L_{A10,18hr}$ - 3 can be taken as an approximation for $L_{Aeq18hr}$. Further details on noise assessment, including converting between different measurement units can be found Planning Advice Note: PAN 1/2011.

7.4.1.4 Methods - Part 1

This is likely to be a largely qualitative assessment at both strategic and project level, considering potential increases or decreases in noise levels arising from the options and approximate numbers of people or sensitive receptors exposed. This should be summarised in the Part 1 AST.

7.4.1.5 Methods Part 2 – Project Level

At the project level, where options involve specific interventions, it is likely that a spatially detailed transport model will be available. The output from this type of model will enable an understanding to be gained of differences in road traffic flows on a link by link basis, which in turn will allow differences in noise for specific communities to be predicted. At this level, a detailed understanding of rail movements is also likely to be available.

Having generated data on road and rail traffic flows, the following four steps are required to calculate the noise impacts of different options. The results should be recorded using Worksheet 7.1.

i) Noise contours, using 3dB(A) and 5dB(A) increments, should be generated along transport alignments using simplified standard prediction methodologies, such as the Calculation of Road Traffic Noise and the Calculation of Railway Noise. Contours are required for the do-minimum scenario and the do-something scenarios for each transport option. More detailed data on properties can provide more accurate estimates of noise levels in given situations. Many factors, such as the type of ground cover, the presence and degree of screening, wind direction and strength, can all influence noise levels and the extent of the noise footprint. Professional judgement is needed to assess the significance of ignoring specific factors.

ii) Populations within these contours should be estimated using the latest available census information. Explicit assumptions may need to be made about population densities in order to estimate population exposure, although, where available, building occupancy databases and other sources can be used.

iii) For each noise contour in the do-minimum and do-something scenarios, the relevant annoyance response relationship shown in Table 7.1 should be applied to the numbers of people exposed to estimate the total population annoyed.

iv) The incremental impact of each option, expressed in terms of difference in population annoyed, can be derived by subtracting, for each noise contour, the population annoyed in the do-minimum from the population annoyed in the do-something and summing over all noise contours.

Worksheet 7.1 – Calculation of estimated population annoyed by noise

Option Name: ________________________ Year: ______				
Noise Level	Estimated Population exposed - do-minimum	Estimated population exposed - do-something	Annoyance Response Function - % highly bothered by noise	Estimated Population Annoyed
Road Traffic Noise LA10,18 hour (dB)				
<57				
57-59				
60-64				
65-69				
70-74				
>75				
Estimated Population Annoyed by road traffic				
Railway Noise LAeq,18 hour (dB)				
<55				
55-59				
60-64				
65-69				
70-74				
>75				
Estimated Population Annoyed by railway noise				
Total Estimated Population Annoyed				

Care is needed where there appears to be the potential for double counting populations exposed to multiple sources of transport noise. As noted above, little is known about annoyance from multiple sources and expert judgement is important in these situations. In some cases, "double counting" could give the correct answer. For example, those disturbed by railway noise may be different from those who would be disturbed by road traffic noise, or, where noise sources are transient in nature, noise from one source might "fill the gaps" in the varying noise levels arising from another. Furthermore, multiple sources may impact different facades of exposed buildings. For example, a road might affect the front of a property, while a railway line might be to the rear of the same property. Even if the façade noise levels generated by the two were similar, there is no reason to assume that the annoyance caused would be identical. If the two sources were dissimilar, the problem is compounded.

Where the levels of noise from different sources are dissimilar, it may be reasonable to make a simplifying assumption and ignore annoyance from the source giving lower annoyance. However, where there is uncertainty, it is more difficult to make such a simplifying assumption and professional judgement will be needed to reduce the risk of double counting populations.

The entries in the Quantitative column of the AST should show the estimated numbers of people who are likely to be annoyed in the longer term in the do-minimum scenario and the do-something scenario in the fifteenth (or worst) year.

The entry in the Overall Assessment column should show the net difference in the estimated population who are likely to be annoyed in the longer term as a result of the option compared to the do-minimum scenario in the fifteenth year.

A qualitative entry in the AST should be used to highlight any factors which cannot be readily understood from the numbers in the Quantitative and Overall Assessment columns. An indication can be given of the main factors causing any change in conditions.

7.4.1.6 Methods Part 2 – Strategic Level

At the strategic level, it is envisaged that options will generally be assessed using a spatially coarse transport model, given that they are reasonably informative and comparatively quick to run. Spatially coarse models will be likely to provide only a broad indication of changes in transport behaviour arising from strategy options, expressed in such terms as changes in passenger car unit kilometres or vehicle kilometres across a model zone or regional study area.

Such model output does not enable noise impacts to be identified at specific receptor sites. Consequently, a more broad brush, two stage assessment must be undertaken, based on determining the *change* in average noise emission and relating this to population data, rather than predicting the expected noise levels. One of the difficulties associated with estimating effects at this level is that the dose response relationship between noise and annoyance is non-linear.

In order to estimate average effects, the method recommends that these relationships should be linearised. However the analyst should be aware that this may have implications for the range of noise levels which can be assessed with any degree of confidence. The results should be recorded using the Calculation Sheets and Worksheet 7.2 provided.

Worksheet 7.2 - Calculation of Change in Estimated Population Annoyed (EPA) by Road Traffic Noise

Option Name: ______________________ Year: ______

Zone	Do-Minimum (2) Average Noise Emission Level (dB)	Strategy Option Average Noise Emission Level (dB)	Change in Average Noise Emission Level (dB)	Length of all Relevant Roads (km)	Width of impact corridor (m)	Area of Population Exposed (km2)	Zonal Population Density (persons / km2)	Population Exposed (numbers of people)	Annoyance Response Function (% population/dB) (1)	Change in Population Annoyed (number of people)
	A	B	C=B-A	D	E	F=D*E / 1000	G	H=F*G	I	J=C*H*I / 100
1										
2										
3										
...n										
Total Change on Population Annoyed								Change in EPA		-585

(I) : 3 %/dB at road traffic noise levels greater than about LA10 18 hour 65 dB
(2) Separate Calculation Sheets should be completed for comparison of the strategy option with the Present and the Future Do Minimum cases.

Traffic Data Sources:
____

Population Data Sources:
____

Assumptions:
____

Assessment scores: (Change in EPA):____

Qualitative comments:
____

Stage 1

The first stage involves using transport model outputs to estimate the difference in noise emissions between the do-minimum and do-something scenarios for hypothetical sections of the road and rail network within model zones. Average noise emission indicators, such as those in the Calculation of Road Traffic Noise and Calculation of Railway Noise (Basic Noise Level) should be used. For example, for road options, data on zonal flows (vehicle kilometres), speed and traffic composition from a strategic transport model can be used to estimate changes in average zonal noise emission levels in each of the model's zones.

When assessing changes in noise under different scenarios, it may not be manageable to predict absolute noise levels over large areas, but it will generally be possible to predict relative difference between the various options. Provided that total traffic flow, traffic composition (e.g. % heavy goods vehicles for roads and freight movements for rail) and traffic speed are used to calculate the noise emission levels, the method should give realistic comparisons between options. Factors such as road surface, distance to receiver and screening effects can be if they do not vary between options.

Stage 2

Comparing options on the strength of the change in zonal noise emission levels alone should be avoided, as it makes no allowance for population distribution and therefore actual noise impacts, which are receptor dependent. For example, an option that moves traffic from local roads to motorways may show increased average noise emission levels because it enables greater traffic speeds; however it may result in a lower total noise impact because motorways tend to be more distant from large communities.

The change in average noise emission levels, between the do-minimum and do-something scenarios, should be related to population data, to enable the change in the estimated population annoyed to be determined. Spatially coarse transport models (and/or their GIS adjuncts) will generally hold data on population levels across model zones. The following steps should be followed:

i) The length of the transport network within each model zone, in km, should be multiplied by the width of the impact corridors in metres, to estimate the magnitude of the noise impact (in terms of area) for each zone, within the study area.

ii) For each zone the area impacted - expressed in km^2 - should be multiplied by the zonal population densities to derive estimates of the population exposed. Zonal population densities, in the form of average household size, can be obtained at the Council Area level from Census data.

iii) An estimate of the difference in population annoyed by noise in each zone can be derived by multiplying the estimate of the population exposed by the percentage of the population annoyed by the change in the average noise emission level.

iv) These estimates by zone can then be summed to arrive at an indicator of estimated change in population annoyed across the whole study area, for each option.

In determining the area of noise impact, assumptions will need to be made about the areas adjacent to transport links which are likely to be affected. For roads, a contour width equal to the width of two house plots, say 50m, would be reasonable to capture the majority of the population exposed, given that the majority of population noise exposure is in urban/suburban areas. However, this may not be appropriate in all cases and other assumptions may need to be made. For rail, more so than for roads, the area of impact will depend more on local conditions. Rail tends to involve much more variation in horizontal and vertical alignment than roads, which will have a bearing on noise levels and, therefore, the appropriate swathe distance to adopt. Broad assumptions will need to be made about the overall length of the rail network in tunnels, cuttings etc. This may be different for each multi-modal study area and it is important that these assumptions are made explicit.

In determining the change in the percentage of the population annoyed, it should be noted that predictions of average noise emission levels, based on outputs from strategic transport models, will often tend to overestimate the actual level of noise emission. Where the average noise emission is predicted to be over 65dB $LA_{eq,18\ hour}$, the change in the percentage of the population annoyed should, based on Table 7.1, be assumed to be 3% per dB for road and
2% per dB for rail.

Population densities within zones may vary, particularly between rural and urban zones. In some cases, this may lead to inaccuracies in the estimated population annoyed, which should be noted on the Worksheet; however the approach does identify the benefits or otherwise (in terms of noise impacts on people in buildings) arising from changes in traffic across these zones. Such an approach is conceptually similar to that applied at the plan level. However at the strategic level vehicle kilometres by zone is used instead of traffic flow data on road/rail links and zonal population densities replace geographic population data.

Worksheet 7.2 has a row for each study zone and for some studies with numerous zones it may be very large. Therefore in these cases it may be useful to summarise separately the information on Worksheet 7.2 and show the numbers of zones where population annoyance is increased, decreased or unchanged, as well as the total change in population annoyance over the whole study area.

The change in population for all the zones should also be shown in a graphical or mapped format, depending on the size of the study. For example, for a 20 zone study a simple bar chart showing the change in community annoyance in each zone may give a clear picture of the benefits and disbenefits of the strategy option. The results of a more complex regional study may be more clearly shown on GIS maps using colour coded ranges of change in population annoyance for each zone.

Quantitative column

The entries in the Quantitative column should show the estimated numbers of people who are likely to be annoyed in the longer term in the do-minimum scenario and the do-something scenario fifteenth year. As with plans, appraisers should also comment where significant impacts are likely to affect important non-residential receptors e.g. schools and hospitals as well as where night time noise levels (not included in the 18 hour measures of noise) are disproportionately affected.

Overall Assessment score

The entry in the Overall Assessment column should show the net difference in the estimated population who are likely to be annoyed in the longer term as a result of the option compared to the do-minimum scenario in the fifteenth year.

Qualitative comment

A qualitative entry in the AST should be used to highlight any factors which cannot be readily understood from the numbers in the Quantitative and Overall Assessment columns. An indication can be given whether there is an overall improvement or worsening of conditions as a result of an option compared to the do-minimum and the main factors causing any change in conditions.

Quiet Areas

In general, noise assessment from transport is limited to the consideration of effects on people in occupied buildings, so-called noise sensitive receivers (dwellings, schools, hospitals etc). The debate on noise impacts stimulated by developing EC noise policy has raised concern about other spaces, particularly those used for recreation, that currently enjoy a peaceful environment, referred to as 'quiet areas'. Some Member States have become concerned that attempts to improve the noise climate in areas of high exposure may lead to a spreading of noise across areas that are currently almost free from transportation noise. There is a perceived need to protect these quiet or tranquil areas. The Scottish Government is addressing this issue, and recently published the first 'noise maps' of Scotland. These will be used to help inform the drawing up of noise action plans, a process which is currently on-going in response to the Environmental Noise Directive (2002/49/EC), and are available at:
http://www.scottishnoisemapping.org/default.aspx

However, 'tranquillity' is one of the features defining landscape, and changes in tranquillity will be taken into account in the assessment of impact under the landscape sub-criterion . Thus, in order to avoid double counting, the noise impact of plans and strategies on quiet or tranquil areas should not be assessed under the noise sub-criterion.

7.4.1.7 Appraisal Summary Table

The Part 2 AST should illustrate the number of people experiencing a significant increase/decrease in noise levels.

For strategic and project level appraisal, the AST should summarise the relative annoyance responses and affected populations for the existing situation, a do-minimum scenario and the proposed scheme. At the strategic level, the change in the number of people annoyed over geographical zones may be an adequate proxy in the absence of more accurate information. Estimated populations affected by changes in noise of greater than 3dB(A) can also be indicated on the AST. The qualitative assessment should relate to the subjective response to noise levels, noting for example, the presence of sensitive receptors such as hospitals, or if the scheme is introducing noise into a previously quiet area where traffic was not the dominant noise source.

At project level, the annoyance response summary should be based on modelled noise contour information.

Worksheets N1 and N2 in Section 17.1 may be used to assist in the assessment of an option's impact in terms of noise and vibration.

7.4.2 Global Air Quality

7.4.2.1 Issues

Climate is strongly influenced by changes in the atmospheric concentrations of a number of gases that trap heat radiated from the earth's surface (the 'greenhouse effect'). Carbon dioxide has been singled out as the most important transport induced greenhouse gas having a direct impact on global warming. Climate change is now widely recognised as a threat to the environment, with the Climate Change (Scotland) Act 2009 establishing ambitious emissions reduction targets with a commitment to reduce carbon emissions by 42% by 2020 and by 80% by 2050. Carbon dioxide (CO_2) emissions are taken as a proxy in STAG for global air quality.

Following the Stern Review, the issue of CO_2 emissions has become significantly more prevalent. Furthermore, with binding carbon budgets applying across the UK economy, a robust approach to valuing emissions is seen as vital in ensuring the UK and Scottish Governments take full account of climate change impacts in appraising and evaluating public policies. As a result of Stern Review, there is an argument that standard Green Book discount rates are not appropriate when dealing with CO_2. At present standard discount rates (see Annex 6 of the Green Book) should be used.

The Department of Energy and Climate Change (DECC) have released a revised approach to valuing carbon dioxide emissions in policy appraisal. (https://www.gov.uk/carbon-valuation). This guidance is outlined below in a manner appropriate for Transport Appraisal.

An important point is that the unit of account is now CO_2 (equivalent) rather then carbon (C equivalent).

7.4.2.2 Sources of Information

- *Local Air Quality Management Guidance (general and technical guidance notes)* - DETR 1999;
- *The Air Quality Strategy for England, Scotland, Wales and Northern Ireland* - DETR 2000;
- Scottish local authorties and local authority Environmental Health Officers - existing data on air quality issues;
- Scottish Government Development Department databases - emission characteristics of traffic in terms of: speed, vehicle mix and flow at representative points on the trunk road network;
- Census of Population - resident population in defined zones may be determined by aggregating Small Area Statistics.
- *The Stern Review on the Economics of Climate Change* - HM Treasury (2006)
- Carbon valuation in UK policy appraisal – DECC (2009)

7.4.2.3 Methods — Part 1

This is likely to be a largely qualitative assessment at both strategic and project level, considering potential changes in CO_2 arising from the options. A description of how the option contributes towards reducing emissions of CO_2 is required for the Part 1 Appraisal. It is viewed as unlikely that quantification will be possible within Part 1, so the degree of impact should be assessed qualitatively.

7.4.2.4 Methods — Part 2 Strategic Level

At the strategic level, outputs from spatially coarse transport models are likely to give a fairly broad picture of the impact of options on CO_2. Total CO_2 emissions for road traffic can be calculated according to the method in DMRB 11.3.2.1 HA 207/07 Air Quality. Care should be taken when interpreting the results of traffic models that do not account for intra-zonal trips or are coarse in urban areas. It may be appropriate to perform upper bound sensitivity test on model output.

Emissions from rail represent a very small proportion of the total transport emissions of CO_2, about 3.6%. The data with regard to the emissions associated with the running of diesel and electric trains is at present limited.. Prior to the outcome of this research the Transport Scotland recommends the use of the Rail Emission Model Final Report that was produced for the Strategic Rail Authority. This provides estimated emission factors and detailed data for individual diesel and electric train types.

The impact of a project on emissions should be calculated for each year over the 60 year appraisal period. It is accepted that extrapolation between model years may be required and this should be done in an appropriate manner.

7.4.2.5 Methods — Part 2 Project Level

For CO_2, similar issues apply at both strategic and project level. At the project level, more spatially defined traffic models may be used and this may remove some of the issues detailed above. Total CO_2 emissions for road traffic can be calculated according to the method in DMRB 11.3.1. For rail Transport Scotland recommends the use of the Rail Emission Model Final Report that was produced for the Strategic Rail Authority.

7.4.2.6 Methods – Monetisation

DECC have recently issued guidance on the monetisation of greenhouse gases. This is to be adopted within STAG Appraisal. This monetised value should be reported separately in the Environment Part 2 AST. The monetised benefits should not be included in the TEE analysis, which is meant to show only economic impacts.

Full details of the DECC methodology can be found at: https://www.gov.uk/government/organisations/department-of-energy-climate-change but this section provides the information required to apply the DECC methodology in a manner appropriate to Transport. The primary issue is that 2010 is currently used as the price base year and values have been adjusted to reflect this.

The first stage is, as has been usual practice, to calculate the Greenhouse Gas impact of the option being examined. The unit of account is t CO_2 rather than t C. Table 7.2 gives the conversion factors between other gases and $C0_2$. For example, 1 t Methane is equivalent to 21 t CO_2.

Table 7.2: Greenhouse gas conversion factors

Greenhouse Gas	Global Warming Potential
Carbon Dioxide (CO_2)	1
Methane (CH_4)	21
Nitrous oxide (N_2O)	310
HFC-134a	1,300
HFC-143a	3,800
Sulphur hexafluoride (SF_6)	23,900
Carbon Dioxide as Carbon	3.67

It is possible in a transport context that estimates are produced in terms of Carbon equivalent. As detailed in the final row of Table 7.2 t C should be multiplied by 3.67 to produce t CO_2. Practitioners should note that, when estimating the **cost** of one tonne of CO_2 from one tonne of carbon, the cost of carbon should be divided by 3.67.

When valuing CO_2 equivalent there is a distinction between the traded sector (those sectors covered by the EU Emission Trading System (ETS), and in the future other trading schemes) and the non-traded sector (those sectors not covered by the EU ETS). A list of those sectors currently in the traded sector is provided below:

- Electricity generation;
- Power stations;
- Refineries and offshore;
- Iron and steel;
- Cement and lime;
- Paper;
- Food and drink;
- Glass;
- Ceramics;
- Engineering; and
- Manufacture of vehicles

The current base value of non-traded price of carbon is £57.44 t CO2 in 2014 (in 2010 prices).

Note again that these figures are in t CO_2e (tons carbon dioxide equivalent). Although carbon dioxide has a relatively low global warming potential compared to other greenhouse gases, it is by far the most abundant. Therefore for convenience, the global warming potential of greenhouse gas emissions is measured in terms of the equivalent amount of CO2 that would give this warming. The standard unit of account is tonnes of carbon dioxide equivalent (tCO2e), and this is how estimates of greenhouse gas emissions should be presented.

Non-traded values of carbon dioxide as far as 2100, as well as higher and lower estimated values for use in sensitivity analysis, are provided in Table 7.3. STAG no longer provides values for traded values of carbon dioxide equivalent.

When carrying out monetary valuation, it is important to distinguish between the emissions from those sectors that are included within the EU Emissions Trading System (EU ETS) – the 'traded sector' - and those that are not – the 'non-traded sector'. The traded sector covers emissions from power and heat generation; energy-intensive industry and, since 2012, aviation. Emissions arising from electricity consumption in transport are in the traded sector. As described above the non-traded sector covers all other greenhouse gas emissions. Emissions from other types of transport fuel, including petrol, diesel and gas oil, are in the non-traded sector.

Inclusion in the traded sector caps relevant emissions and creates a market for them. In this way, they are 'internalised' through the requirement for the relevant sectors to purchase EU allowances (EUAs) to cover relevant emissions. The cost of any EUAs to cover traded emissions will be reflected in the purchase price of traded sector goods. Since the purchase price is used in transport appraisal, the cost of the relevant EUAs will be included in the cost benefit analysis – it is for this reason that STAG no longer provides the traded values of CO_2 equivalent.

In principle, appraisal should consider all greenhouse gas emissions, including those resulting from the production of materials used in any infrastructure, for example cement, steel etc. (otherwise known as embedded carbon), as well as those resulting from changes to the use of transport fuels. The majority of such embedded emissions are likely to be covered by the EU ETS and will therefore already be "internalised" (see above).

Where a large volume of embedded emissions are not covered by the EU ETS, e.g. imported materials from countries with no carbon pricing, they should be taken into account within the appraisal in line with DECC guidance (DECC, 2012). For the majority of major transport schemes, however, such additional analysis is likely to be disproportionate, and the analysis may be limited to emissions from fuel consumption and electricity generation.

Table 7.3: Non-Traded Values, £ per Tonne of CO_2 Equivalent expressed in 2010 prices (Source: WebTAG data book Table A3.4)

	Low	Central	High
2010	26.64	53.28	79.92
2011	27.04	54.08	81.12
2012	27.45	54.89	82.34
2013	27.86	55.72	83.58
2014	28.28	56.55	84.83
2015	28.70	57.40	86.10
2016	29.13	58.26	87.39
2017	29.57	59.14	88.70
2018	30.01	60.02	90.03
2019	30.46	60.92	91.39
2020	30.92	61.84	92.76
2021	31.43	62.87	94.30
2022	31.95	63.90	95.85
2023	32.46	64.93	97.39
2024	32.98	65.96	98.94
2025	33.50	66.99	100.49
2026	34.01	68.02	102.03
2027	34.53	69.05	103.58
2028	35.04	70.08	105.12
2029	35.56	71.11	106.67
2030	36.07	72.14	108.22

2031	39.42	78.84	118.26
2032	42.77	85.54	128.31
2033	46.12	92.24	138.36
2034	49.47	98.94	148.41
2035	52.82	105.64	158.46
2036	56.17	112.34	168.51
2037	59.52	119.04	178.56
2038	62.87	125.74	188.60
2039	66.22	132.44	198.65
2040	69.57	139.13	208.70
2041	72.92	145.83	218.75
2042	76.27	152.53	228.80
2043	79.62	159.23	238.85
2044	82.97	165.93	248.90
2045	86.31	172.63	258.94
2046	89.66	179.33	268.99
2047	93.01	186.03	279.04
2048	96.36	192.73	289.09
2049	99.71	199.43	299.14
2050	103.06	206.12	309.19
2051	105.64	213.41	321.19
2052	108.03	220.48	332.92
2053	110.37	227.57	344.77
2054	112.64	234.67	356.70
2055	114.73	241.54	368.35
2056	116.77	248.45	380.14
2057	118.63	255.12	391.60
2058	120.34	261.62	402.89
2059	121.95	268.01	414.08
2060	123.41	274.25	425.08
2061	124.24	279.19	434.15
2062	125.01	284.11	443.21
2063	125.51	288.53	451.55
2064	125.87	292.71	459.56
2065	125.97	296.39	466.81
2066	126.01	300.02	474.03
2067	125.76	303.05	480.33
2068	125.38	305.82	486.25
2069	124.81	308.16	491.52
2070	124.08	310.19	496.30
2071	123.32	312.20	501.09
2072	122.41	313.87	505.33
2073	121.39	315.29	509.19
2074	120.13	316.14	512.14
2075	118.89	317.03	515.17
2076	117.33	317.10	516.88
2077	115.78	317.22	518.65
2078	114.06	316.82	519.59
2079	112.26	316.24	520.21
2080	110.28	315.08	519.89
2081	108.65	314.92	521.20
2082	106.83	314.21	521.59
2083	104.94	313.26	521.58

2084	103.00	312.11	521.22
2085	101.11	311.10	521.09
2086	99.03	309.48	519.93
2087	96.90	307.62	518.34
2088	94.77	305.71	516.65
2089	92.57	303.51	514.45

As an example, a tonne of Carbon Dioxide Equivalent emitted in 2020 in the traded sector has a value of £27.89, while in the non-traded sector the value is £62.18. The total monetised value of CO_2 should be calculated by discounting the monetised value for each scheme year (over a 60 year appraisal period) in the standard way. A worksheet is provided for this purpose that may be useful.

Practitioners may also want to know the amount of CO_2e emitted per unit of fuel/energy consumed. These are given below in Table 7.4. These figures are assumed to change over time as the proportion of bioethanol blend in the UK market increases; average car values can be calculated using the proportions of petrol, diesel and electric cars in the UK from section 9.5.18. Note that the values given are kilograms of CO_2e, and not tonnes.

Table 7.4: CO_2 emissions per litre of fuel burnt/kWh used (Source: WebTAG data book Table A3.3)

Year	Petrol (KgCO_2e/l)	Diesel (KgCO_2e/l)	Gas Oil (KgCO_2e/l)	Electricity (Road) (KgCO_2e/kWh)	Electricity (Rail) (KgCO_2e/kWh)
2010	2.2439	2.5691	3.0212	0.3902	0.3617
2011	2.2250	2.5739	3.0212	0.3831	0.3552
2012	2.2135	2.5607	3.0212	0.3756	0.3481
2013	2.2019	2.5474	2.8867	0.3675	0.3406
2014	2.1791	2.5332	2.8719	0.3588	0.3326
2015	2.1562	2.5190	2.8572	0.3495	0.3240
2016	2.1334	2.5048	2.8424	0.3396	0.3148
2017	2.1105	2.4905	2.8276	0.3291	0.3050
2018	2.0877	2.4763	2.8129	0.3178	0.2945
2019	2.0648	2.4621	2.7981	0.3057	0.2833
2020	2.0419	2.4479	2.7834	0.2928	0.2714
2021	2.0419	2.4479	2.7834	0.2789	0.2586
2022	2.0419	2.4479	2.7834	0.2642	0.2449
2023	2.0419	2.4479	2.7834	0.2484	0.2303
2024	2.0419	2.4479	2.7834	0.2316	0.2146
2025	2.0419	2.4479	2.7834	0.2135	0.1979
2026	2.0419	2.4479	2.7834	0.1943	0.1801
2027	2.0419	2.4479	2.7834	0.1737	0.1610
2028	2.0419	2.4479	2.7834	0.1517	0.1406
2029	2.0419	2.4479	2.7834	0.1281	0.1188
2030	2.0419	2.4479	2.7834	0.1030	0.0955
2031	2.0419	2.4479	2.7834	0.0963	0.0893
2032	2.0419	2.4479	2.7834	0.0901	0.0835
2033	2.0419	2.4479	2.7834	0.0843	0.0781
2034	2.0419	2.4479	2.7834	0.0788	0.0730
2035	2.0419	2.4479	2.7834	0.0737	0.0683
2036	2.0419	2.4479	2.7834	0.0689	0.0639
2037	2.0419	2.4479	2.7834	0.0645	0.0598

2038	2.0419	2.4479	2.7834	0.0603	0.0559
2039	2.0419	2.4479	2.7834	0.0564	0.0523
2040	2.0419	2.4479	2.7834	0.0527	0.0489
2041	2.0419	2.4479	2.7834	0.0457	0.0423
2042	2.0419	2.4479	2.7834	0.0478	0.0443
2043	2.0419	2.4479	2.7834	0.0395	0.0366
2044	2.0419	2.4479	2.7834	0.0318	0.0294
2045	2.0419	2.4479	2.7834	0.0303	0.0281
2046	2.0419	2.4479	2.7834	0.0305	0.0283
2047	2.0419	2.4479	2.7834	0.0294	0.0273
2048	2.0419	2.4479	2.7834	0.0326	0.0302
2049	2.0419	2.4479	2.7834	0.0293	0.0271
2050 onwards	2.0419	2.4479	2.7834	0.0249	0.0231

7.4.2.7 Embodied Carbon

In a transport context the term embodied carbon refers to carbon dioxide emitted at all stages of the construction process. There is a small but increasing evidence base for the incorporation of embodied carbon into transport appraisal. At this stage Transport Scotland will pursue a methodology based on the existing data available. The approach and values will be updated and refined as the evidence base matures.

The recommended values are shown below. Values for maintenance are not currently available.

Rail

Category	Tonnes CO_2/stkm
Track	500
Electric infrastructure	450
Stations	100
Bridges	2,500

Road

Category	Tonnes CO_2/lkm
Major road	325
Urban minor road	300
Rural minor road	225
Lighting (trunk)	20 pa
Bridges	2,500

Optimism bias and embodied carbon

Insofar as optimism bias uplifts reflect increases in capital cost above construction price inflation, assuming that cost is directly correlated to quantity suggests that it would be appropriate to apply optimism bias uplifts to these emissions.

Valuation of carbon emissions

Assuming that most transport projects will now be built post-2012, these emissions will occur within the traded sector, and therefore will be included in the capital cost of the project, as firms will have to buy permits to emit the associated carbon. Therefore, the emissions should be included in the overall calculation of carbon emissions but not valued within the appraisal.

There will be additional emissions associated with construction that will be outside the traded sector, and should be measured and valued in the standard way using the non-traded value of CO_2 (see section 7.4.2.6). Evidence on the scale of these impacts is limited, so a 20% uplift to the base values is recommended.

7.4.2.8 Appraisal Summary Table

Indicators to be used include the change in:

- CO_2 emissions (expressed in tons of CO_2 and tons of carbon equivalent t C);
- The monetised present value of the change in CO_2 emissions.

Further guidance on how to report monetised values of emission savings is set out in Section 12.7 – Headline indicators in STAG.

7.4.3 Local Air Quality

7.4.3.1 Issues

Several air pollutants can cause specific local problems if they occur at high concentrations. Substances that potentially have impacts on human health, flora and fauna include CO, volatile organic compounds (VOCs), NO_2, and PM_{10} (particulate matter). At very short distances, heavy metals (e.g. lead and cadmium) may also be significant. Pollutant concentrations exceeding ambient air quality standards are normally only measured directly adjacent to roads and airports. The key pollutants to be considered in STAG are NO_2 and PM_{10} (of primary concern in terms of health), which together are taken to account for local air quality.

7.4.3.2 Sources of Information

- *Local Air Quality Management Guidance (policy and technical guidance notes)* — DEFRA (2003);
- *The Air Quality Strategy for England, Scotland, Wales and Northern Ireland* — DEFRA (2007);
- Local authority Environmental Health Officers — existing data on air quality issues;
- Scottish Government Development Department databases - emission characteristics of traffic in terms of: speed, vehicle mix and flow at representative points on the trunk road network;
- Census of Population — resident population in defined zones may be determined by aggregating Small Area Statistics.
- UK National Air Quality Archive — (www.airquality.co.uk)
- National Atmospheric Emissions Inventory — (www.naei.org.uk)
- The Scottish Transport Emission Partnership (STEP) has a collaborative role in managing transport related air quality in Scotland, and should be consulted where appropriate.
- The Scottish Government has committed to consulting and delivering a Low Emission Strategy for Scotland and schemes should be assessed in accordance with the latest position on this.

7.4.3.3 Methods — Part 1

This is likely to be a largely qualitative assessment at both strategic and project level, considering potential changes in air quality arising from the options and approximate numbers of people or sensitive receptors exposed. A description of how the option contributes towards reducing emissions of pollutants and promotes better air quality is required for the Part 1 Appraisal.

7.4.3.4 Methods — Part 2 Strategic Level

At the strategic level, outputs from spatially coarse transport models are unlikely to be suitable for estimating the exposure of properties to levels of air pollution. It would be more appropriate to estimate the total emissions likely to be generated in the study area on a zonal basis and to relate this to the magnitude of changes in emissions and where these changes occur.

Output from this type of spatially coarse transport model, which can be used in the assessment of emissions, includes:

- Changes in speed by mode by model zone/study area (as defined in the transport model); and
- Changes in passenger car unit/vehicle kilometres travelled by mode by model zone/study area (as defined in the transport model).

This data, in conjunction with appropriate emission factors (see below), can be used to estimate the likely total emissions from a study area, or each model zone within it, resulting from a strategy option. This approach may lead to some anomalies in that the relationship between emissions and exposure to air pollution is not always direct and linear, but in most cases will allow a fair comparison between alternative modes or projects.

Changes in total emissions can be used as a surrogate or proxy for micro-scale air quality impacts. Generally reductions in total emissions in an area are likely to result in improved air quality, although to what extent will not be clear from an understanding of emissions alone. It is the change in personal exposure to air pollutants that is the key factor in understanding potential health effects. A reduction in total emissions may not in all cases lead to a reduction in the population's exposure to air pollution. For example, options which result in more people living and walking near busy road links may result in adverse effects due to greater exposure to air pollutants, even though emissions would reduce overall. These effects are on the micro-scale and, for those multi-modal studies that are undertaken at a spatially coarse level of assessment, cannot be quantified reliably.

Ideally, in appraising options at the strategy level, one would want to include some consideration of the population exposed to changes in air pollution. While the use of population data works well for assessing noise, relating population densities to changes in emissions is not a valid approach for assessing local air quality impacts at the strategic level and, in fact, may be misleading. The population exposed to a level of emissions does not give an indication as to whether air quality standards are exceeded and therefore whether human health is affected to any significant degree. Emissions of air pollutants can undergo physical and chemical transformation in the atmosphere. Hence, emissions do not always equate directly with the resulting ambient concentrations affecting a population. An understanding of changes in ambient air quality in relation to air quality standards at specific receptor sites and effects on population can only be accurately determined where specific link traffic flows and speeds are available, as in the method for Plans. For this reason the swathe of exposure approach used in the noise methodology has not been translated into the assessment of local air quality impacts.

However, it is important that account is taken of both the magnitude of changes in emissions and where these emissions occur. For example, strategies that switch emissions from town centres to rural areas may result in fewer people being exposed to pollution. Zones within transport models will usually be of differing sizes. Study areas will also differ in size. Therefore total emissions should be expressed in terms of emission per unit area (e.g. tonnes per km^2 per year). In view of this, the indicator selected for the appraisal of local air quality impacts is the total emission rate per unit area multiplied by a population density for the same unit area.

This approach allows two options that may yield the same benefits across the study area, in terms of the change in tonnes of emissions, to be differentiated if one tends to favour emissions savings in populated areas. Populations within these zones can be estimated from population databases (e.g. Ordnance Survey Codepoint or Addresspoint).

The concept of an 'emissions exposure estimate' should be used. The steps to calculate this are outlined in the Calculation Sheets and Worksheets provided in Section 17.1. In summary they involve the following steps:

i) Calculate the total emissions (tonnes per year), for each zone, for NO_2 and PM_{10};

ii) Estimate the total population per zone;

iii) For each zone, multiply i) by ii) and divide the result by the area of the zone, expressed in km^2;

The three steps above should be carried out for the base year and opening year do-minimum scenario and for the opening year do-something scenario. If the option would be operational in 2005, then the calculations should be carried out for this year instead of the opening year.

iv) For each zone, subtract the value in iii) for the strategy from each of the do-minima (i.e. the strategy minus the base year do-minimum and the strategy minus the future do-minimum);

v) Count the number of positive values in iv) - these are zones in which the strategy is unlikely to improve air quality over the do-minimum;

vi) Count the number of negative values in iv) - these are zones in which the strategy is likely to improve air quality over the do-minimum; and

vii) Sum the values in iv) over all zones to create the emissions estimate (do this for NO_2 and PM_{10} separately and for the strategy compared to both the present and future do-minima).

The estimation of total emissions on the basis of vehicle kilometres, speed and emission factors can lead to inaccuracies of which the analyst should be aware. However, small differences in totals should not be given undue weight in the decision making process. Some of the reasons for potential errors are given below and the degree to which any particular study might be prone to them should be borne in mind when considering the outputs of any calculations.

- The distribution of speeds about the mean is important in determining total emissions;
- The relationship of vehicle speed to emission rate per kilometre is not linear and varies with pollutant. A series of transport strategies may well change the distribution of speeds about an unchanging mean. These effects would not be evident if a single mean speed was used;
- The distribution of traffic in relation to populations may be affected by a transport strategy. Without examining micro-scale effects this effect may not be picked up at the strategic level; and
- The mix of vehicle types is often crucial in determining the overall emissions of individual pollutants. The level of emission control in the vehicle fleet is important, as is the split in fuel between diesel and petrol.

DMRB 11.3.1 (updated to include HA207/07) contains a simple method that allows total emissions to be estimated and this should be used for assessing strategic options. The calculation method is available as an Excel spreadsheet and can be downloaded from the Highways Agency website (search for air quality spreadsheet). Guidance on how to operate the spreadsheet is contained in DMRB 11.3.1. Emissions can be calculated using the 'regional' worksheets. The following input data is required to run the spreadsheet:

- The number of vehicle kilometres travelled;
- The year of assessment;
- Average vehicle speed;
- The proportion of heavy duty vehicles; and
- Road type (used to define vehicle fleet composition).

The number of vehicle kilometres travelled should be entered by input to the traffic flow and link length cells to give the required distance travelled.

The predictions of emissions will be more accurate the more disaggregated the traffic flow data is in terms of modes (car, light duty vehicle, rigid HGV, articulated HGV, and coaches/buses). If detailed information on the vehicle fleet composition across the study area or on distance travelled by road type is not available, the road type should be entered as A in the spreadsheet to represent motorways and A-roads, as these will carry the bulk of the traffic. Grossly aggregated data can lead to significant errors and expert opinion may be required in order to determine the validity of any conclusions drawn from numerical differences in calculated emissions.

7.4.3.5 Methods — Part 2 Project Level

An assessment of the change in roadside levels of PM_{10} and NO_2 is to be made for all affected routes using the method described in DMRB 11.3.1. Options for modes other than road traffic will have implications for road traffic on particular routes due to factors such as modal shift or the generation of additional traffic to transport nodes (stations, ports, transhipment points etc). The exposure of properties to this general change can be calculated by banding properties according to their distance from the road (0-50m, 50-100m, 100-150m, 150-200m), and using the air quality spreadsheet available from the Highways Agency website.

At the project level, individual link data is likely to be available. Therefore the aim at this level is to quantify the change in exposure at properties in the opening year as a result of each option. The quantification needs to take account of all significant changes in exposure, whether on the existing or new routes, or elsewhere on the local network.

If the project is within one or more AQMA and Action Plans are proposed or exist, it is particularly important to understand the consequences of the option. Analysts are reminded of the need to consider not just changes in traffic flow but also changes in traffic composition and operating conditions (perhaps as a result of traffic management projects). Potential traffic management measures can be found at Annex 3 of *The Role of the HA in Local Air Quality Management* (2003).

Step 1
In the first step, pollutant concentrations for the appropriate assessment years for the routes affected as discussed in DMRB 11.3.2, for both the do-minimum and do-something scenarios should be calculated. The calculation of pollutant concentrations is to be carried out using DMRB 11.3.1 air quality screening method.

Step 2
The second step is to quantify the exposure to this general change. The most readily available information, which will have already been used in the normal assessment approach, is the property count. However properties should be banded to take account of the diminishing effects of pollution over distance. This assessment will produce a value which will define the magnitude of exposure due to the addition, or removal, of pollution from a specific number of properties. The method takes account of all significant changes in exposure, whether on existing or new routes, or elsewhere on the local network. A negative value will indicate that there is reduced exposure and therefore a general improvement in air quality, due to an option. A positive value will indicate an increase in exposure and therefore a general detrimental effect upon air quality due to an option. A qualitative comment will provide an indicator as to whether the option will cause an Air Quality Strategy objective to be exceeded or whether an exceedance has been removed.

The Calculations
The requirement to produce the quantified results for the worksheets below can be carried out in two ways. Either the Local Air Quality LAQ Excel Spreadsheet (see Section 17.1) can be completed, which is recommended as an easy to use approach, particularly as the summary tables in the spreadsheet collate the information for each route to produce the entries required for the Appraisal Summary Table. Alternatively, a separate spreadsheet/alternative means can be devised if preferred. The latter may be a preferred option for more complex assessments, but in this case, the ability to show the input data and results for individual routes will still be required (see the spreadsheet for an example of this).

The following steps can be taken to produce the quantified results, using the LAQ Excel spreadsheet, facilitating the entry of all routes and the summary tables:

- For each affected route, the properties should be "banded", and the number of properties within each band recorded for the scheme and do-minimum scenarios. The splits which the bands define closely relate to the diminishing contribution that vehicle emissions make to local air quality over distance. The bands are defined as:

    - Road centre to 50m from road centre
    - 50m - 100m from road centre
    - 100m - 150m from road centre
    - 150m -200m from road centre

- Beyond 200m, the contribution of vehicle emissions from the road centre to local pollution levels is not significant.

An assessment of annual mean concentrations of NO_2 and PM_{10} within each of these bands, for all affected routes, is to be made using the method described in DMRB 11.3.1. Concentrations should be determined at 20m, 70m, 115m and 175m from the road centre to represent average concentrations within each band. If concentrations at 20m are not representative of average concentrations encountered at properties within the first band due to the road occupying a large proportion of this band, then concentrations at a more representative distance should be used. If a new route is being assessed, the concentrations with the do-minimum should be taken to be the same as the background level. This assessment should be carried out for the opening year, for both the do-minimum and do-something scenarios. Affected routes are defined as the existing route, the new route (if the option provides one), and any other local routes on which traffic flow changes are considered to be significant.

In most cases, the same number of properties will be entered for the do-minimum and do-something scenarios. However, there may be a change where the area occupied by the carriageway changes, due to properties being demolished or the road centreline moving.

- For each affected route for the do-minimum and do-something scenarios, the following values are to be calculated:
  - (pollutant concentration at fixed location within band) x (number of properties within that band)

  This should be carried out for each of the four bands and the results added together to give a total for each scenario. The do-minimum value should be deducted from the do-something value for each affected route. A positive value should be assigned where an increase in concentration has been identified due to the option, and a negative value for a decrease in concentration.

- The LAQ Excel spreadsheet will carry out much of these calculations. Property counts and estimated concentrations should be entered into the pink cells in the spreadsheet. The spreadsheet will then calculate the change in concentrations for each route and will sum the changes for each of the routes to give the Overall Assessment Score which is described below. The spreadsheet is currently set up for five routes but any number of additional routes can be added by pressing the 'add route' button. It is best to add any additional routes before any of the cells are filled in, otherwise the additional route cells will contain the entries for route 1, however, the entries in these new cells can be easily modified. Once a route has been added to the spreadsheet, it should not be deleted as this would invalidate the summary table. If additional routes are added, the blue line below route five can then be dragged down below the final route. This will bring the colour back to all of the added route tables. After this procedure, if page dividing lines are lying over particular routes, they can simply be dragged between route tables, which will aid printing.

To provide an estimate of the number of properties experiencing improvement or worsening in air quality over the entire scheme, the affected routes are divided into two groups — those where air quality would be improved (negative values) and those where it would be worse (positive values). The number of properties affected in each group is then calculated by summing over the four bands listed above and then aggregated for the area as a whole.

7.4.3.6 Appraisal Summary Table

Indicators to be used include the change in:

- The number of people/properties experiencing an increase/decrease in PM_{10} concentrations (micrograms/cubic metre);
- The number of people/properties experiencing an increase/decrease in NO_2 concentrations (micrograms/cubic metre); and
- An indication of the relative magnitude of emissions exposure using indices or distance bands should be provided. At the qualitative level the performance relative to the Air Quality Strategy for England, Scotland, Wales and Northern Ireland should be reported.

Worksheets A1 to A4 in Section 17.1 may be used to assist in the assessments required to appraise the air quality impacts of an option. Worksheet A4 is a supporting worksheet provided to address the wider reporting issues such as the performance of the option in relation to objectives or whether particular spatial and/or social groups are particularly affected. It may also be used to record the need for any mitigation or monitoring actions, uncertainty and the issue of significance.

7.4.3.7 Economic Valuation of Air Pollution

Air quality impacts should be valued using a hybrid approach which combines the damage cost and marginal abatement cost (MAC) methodologies developed by the Inter Departmental Group on Costs and Benefits (Air Quality) (IGCB(A)) and published in HMT supplementary Green Book guidance. The MAC approach has been developed for interventions that are expected to result in changes to air quality in areas exceeding EU limit values, or where those limits will be exceeded following the intervention.

Application of the MAC approach does not imply that breaches of legal obligations can be permitted in cost-benefit terms but represents the indicative costs of additional abatement effort that would be required to comply with legal obligations if the scheme were to go ahead (or savings from reduced abatement effort if the scheme results in an improvement). Therefore the MAC approach helps the delivery of legal air quality obligations by reflecting the need to deliver obligations and the costs associated with rectifying any breach.

For Particulate Matter (PM_{10}), valuation should be applied to changes in **PM_{10} concentrations**. Defra’s reports to the European Commission indicate that concentrations exceeding the PM_{10} daily mean limit value have only been recorded in London in recent years, before natural sources of particulate matter and the time extension which was in place in London until June 2011 had been taken into account. Therefore valuation of changes in PM_{10} concentrations should be based on the damage cost approach. The MAC approach may be applicable where an intervention results in large increases in PM_{10} concentrations, particularly in London. In such situations analysts should contact TASM or IGCB(A).

As the IGCB(A) do not currently publish values for NO_2 concentrations and NO_x emissions can cause health problems over long distances through secondary particle formation, values for **NO_x emissions** are used at the economic valuation step in the appraisal of air quality impacts. The MAC approach should be applied to changes in NO_x emissions in areas where the EU NO_2 annual mean limit value (referred to as “the NO_2 limit value” from here on) is exceeded. Changes in NO_x emissions in other areas should be valued using the damage cost approach. Therefore the first step in the valuation of air pollution impacts is to separately identify NO_x emissions where the NO_2 limit value is and is not exceeded in the opening year.

Depending on whether detailed information on traffic flows and air quality is available, two methods are presented for identifying NO_x emissions where the NO_2 limit value is exceeded. The recommended approach is a detailed, link-by-link method which takes into account the location and magnitude of exceedences. This method should be used where possible and in particular for schemes which are expected to lead to a worsening of air quality in areas with existing exceedences or to cause new exceedences. An alternative, higher-level approach can be used where the detailed information required for the link-by-link method is not available (for example when appraising national policies) and this method is described in Appendix C.

Identifying emissions where the NO_2 limit value is exceeded

Information on the NO_x emissions from a scheme can be generated using the methods described for the Regional Assessment in section 3 above. Supplementary Green Book guidance on valuing air quality impacts is clear that the MAC approach should only be used where the NO_2 limit value is breached. Defra's Pollution Climate Mapping (PCM) model is used to supplement results from fixed monitoring to assess national compliance with pollutant limits and targets in the Air Quality Directive 2008/50/EC and Fourth Daughter Directive 2004/107/EC. The model has been designed to assess compliance with the limit and target values at locations defined within the Directives. For example, the Air Quality Directive is clear that assessment should not be undertaken where there is no public access or within 25 metres of major junctions. It should be noted that not all roads in the UK are included in the national assessment; the assessment is conducted in line with the requirements Annex III of the relevant Directive on Ambient Air Quality. Approximately 9000 urban road links are included. These are all in urban areas and are all A roads and Motorways. Their inclusion is based on their classification in the underlying Department for Transport traffic data, only urban A roads and Motorway links are included in the PCM modelling.

Therefore, results from the PCM model should be used as the basis for identifying where the NO_2 limit value is exceeded. As the PCM model only covers major roads ('A' roads and motorways) in urban areas, there may be situations when none of the links in the identified affected road network are included within the PCM model. In such situations it is not necessary to separately identify NO_x emissions where the NO_2 limit value is and is not exceeded and all of the change in NO_x emissions should be valued with the damage cost approach.

The link-by-link method for identifying emissions where the NO_2 limit value is exceeded

Where detailed data on link-by-link concentrations and emissions are available, PCM forecasts of NO_2 concentrations by road link can be requested from the following email address: aqinfo@ricardo-aea.com. The assessment should use the most recent projections that have been made available (note these will be based on the most recently available reference year, which may not be the same as the most recent compliance assessment year). The most recent reference year can be confirmed by contacting the PCM modelling team at the email above. The identified affected road network (preferably defined using the criteria from the local air quality analysis) should be mapped against PCM outputs to identify the links where the NO_2 limit value of 40 $\mu g/m^3$ is exceeded by adding the change in NO_2 concentration from the local air quality assessment (for the closest distance to the road) to the PCM concentrations in the opening year. PCM projections are available for the following 'projection years': 2015, 2020, 2025 and 2030. Where PCM forecasts are not available for the opening year they should be calculated by linearly interpolating between projection years.

Table 7.5 summarises the scenarios that can arise from this process and the valuation approach which should be followed in each scenario.

Table 7.5: Scenarios and valuation approaches for the link-by-link assessment of NO_2 exceedances	
Scenario	**Valuation approach**
1. Scheme links do not map onto any PCM modelled links	Damage cost approach for emissions from all links.
2. Scheme links map onto PCM links which are all compliant with the NO_2 limit value both with and without scheme	Damage cost approach for emissions from all links.
3. Scheme links map onto PCM links which are non-compliant with the NO_2 limit value both with and without scheme	MAC approach for emissions from any non-compliant links.
4. Scheme links map onto PCM links which are compliant with the NO_2 limit value and the scheme results in non-compliance with the NO_2 limit value on some links (or vice versa if the scheme reduces emissions).	Apply both MAC and damage approaches on these links proportionately based on the change in concentrations resulting from the scheme.

The next step is to identify the NO_x emissions in the without scheme and with scheme cases on those links where the NO_2 limit value is exceeded. This information should be available from the regional assessment described in section 3.3.

For the purposes of economic valuation we are primarily concerned with changes in air pollution as a result of the scheme and the MAC approach should only be applied to changes above legally binding limit values. If the identified affected road network does not contain any links modelled by the PCM model (scenario 1) or this process does not identify any links exceeding the NO_2 limit value (scenario 2), all of the change in NO_x emissions should be valued with the damage cost approach.

In scenario 3 (where PCM opening year concentrations for a link exceed the NO_2 limit value) all NO_x emissions for that link in the without scheme and with scheme cases should be reported as exceeding the limit, meaning that all of the change in NO_x emissions on that link will be valued with the MAC approach.

In scenario 4 (where the scheme results in concentrations for a link moving above or below the NO_2 limit value), the higher abatement costs should only be applied to a proportion of the change in NO_x emissions. For this purpose it is reasonable to assume that NO_2 concentrations increase proportionately with NO_x emissions so that the proportion of the emissions on an exceeding link should be based on the proportion of the change in concentration above (or below) the NO_2 limit value. For example, if the scheme results in concentrations increasing from 38μg/m^3 to 42μg/m^3 (or reducing from 42μg/m^3 to 38μg/m^3), half of the emissions on that link in the without scheme and with scheme cases should be reported as in exceedance. This will result in half of the change in emissions on that link (above the NO_2 limit value) being valued with the MAC approach and half (below the NO_2 limit value) being valued with damage costs.

The next part of this step of the analysis is to determine how the profile of emissions where the NO_2 limit value is exceeded will change over time. Analysts should take a proportionate approach to how this is assessed. PCM modelling outputs contain forecast concentrations for 2015, 2020, 2025 and 2030. Based on the availability of information, detailed link-by-link analysis using these forecasts can be used to determine when compliance with the NO_2 limit value will be achieved for the links identified as exceeding. This should be repeated for as many forecast years as is required, repeating the analysis above for a further forecast year and interpolating and extrapolating between PCM output years to cover the appraisal period.

Reporting the change in NO_x emissions

This method will provide estimates of NO_x emissions on links exceeding the NO_2 limit value for the without scheme and with scheme cases. The final part of this step of the analysis is to calculate the change in emissions, by subtracting the without scheme NO_x emissions from the with scheme emissions, on links where the NO_2 limit value is and is not exceeded. As for local air quality, a positive result reflects a worsening of air quality, while a negative value represents an improvement. The results of the analysis should be summarised in Worksheet 2, below, which is generated by the Air Quality Valuation spreadsheet. Qualitative comments should include a description of how changes in emissions in areas exceeding limit values have been calculated.

Valuing changes in air pollution

All of the damage costs and marginal abatement costs required to value air quality impacts are included in Table 7.6.

Table 7.6: Damage cost and marginal abatement cost values by pollutant (2010 prices, 2010 values)

	Central Value	Low value	High value
PM_{10} damage costs (£/household/1μg/m³)	92.7	48.6	105.4
NO_x damage costs (£/tonne)	955	744	1085
NO_x marginal abatement costs (£/tonne)	29,000	27,000	73,000

Values for NO_x emissions are in £ per tonne, while PM_{10} values are £ per household per 1μg/m³ and should be applied to the overall score for the scheme as reported in the TAG LAQ Workbook.

The damage costs are based primarily on the health impacts of air quality pollutant. The NO_x values also include impacts on crops and the PM_{10} values include building soiling impacts. The damage costs for both NO_x emissions and PM_{10} concentrations are derived from analysis by IGCB(A) of the typical health impacts arising from changes in NO_x emissions and PM_{10} concentrations, respectively. The high and low values represent uncertainty around the potential time lag between a change in air quality and health impacts, ranging from a zero lag (for the high values) to a 40 year lag (for the low value). Estimates based on this range should be reported in the appraisal.

Abatement costs will vary depending on the abatement options available in a particular location. However, for simplicity and proportionality average marginal abatement costs should be used to value changes in NO_x emissions on links where the NO_2 limit value is breached. Use of these values does not imply that breaches are permissible but represents the indicative change in the cost of abatement effort that would be required to comply with the NO_2 limit value if the scheme were to go ahead. The values given in Table 7.6 are indicative of the costs of a range of technologies that could form the marginal abatement option. As for the damage costs, estimates based on the range of values should be reported in the appraisal. The MAC approach has been developed by IGCB(A) using a technology Marginal Abatement Cost Curve (MACC), including all current air quality abatement technologies, their costs and abatement potential.

TAG Air Quality Valuation Spreadsheet
A TAG Air Quality Valuation Workbook has been developed by DfT alongside their environmental impacts unit to facilitate the necessary steps for calculating the monetary values for air pollutants.

For NO_x, the total emissions in the without scheme and with scheme cases for the opening and forecast years (resulting from the regional assessment) should be entered in the "Emissions and concentrations" sheet.

Emissions on links exceeding the NO_2 limit value should be entered in the "NO_x exceedances and extrapolation" sheet. Where the link-by-link method has been used, the "custom" option should be selected in the drop-down box and the profile of emissions calculated following the process described above should be entered in columns L (for the without scheme case) and M (for the with scheme case). In cases where no exceedances have been identified, "custom" should be selected and columns L and M left blank.

For rail schemes, the "rail" option should be selected from the drop-down box. This will automatically calculate the profile of emissions where the NO_2 limit value is and is not exceeded for the appraisal period, and apply the appropriate abatement or damage costs.

For PM_{10}, the PM_{10} assessment score for the without scheme and with scheme scenarios should be entered into the "Emissions and concentrations" sheet for the opening and forecast years.

The spreadsheet linearly interpolates and extrapolates the changes in emissions and concentrations over the appraisal period and calculates the value of changes in air quality, incorporating real changes in the values over time. Damage cost values in future years increase with the forecasts of real GDP per capita, for NO_x emissions, or real GDP per household, for PM_{10} concentrations. TAG Data Book Annual Parameters Table contains the appropriate growth factors. It is uncertain how marginal abatement costs will change over time. Costs could increase as the cheapest abatement options are exhausted or decrease as new, cheaper options become available. Therefore the abatement costs do not increase in real terms over time.

The values calculated for each year are then discounted at standard HM Treasury rates to give a present value (PV) in the Department's standard base year for that particular year. This is then summed over the appraisal period, to give the net present value (NPV) of the change in air quality for the scheme in question. In addition to the primary output of the central NPV values, the high and low NPV values are also calculated by this spreadsheet, for the purposes of sensitivity analysis.

In exceptional circumstances NO_x emissions or the overall score for the scheme for PM_{10} might only be estimated for one year (the opening year). In such cases the opening year emissions and assessment score should be applied to each year over the appraisal period. In the spreadsheet this can be done by selecting a nominal forecast year within the appraisal period and entering the opening year emissions and assessment scores against both the opening and forecast years. However, this will provide an approximate estimate only as it does not take any account of future changes in variables including vehicle emission standards, traffic flows, and the number of households located near links. Analysts will also have to consider how the proportion of NO_x emissions in areas exceeding the NO_2 limit value will change over the appraisal period. Therefore this approach is not recommended.

Presentation of Results

The analyses of impact on local air quality, regional air quality and the economic valuation of air pollution all result in Summary Worksheets. These worksheets should be included in documentation of the air quality appraisal work.

The central monetary estimate for the changes in air quality, estimated using the methodology described in section 3.4 above, should be recorded in the Monetary column of the Appraisal Summary Table. The monetary valuation should be presented as a Net Present Value (NPV), calculated using the methodology provided above. Net Present Values for change in emissions (for NO_x) and for change in concentrations (for PM_{10}) should be reported separately and as a total Net Present Value for change in air quality.

In addition to the monetary valuation of air quality impacts, the quantitative assessments of air quality impacts in the opening year, estimated using the methods outlined in sections 3.2 and 3.3 above, should be reported in the Quantitative Assessment column of the Appraisal Summary Table.

Where possible input and output data should also be provided to Transport Scotland in digital format, as shape files or contour maps.

Finally, a comment should be provided in the Summary of key impacts column of the Appraisal Summary Table to support the assessments. If any properties are demolished or constructed as part of the scheme, then this should be noted here. If any of the Air Quality Strategy objectives are predicted to be exceeded or an exceedance is removed due to the scheme, then this should be noted here also. In particular, a comment must be provided if the scheme affects air quality within an Air Quality Management Area and state what the effect is.

Note that the Qualitative column should not be used.

Example of presentation of results in the appraisal summary table					
Impacts	**Summary of key impacts**	**Quantitative**	**Qualitative**	**Monetary**	**Distributional**
Air Quality	Overall there is a net improvement in local air quality with the scheme, but there is a negative impact on regional emissions for NOx. The scheme does not result in any exceedances	**Assessment Score** PM_{10}: -210 NO_2: -459 **Emissions** NO_X: +10.5 tonnes	N/A	Value of change in PM_{10} concentration: NPV: £Xm Value of change in NO_X emissions:NPV : £Xm Total value of change in air quality: £Xm	Moderate beneficial for most vulnerable groups

Monetised air quality impacts should be an optional inclusion where appropriate, i.e. where local air quality impacts are among the main objectives for the scheme being appraised. Where appropriate they should be included in the core benefits/BCR.

7.4.4 Water Quality, Drainage and Flood Defence

7.4.4.1 Issues

Water quality is of critical importance to people, biodiversity, agriculture and recreation. The development and operation of new transport infrastructure has the potential to have a significant effect on water quality, for example through entrainment of sediments during construction or runoff containing pollutants once the option is in operation. Increases in shipping movements could increase the risk of pollution or disturbance to marine or littoral environments. New structures may affect the capacity of flood plains or flood defences. EC Directive 2000/60/EC, the Water Framework Directive, is now implemented in Scotland. This stipulates future water protection mechanisms and quality criteria, and should be referred to within strategy / project objectives, as appropriate. Works affecting watercourses and wetlands are now subject to regulation by SEPA under the Water Environment (Controlled Activities) Regulations 2005.

7.4.4.2 Sources of Information

- Scottish Environment Protection Agency (SEPA) — National Water Quality Classification, published annually (for river quality, coastal waters, lochs and estuaries);
- SEPA — groundwater vulnerability maps and policy statements;
- SEPA — indicative flood maps;
- SEPA — *Policy 19: Groundwater Protection Policy for Scotland* (2003);
- SEPA — Water Framework Directive information, including river basin management plans and classification data and maps;
- Scottish Government - *Scottish Planning Policy (SPP) 7 - Planning and Flooding* (2004); and
- Scottish Government — *National Planning Policy Guideline 13 "Coastal Planning"*.

7.4.4.3 Methods — Strategic Level

A qualitative assessment needs to be made of the sensitivity of the water environment within the study area. This should take into account factors such as the quality of the resource, the scale at which it is important to policy makers, the rarity of the resource and whether it might be substitutable over time. Assessing the quality of the resource may include factors such as fisheries and conservation value as well as water quality. Information about the nature of the option may then be used to make a qualitative assessment of the nature and likely magnitude of associated effects and the significance of the impact on the resource.

7.4.4.4 Methods — Project Level

The appraisal of water quality, drainage and flood defence requires the consideration of impacts in terms of the number and value of the affected watercourses, as well as undertaking a risk analysis to assess the overall beneficial or adverse impacts on the water environment and flooding hazard. The process should use the SEPA River, Loch, Coastal Water and Estuary Classification Schemes and incorporate the agency's groundwater source protection classification as well as EC Freshwater Fisheries designations and other contemporary material considerations. An assessment should also be made of effects on floodplain capacity (if appropriate), and loss of floodplain capacity should be calculated and recorded. Impacts on the quality of run-off, and the risk of contamination to both surface water and groundwater should be assessed.

7.4.4.5 Appraisal Summary Table

The AST should record the risk to the water environment in qualitative terms based on an overall assessment of significance using a seven-point scale. Where options could result in deterioration in water quality this would be recorded as a negative effect. The AST can also include the names, uses and quality of affected surface and groundwater resources.

Worksheet W1 in Section 17.1 may be used to assist in the assessments required to complete the ASTs.

7.4.5 Geology

7.4.5.1 Issues

The underlying geology has played a fundamental role in determining the landscape character of Scotland. Transport options could have a direct impact on strata by imposing different loads, which could cause ground to collapse, by altering the hydrogeology or by burying or damaging important deposits or outcrops. Some geological or geomorphological features are of scientific interest and educational value. They may be designated as statutory Sites of Special Scientific Interest (SSSIs) or non-statutory Regionally Important Geological Sites (RIGS). Options could also prejudice the future working of important mineral reserves or have an indirect impact on resources through, for example, the demand for construction materials. Resource usage may be a key factor in selecting between options at the strategic level.

7.4.5.2 Sources of information

- British Geological Survey — survey information and geological maps;

- Royal Society for Nature Conservation — Regionally Important Geological Sites (RIGS);
- Scottish Natural Heritage (SNH) — SSSI designations.
- Scottish National Heritage – Geological Conservation Review Sites and Local Geodiversity Sites.

7.4.5.3 Methods — Strategic Level

At the strategic level, assessment will be restricted to identifying those sites of particular geological importance (designated sites) or significant mineral reserves and making a qualitative assessment of the degree to which the option may affect such sites.

7.4.5.4 Methods — Project Level

A more detailed assessment should be made of the significance of any designated site or significant mineral reserve which may be affected by the option, the proportion of the site which may be affected by it and the significance of this scale of effect.

7.4.5.5 Appraisal Summary Table

The AST should record numbers of each type of designated site or reserves affected by the option, e.g. 1 SSSI, 2 RIGS. The qualitative field should be used to summarise the overall effect on each affected site. Assessment of strategic options may need to be reported in the qualitative field only.

Worksheet G1 in Section 17.1 may be used to assist in the assessment.

7.4.6 Biodiversity and Habitats

7.4.6.1 Issues

Biodiversity, the richness of species, ecosystems and habitats, is now recognised as a key issue that underpins policy making in many countries. The development of transport infrastructure has a number of potential effects on biodiversity, including:

- Direct damage to important nature conservation sites or the habitats of protected species;
- Fragmentation or loss of habitats, thereby reducing species diversity and opening the way for the influx of other species;
- Creation of barriers to the movement and genetic interchange between populations; and
- Disturbance of habitats and species due to factors such as noise, light pollution and contaminated run-off which may depress populations and reproduction in some flora and fauna.

The overall objective should be to maintain biodiversity in the study area, including wildlife habitats and species and to improve the status of rare and vulnerable species wherever possible. Transport options should therefore be designed:

- To avoid harmful development affecting protected habitats. All EU member countries have such areas and networks, for example, those established under the Birds Directive (79/409/EEC) and the Habitats Directive (92/43/EEC) — the Natura 2000 sites, National Nature Reserves, Sites of Special Scientific Interest and regionally and locally designated sites;

- To avoid development in, or close to, unprotected but valuable and sensitive habitats (e.g. important bird areas);
- To avoid fragmentation of wildlife migration routes, e.g. by avoiding migration zones, or by mitigating the barrier effect by providing a tunnel or 'ecoduct' for wildlife; and
- To adopt the "no net effect" principle, providing full compensation for lost biodiversity values where loss is unavoidable.

7.4.6.2 Sources of Information

- SNH - information on designated sites, Biodiversity Action Plans, protected species and a wide range of nature conservation issues;
- Scottish Wildlife Trust - information on habitats, species and reserves;
- Macaulay Land-Use Research Institute - detailed land cover map and aerial photographs;
- Local Plans - location of Local Nature Reserves, Sites of Importance for Nature Conservation, Tree Preservation Orders etc.;
- Local Biodiversity Action Plans;
- Scottish Government, *Planning Advice Note 60 "Planning for Natural Heritage"*;
- Ratcliffe D.A. (ed) (1997), *A Nature Conservation Review,* Cambridge University Press; and
- Nature Conservancy Council (1990), *Handbook for Phase 1 Habitat Survey: A Technique for Environmental Audit.*

7.4.6.3 Methods – Part 1

This is likely to be a qualitative assessment at both strategic and project level. The aim should be to undertake a simple appraisal of biodiversity, by identifying the presence of designated sites in the study area — Special Areas of Conservation (SAC), Special Protection Areas (SPA), National Nature Reserves (NNR) and Sites of Special Scientific Interest (SSSI) — and identifying the potential for significant effects on these sites or the species they support.

7.4.6.4 Methods — Strategic Level

At the strategic level, the aim should be to undertake a broad appraisal of biodiversity, identifying in particular, the presence of designated sites in the study area — Special Areas of Conservation, Special Protection Areas, National Nature Reserves and Sites of Special Scientific Interest. Local designations, including sites protected by policies in development plans, should also be identified. The relative importance of parts of the study area should be evaluated with reference to the following factors:

- Attribute/feature;
- Scale at which it matters;
- Importance;
- Abundance/trend; and
- Substitution possibilities.

This evaluation may be undertaken at a broad-brush level based on desk study or initial site survey. Assessment of effects at this level may have to be based on an approximate indication of the scale of land take and the effect which this might have on the nature conservation importance of parts of the study area.

Where there is potential for an option to have significant effects on an European site (SAC or SPA) then the requirement for an appropriate Assessment under the Habitats

Regulations (1997) should be considered at an early stage. This should be discussed with Transport Scotland.

7.4.6.5 Methods — Project Level

A more detailed assessment of the biodiversity of the area will be required where specific projects are proposed. This is likely to require a Phase 1 Habitat Survey, supplemented by specialist surveys of flora and fauna (particularly focussed on protected species suspected of being present). Evaluation of sites should be carried out according to the Ratcliffe criteria (DMRB 11.3.4 Annex VI). The impact of the option on particular sites can also be evaluated using these criteria, given information about the construction and operation of the option.

Where there is potential for an option to have significant effects on an European site (SAC or SPA) then the requirement for an appropriate Assessment under the Habitats Regulations (1997) should be considered at an early stage. This should be discussed with Transport Scotland.

7.4.6.6 Appraisal Summary Table

The AST should record, and describe if necessary, all designated sites or reserves and the presence of rare and protected species affected by the option. The qualitative field should be used to summarise the distribution of impacts on each affected site. Assessment of strategic options may need to be reported in the qualitative field only.

The Appraisal Summary Sheet worksheets in Section 17.1 may be used to assist in the assessments.

7.4.7 Landscape

7.4.7.1 Issues

Scotland has a wide range of landscape types, many of which are highly valued and some being of national or international importance. The landscape contributes to the Scottish national identity and, while recognising that it is constantly evolving, it is clearly a resource of value to future generations. Valuable and visually sensitive landscapes, culturally interesting elements and patterns and natural areas are protected by designations. The designation of National Parks is one indication of landscape quality. SNH’s landscape character assessment programme covers the whole of Scotland.

The visual appearance of linear transport infrastructure (both the infrastructure itself and the traffic it carries) can have a major impact on the existing landscape. Major trunk roads and railways must have gentle, not sharp, curves and gradients. Consequently they often need long, high and visually dominant bridges, cuttings, embankments, etc., where rivers, mountains, valleys or other infrastructure have to be crossed. Therefore, sensitive visual (cultural and natural) elements and patterns, which are important at the small scale, cannot always be avoided and are easily damaged or fragmented. Changes to elements which are fundamental to the character of the landscape, such as the removal of field boundaries or vegetation or the introduction of alien materials, can affect the sense of place. Inappropriate routing may conflict with the natural grain of the land. The built environment and townscape character might also be affected.

At the strategic level, defining areas of different character and quality can be an important means of influencing the selection of modes and route corridors.

7.4.7.2 Sources of information

- SNH — information on designated landscapes (National Parks, National Scenic Areas, Natural Heritage Zones) and landscape character assessments;
- Planning authorities — information on Areas of Great Landscape Value, Regional Parks, Country Parks and other areas designated for planning purposes;
- National Trust for Scotland - details of landscapes held in trust for the benefit of the nation;
- Garden History Society for Scotland — information on historic and designed landscapes; and
- Historic Scotland — information on scheduled monuments (where setting can be an important issue), historic land-uses and designed landscapes.

7.4.7.3 Methods — Strategic Level

At strategic level, a broad assessment of landscape character and quality should be attempted and any specific designations identified. There are several methodologies available which take into account factors such as topography, land cover (vegetation) and historical/cultural associations to establish the character of a landscape. However, reference should first be made to landscape character assessments published by SNH prior to undertaking a more detailed assessment. In the absence of detailed project options it may only be possible to say whether the option may have a positive, neutral or negative impact on the landscape. At the strategic level, defining areas of different character and quality can be an important means of influencing the selection of modes and route corridors.

7.4.7.4 Methods — Project Level

A similar approach to that above may be adopted, though at a finer level of detail. Reference should initially be made to the landscape character assessments published by SNH. Thereafter a further subdivision of character areas should be made if appropriate to the scale and detail of the landscape and project options. A number of alternative approaches are available. DMRB 11.3.5 sets out a methodology that has been used over a long period, however this is being updated in accordance with more recently published guidance. The most recent guidance is *'Landscape Character Assessment Guidance for England and Scotland'* (2002) published by Scottish Natural Heritage and the Countryside Agency. Landscape impacts would normally be assessed at Year 1 and the assessment year (see paragraph 7.7.12 *et seq*) — the latter to be recorded on the AST.

7.4.7.5 Appraisal Summary Table

The Part 2 AST should record, and describe impacts on the fabric and character of the landscape. For strategic assessments this will be an overall assessment, perhaps focusing on the areas most vulnerable to the type of change proposed. For project level assessments the impacts may be broken down to each character area. If necessary, all designated sites affected by the option, with their designations, should also be recorded. The qualitative field should be used to summarise the overall effect on each affected character area or designated site. Assessment of strategic options may have to be reported in the qualitative field only.

7.4.8 Visual Amenity

7.4.8.1 Issues

Transport options can have a significant impact on the quality of panoramas, specific views and the visual environment of sensitive receptors. This is particularly so where new infrastructure is introduced into an established scene, where the intensity of traffic movements increases or where new lighting is provided in formerly "dark" areas. Overlooking of existing private spaces from new or improved routes should also be taken into account, as this may be perceived by local residents as intrusive. Visual impacts are normally assessed for residential properties, but also for public buildings, including workplaces, recreational buildings and outdoor locations to which the public has access. In certain cases an improvement in views may result if, for example, the option results in the removal of dereliction or a reduction in levels of traffic. In rural areas, particularly those popular for outdoor recreation, it will be important to identify key viewpoints and publicly accessible areas which might be affected by an option.

There is also the possibility that an option may allow access to vistas of an aesthetically pleasing nature, where access was previously difficult or unlikely.

Where the option is of a strategic nature, the lack of detail about the physical (and visual) implications of the option will make assessments under this heading more difficult to carry out. Nevertheless the potential for impacts on key viewpoints (particularly where these are associated with protected landscapes or important heritage sites) would be worthy of record. This may, subject to issues in the previous paragraph, be viewed as a benefit.

7.4.8.2 Sources of Information

- Development plans — the extent of existing and proposed developed areas and public spaces, policies relating to key views;
- Local authorities — the selection of key and representative viewpoints may be agreed with the relevant department(s);
- SNH — as with local authorities SNH may have concerns relating to particular locations; and
- Local maps and guides — key viewpoints.

7.4.8.3 Methods — Strategic Level

At the strategic level, impacts on views will be difficult to determine as the precise relationship between the option and receptors will be unclear. At best a subjective assessment may be made, drawing upon desk studies and map exercises to identify key receptors and their views, which could potentially be affected by an option, and the sensitivity of receptors.

7.4.8.4 Methods — Project Level

There are well-developed methodologies for visual impact assessment. The current guidance in DMRB 11.3.5 is in the process of being updated to incorporate more recently published guidance on methodologies. This includes the revised *'Guidelines for Landscape and Visual Impact Assessment'* (2002) published by the Landscape Institute and Institute for Environmental Management and Assessment. Visual impact would normally be predicted for Year 1 and the assessment year — the latter to be recorded on the AST.

7.4.8.5 Appraisal Summary Table

The qualitative field should be used to summarise the overall effect on the topic for both strategic and local options. Where sufficient detail is available, an estimate of the number and type of affected locations should be made in the quantitative field, with potential magnitude and significance of impact recorded. This will be more possible at the project level than strategic.

7.4.9 Agriculture and Soils

7.4.9.1 Issues

The loss or severance of agricultural land by new transport infrastructure may affect the viability of farm holdings. This can be particularly important in marginal agricultural areas. Soils close to any new construction can be affected by pollution from runoff and aerial deposition. Construction can cause the loss of valuable agricultural soil, which even if kept and stored is likely to degrade in quality. If soil is taken from a site of nature conservation interest there is the possibility of losing valuable seed banks. Land that is contaminated with toxic and hazardous materials can pose a threat to human health and safety if disturbed. Alternative options may have quite different implications for land take.

7.4.9.2 Sources of Information

- James Hutton Institute - agricultural land classification maps;
- Scottish Government Environment and Rural Affairs Department (SGERAD) — information on Environmentally Sensitive Areas;
- SEPA / local authorities — information on contaminated land.

7.4.9.3 Methods — Strategic Level

At the strategic level it would be sufficient to identify the relevant grades of agricultural land in the study area and to make a qualitative assessment of the likely scale of land take.

7.4.9.4 Methods — Project Level

For specific options, more detailed assessment of land quality is justified, especially where Class 1, 2 or 3_1 land is involved, in order to ensure that land take of the best quality land is minimised as far as possible. In addition, consultation with farmers and SGERAD should be carried out to enable an assessment of impact on the viability of individual holdings to be made (DMRB 11.3.6). The potential for encountering contaminated land should also be assessed.

7.4.9.5 Appraisal Summary Table

The AST should record the extent of land take of Class 1, 2 and 3_1 land. The qualitative field should be used to summarise the overall effect on the topic.

Worksheets AG1 and AG2 in Section 17.1 may be used to assist in the assessments required to complete the ASTs.

7.4.10 Cultural Heritage

7.4.10.1 Issues

Today's landscape is the product of human activity over thousands of years. There is a rich variety of remains from every period — some in the form of buildings such as castles and great houses, others less obvious, such as field systems or buried archaeological remains. Archaeological remains offer a tangible physical link with the past. They are often fragile and vulnerable to damage and care must be taken to ensure that they are not needlessly damaged or destroyed. In some parts of Scotland, extensive areas may be so influenced and characterised by archaeological features as to constitute archaeological landscapes — for example the West Mainland of Shetland, and the industrial landscapes of parts of Ayrshire and Lanarkshire.

Transport schemes also have the potential to impact on the built environment of our cities, towns and villages, which may contain historic buildings and conservation areas. Although modern buildings are susceptible to change, historic buildings and conservation areas are more vulnerable due to their historic value and more sensitive to deterioration in their surroundings.

Potential impacts of transport on the historic environment include:

- Physical impacts on buildings or on sites of archaeological interest or potential;
- Increased visual intrusion;
- Increases in noise, vibration, disturbance;
- Severance from other linked features;
- Changes in original landscapes and settings;
- Loss of amenity; and
- Changes in conservation factors e.g. dewatering.

7.4.10.2 Sources of Information

- The Royal Commission on the Ancient and Historical Monuments of Scotland — database of monuments and listed buildings;
- Historic Scotland — advice on the protection and management of ancient monuments and historic buildings, holds inventory of gardens and designed landscapes, and information on historic land-uses;
- The Council for Scottish Archaeology — information on sites of interest;
- Scottish Civic Trust — information on sites of interest;
- The Garden History Society — information on sites of interest;
- The Architectural Heritage Society of Scotland — information on sites of interest;
- Scottish Government — *National Planning Policy Guideline 5 "Planning and Archaeology"*;
- Scottish Government — *National Planning Policy Guideline 18 "Planning and the Historic Environment"*;
- Scottish Office Environment Department — *Planning Advice Note 42 "Planning and Archaeology"*;
- Planning authorities — boundaries of Conservation Areas;
- Regional Archaeologists should be consulted regarding the existence, importance and sensitivity of archaeological sites and areas.

7.4.10.3 Methods — Strategic Level

At the strategic level, it would be sufficient to identify the relevant heritage designations in the study area and to make a qualitative assessment of the likely impact of the option on the importance and integrity of the resource. These should be recorded in terms of their international, national, regional and local/other importance, so that a more balanced view can be taken of likely impacts . Where the level of detailed information permits, the option should be assessed in terms of the 7-point scale (major negative to major positive). A strategic level assessment worksheet and guidance on the determination of assessment scores is provided in Section 17.1.

7.4.10.4 Methods — Project Level

The project level assessment should be based on an appraisal of the character of the heritage components in the study area, including buildings, monuments and areas such as Conservation Areas and areas of archaeological importance. The appraisal of each of these components should consider their importance in terms of their intrinsic archaeological/historic value and in policy terms. Information about the construction of the option and its subsequent operation should enable an informed judgement to be made of the likely impact on these attributes caused by land take or other indirect effects. A project level assessment worksheet and guidance on the determination of assessment scores is provided in Section 17.1.

7.4.10.5 Appraisal Summary Table

The AST should record, and describe if necessary, all designated sites affected by the option, with their designations. The qualitative field should be used to summarise the overall effect on each affected site. Assessment of strategic options may need to be reported in the qualitative field only.

7.4.11 Physical Fitness

7.4.11.1 Issues

There is an increasing awareness of the costs that physical inactivity impose upon society. In Scotland, this has been recognized through the Scottish Government's Strategic Objective of a Healthier Scotland. The physical activity provided by active, healthy, and sustainable modes of transport such as walking and cycling provide wider benefits than those captured by traditional transport appraisal, and contribute to the Government's Purpose by raising healthy life expectancy, increasing the productivity of Scotland's workforce, reducing absenteeism, and increasing participation in the labour market by decreasing the number of people on incapacity benefit.

7.4.11.2 Sources of Information

Recommended sources of information are as follows:

- DETR (1999) Monitoring Local Cycle Use, TAL 01/99, January;
- DETR (2000) Monitoring Walking, TAL 06/00, June;
- World Health Organisation (WHO) (2007), Health Economic Assessment Tool (HEAT) for cycling; and
- WHO (2003), Health and development through physical activity and sport.

7.4.11.3 Methods – Strategic Level

At the strategic level, estimates of changes in the levels of walking and cycling will be able to give a fairly high-level assessment of the impact of options on physical fitness. Care should be taken when interpreting such coarse results and attempting to link them to precise endpoints. A qualitative assessment of the likely final impact on health should be carried out, in order to allow a ranking of different options.

7.4.11.4 Methods – Project Level

For appraising different options, a more detailed assessment of the scheme benefits is generally justified. Walking and cycling schemes which increase physical activity can be expected to deliver two types of benefits:

- Reduced mortality rates; and
- Reduced absenteeism rates.

Both walking and cycling schemes are typically relatively small in nature. As such, it is important that the level of resources devoted to their appraisal is proportionate to the scale of the project or the likely impact of the project.

The methodology to be employed is that set out by the Department for Transport in WebTAG Unit A5.1, and is described below.

Estimating the impact on mortality

The methodology for calculating the former is taken from the World Health Organisation project *Quantifying the health effects of cycling and walking* (2007) and its accompanying model the Health Economic Assessment Tool for cycling (HEAT). Although this approach captures only the benefits associated with reduced mortality and not those associated with reduced morbidity, these impacts will to some degree be captured by the assessment of absenteeism rates.

The HEAT methodology involves calculating the number of preventable deaths per person taking up moderate physical exercise through walking or cycling. The modeller should make use of standard values for the prevention of a fatality, giving a value to the benefits of changes in mortality as a result. As with the evaluation of accident benefits over the appraisal period, the value of a life will increase in line with real GDP growth per capita (i.e. where people are becoming more economically productive), largely offsetting the discounting effect that applies to other costs and benefits. See the NESA Manual for these values.

In 2013, a new systematic review, carried out by the World Health Organisation, on the reduced relative risk of all-cause mortality from regular cycling found that individuals that cycle for 100 minutes per week reduce their relative risk of all-cause mortality to 0.90 compared to those who do not cycle. It is intuitive that the relative reduction in all-cause mortality of walking is different to that of cycling; a maximum achievable relative risk of 0.89 for walkers (at 168 minutes per week) is recommended. The modeller should assess the impact of a proposed scheme on journey distances and also on cycling speeds if it is considered that this will be affected significantly. From this, an average journey time may be estimated for new users.

From the average journey time, a relative risk of all-cause mortality specific to the average individual using the scheme may be calculated. This may be done by a linear interpolation between 0.90 and 1 for cycling, or 0.89 and 1 for walking, if the average travel time per day is less than cited above for each mode, taking into consideration the proportion of users that make return trips along the route. Linear extrapolation can be used where average walking and cycling times are expected to be greater than cited above for each mode. For the period of the appraisal, the health benefits must be calculated each year and then discounted in the usual way.

To avoid inflated values at the upper end of the range, the risk reduction available from the HEAT is capped. The data reviewed by the World Health Organisation suggests that no significant further risk reductions were achieved after approximately 45% risk reduction for cycling (450 minutes/week) and 30% for walking (458 minutes/week).

Note that if more accurate figures for mortality from physical inactivity are available from the locality concerned, these should be used but as local values may be highly variable there is a risk of bias. Any large deviations from the average should be noted and comparisons made with the average value.

The methodology above is based upon a range of assumptions which are discussed in more detail in WebTAG Unit A5.1; however, one important assumption is that of accrual, which is discussed below.

It is accepted that there is a period where the health benefits will accrue over time until an individual is deemed "fully active" and to derive the full health benefits of their trip-making activities by active modes. Further research is required to better define this accrual period. Therefore, making the benefits instantaneous to new users will be an-overestimate, which the practitioner may address through estimating the accrual period and applying this in the appraisal calculations. A five year accrual period is recommended. A linear interpolation between 0 and 100% can be used to distribute benefits across this period.

Transport Scotland recognizes that the appraisal of the health benefits associated with walking and cycling is an area of appraisal that is still immature and for which the evidence base is still growing. Transport Scotland will continue to monitor developments in this area to ensure that this guidance represents best-practice.

Estimating the impact on absenteeism

Reductions in short term absence from work can result from the improved levels of health of those who take up physical activity as a result of a walking or cycling intervention. These benefits can be monetised and entered into the appraisal as a value in the AST Table under the physical fitness heading though it should be noted that these are business benefits rather than consumer benefits. The method suggested here is that used in TfL (2004).

In the USA, physical activity programmes involving 30 minutes of exercise a day have been shown to reduce short-term sick leave by between 6% and 32% (WHO, 2003). In the UK and Scotland the average absence of employees is 6.8 days, of which 95% is accounted for by short-term sick leave (CBI, 2003). Therefore, for each employee who takes up physical exercise for 30 minutes a day for 5 days a week as a result of a walking or cycling intervention, the annual benefit to employers is likely to be (on average) at least 0.4 days gross salary costs (6% of 95% of 6.8 days).

In order to calculate the benefits, this figure needs to be combined with the average gross salary costs and the number of affected working people. Average gross salary cost figures may be found in Section 9.5.12. This can be combined with average hours worked per day to generate a gross salary figure. 2002 market price values should be used, for consistency with other elements of the appraisal. This value should also increase over time to reflect increased wages and productivity in line with real GDP per capita.

Table 7.7: Example application to a walking scheme

Extra walkers encouraged by scheme relative to "without intervention" case	100
Gross days lost avoided (low) = 6%*95%*6.8*100	38.76
Gross days lost avoided (high) = 32%*95%*6.8*100	206.72
Average gross hourly wage of walker (Value of Time)	£24.51
Average hours worked per day (Census, Scottish average)	7.5
Average gross daily wage of walker	£183.82
Average gross employer savings (low) =38.76*£183.82	£7,124.86
Average gross employer savings (high) =206.72*183.82	£37,999.27

Regional estimates of average hours worked per day may be obtained from the Census.

The number of working people affected may be calculated from the number of new walking and cycling commuters who are expected to use the facility. These benefits should not be subject to the 'rule of a half' which is consistent with the treatment of other benefits from improved levels of health and accident costs.

Practitioners should report the benefits associated with a reduction in short-term sick leave of 6% as a scheme's core benefits. The level of benefits associated with a reduction of short-term sick leave of 32% may be reported as a sensitivity.

7.4.11.5 Appraisal Summary Table

Indicators to be used include the change in:

- Lives saved, per year and over the appraisal period;
- Lost working days avoided, per year and over the appraisal period; and
- The monetised present value of each of these changes.

Further guidance on how to report monetised values is set out in Section 12.7 – Headline indicators in STAG.

7.5 Participation and Consultation

Throughout the process it will be important to consult with statutory bodies and special interest groups who may have a responsibility and/or interest in the environmental effects of options. Under the SEA Act, Responsible Authorities must consult with Consultation Authorities at certain reporting stages in the SEA's development. They may be called upon to give information and advice during the preparation of an assessment. The main areas of expertise of statutory bodies are set out in Table 7.9. In addition to statutory bodies, non-statutory national and local interest groups, community organisations and individuals may also have an interest in the assessment of environmental effects.

The approach to each organisation may be different as some will be principally information providers, while others have statutory functions to perform or simply hold opinions on particular topics. Local knowledge may raise issues of which the statutory bodies may not be aware (e.g. presence of protected species). It is good practice to develop a consultation strategy and protocol, at an early stage in the process. This will identify the relevant parties for consultation and the appropriate method of approach

Table 7.8: Environmental Consultation Bodies

Consultation body	Area of expertise
Scottish Natural Heritage (SNH) (Consultation Authority under SEA)	Natural heritage including wildlife, landscape and earth science interests, recreation and access.
Scottish Water	Exercising water and sewerage functions and having a duty to further the conservation and enhancement of natural beauty, flora and fauna and geological and physiological features of special interest.
Scottish Environment Protection Agency (SEPA) (Consultation Authority under SEA)	Control of pollution to land, air, sea and water; conservation; waste management and flooding risk.
Health and Safety Executive (HSE)	Hazardous installations, Control of Major Accident Hazard Regulations (COMAH) sites, licensed explosives factories, magazines and ports, licensed nuclear sites.
Historic Scotland (HS) (Consultation Authority under SEA)	Built heritage, including scheduled monuments and other archaeological sites/landscapes, listed buildings and conservation areas, historic gardens and designed landscapes
Scottish Government Environment and Rural Affairs Department (SEERAD)	Air, waste and water interests, agricultural land and fisheries.
Planning authorities	Land-use planning policies and options.

It is important to note that for options requiring a SEA or EIA to be completed, there are specific reporting and consultation requirements. Further guidance is provided in the SEA toolkit.

7.6 Reporting

The environmental appraisal information in the STAG Report should include a discussion of what the likely environmental effects may be and the extent to which these effects have been investigated. The methodologies used should be described and data sources listed. Particular attention should be given to explaining the indicators and significance criteria used in evaluating the impacts. Any mitigation measures that have been developed to remove or reduce the adverse effects should be outlined.

The distribution of environmental impacts should be identified. Depending on the context, the distribution of impacts by social group and/or geographic area might be considered important.

The results of the appraisal of environmental impacts should be presented in a manner which will assist decision makers and summarised in the Part 2 AST.

In order to provide confidence about the objectivity of the assessment underlying this summary, worksheets or working papers should be prepared for each topic and summarised within the report. These should not be included within the STAG Report although it would be expected that they could be called upon for audit or enquiry purposes at a later stage.