Economic, Environmental and Social Impacts of Changes in Maintenance Spend on Local Roads in Scotland

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Economic, Environmental and Social Impacts of Changes in Maintenance Spend on Local Roads in Scotland

Transport Research Laboratory

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Contents

List of Figures

List of Tables

Executive summary

This study assessed the economic, environmental and social impacts of cuts to the roads maintenance budgets for **local roads in Scotland**. It describes the methodologies adopted, the results from the analyses and the conclusions from the investigation. This study and the associated study for the assessment of impacts of reductions in maintenance funding for trunk roads in Scotland provided evidence for the National Road Maintenance Review for Scotland initiated by the Scottish Government in 2011.

The study showed that the economic and social disbenefits to Scotland are greater than the savings in maintenance budgets. The **net effects of the reduced budgets** were decreases in economic welfare of £524m and £974m (Net Present Value at 2002 prices) for the overall maintenance funding reductions of 20% and 40% respectively.

The study examined the **economic, environmental and social effects** of reductions in the level of maintenance funding for local roads in Scotland between 2010 and 2030. In addition to a **quantitative assessment** of the impacts of reductions in maintenance funding, a literature review and a workshop with a wide range of stakeholders were used to better understand the **qualitative effects that could not be monetised**.

The **literature review** found few reports that contained quantified evidence of the consequences of reduced road maintenance funding particularly on the impacts for cycle-tracks and drainage. There was a great deal of qualitative evidence of the effect of low maintenance much of which did not fit directly with the current Scottish Transport Appraisal Guidance (STAG) criteria.

The literature review showed the user group most affected by a reduction in road maintenance would be **pedestrians**, especially those with mobility and visual impairments. Pedestrians would see the impact in terms of **noise and vibration, global air quality, visual amenity, cultural and landscape, physical fitness, accidents, security, community and comparative accessibility.**

The **qualitative analysis** identified key impacts of reduced road maintenance funding that, although not quantified, further supported the overall conclusion from the study that the wider impacts of reduced maintenance exceed the direct savings made by Local Authorities from reduced maintenance budgets. The review highlighted the links between road maintenance and other Government and local activities (e.g. cycling initiatives, links to health service costs and effects on housing and retail developments). The indirect effects of a road network in poor condition include the further deterioration of the neighbourhood and the deterrent to travel, particularly by pedestrians and those with visual and mobility impairments. Evidence was found that showed the benefits of an improved street-scene lead to higher commercial activity (and increased retail rents) and higher house prices.

Examples of studies into **customer satisfaction** by Local Authorities were used to assess the importance given to network condition by road users. Local Authority customer surveys cover the full range of services provided by Authorities but part of the results from the surveys available showed the public are aware of changes in the level of service provided by the road network and take a strong view of effects of levels of maintenance of the road network.

To quantify those impacts for Local Authorities that could be monetised, a **sample of eight Local Authorities** was selected for the detailed quantitative analysis. Sample

Authorities were chosen for four Authority types (i.e. urban, semi-urban, rural and city) and were considered representative of the whole local road network. The results from the sample Authorities were then scaled to represent the impact on the road network in all 32 Local Authorities.

The **three funding scenarios** considered in the study for the 8 sample Authorities were the same as used for the trunk road network for the 20 years analysis period. These all considered constant levels of spend through the first 10 years of the period. The first assumed the spending level in 2010/11 continued and the other scenarios assumed the 2010/11 level of funding was reduced by 20 percent and 40 percent. The first scenario assumed the constant (2010/11) funding also continued for the last 10 years of the analysis period. For the two scenarios with reduced funding, during years 10 to 15 of the analysis period, the funding was restored uniformly to the 2010/11 level and from years 15 to 20, the funding was assumed to increase by 2.5% per year. In line with the Scottish Transport Appraisal Guidance (STAG) requirements, the results of all the analyses given in this report are given in 2002 prices.

Real increases were assumed for the costs of vehicle fuel and road user time in line with standard UK guidance, costs of maintenance works and carbon emissions. The effects of discounting all future costs at the annual Treasury Test Discount Rate were considered. The study examined the **amount of maintenance undertaken** on the local road network, assuming standard national growth rates in traffic flow, and assessed the impacts of reducing the current maintenance funding in terms of changes in network condition, accident rates, vehicle operating costs, road user journey time and global (i.e. CO_2) emissions.

The change in the level of overall maintenance funding was specified for each Scenario but it was recognised that the overall reductions may not affect all aspects of maintenance equally. A **subjective assessment** was made of the likely distribution of the overall budget reductions across Local Authority maintenance activities. The results of the assessment were applied to each of the sample Authorities. This analysis showed that pavement maintenance would suffer a bigger share of the budget reduction than other maintenance areas. An investigation into the likely effects on different maintenance activities suggested the pavement maintenance budget would be reduced by 35% and 69% for reductions in the overall maintenance budgets of 20 percent and 40 percent respectively.

The future condition of the road network was predicted using the WDM pavement network model, used for similar analyses on behalf of Local Authorities in Scotland in 2010, with network data for each of the sample Authorities. For all 3 Scenarios and all sample Authorities there is a **worsening in network pavement condition** for the principal aspects of condition used in the analysis (i.e. 3m Longitudinal Profile Variance and rut depth).

The ISOHDM model, HDM-4, was used to assess the effects on **vehicle operating costs**, including vehicle depreciation, of changes in network condition resulting from the reduction in maintenance funding. Using typical UK vehicle types in HDM-4, it was estimated that in 2030 there will be an increase in undiscounted vehicle operating costs of more than £5 billion per year compared with the 2010 level, for the scenario which retains the current level of maintenance spend (i.e. Scenario 1). Bigger increases were predicted following cuts in the maintenance budget. With a 40 percent overall budget reduction, the undiscounted vehicle operating costs were predicted to be £5.3 billion per year more in 2030 than in 2010.

The effect of changing vehicle speeds as the carriageway deteriorates was assessed for A roads using the results of a brief study carried out some years ago into the effects of pavement condition on traffic speed. The **annual undiscounted costs of increased travel time**, by 2030, resulting from the worsening in pavement condition, were estimated to be £105m, £120m and £127m for the constant level of spend, 20 percent and 40 percent overall budget reduction scenarios respectively.

QUADRO analyses were used to assess the impacts on road users from changes in the number of maintenance schemes with the reduced maintenance funding. Typical schemes, based on the results of the network condition predictions, showed an increase in the **undiscounted costs of traffic delays to road users at roadworks** of £50m, £93m and £124m for the constant level of spend, 20 percent and 40 percent overall budget reduction scenarios respectively.

Maintenance operations contribute to the carbon footprint of the road network in a number of ways. This study considered the changes in levels of carbon dioxide emissions from production and use of asphalt materials, the change in the level of disruption to road users caused by road maintenance and the change in CO_2 from increased fuel consumption on rougher pavement surfaces. The analysis showed a predicted increase in the **undiscounted costs of carbon emissions** of £296m per year in 2030 if the current level of maintenance funding is retained. With the 20 percent and 40 percent cuts in maintenance funding, that increase was predicted to be further increased by £6m and £10m respectively. For all scenarios the cost of the emissions due to vehicles travelling on poorer road surfaces was predicted to contribute more than 95 per cent of the total increase.

The reductions in maintenance funding were expected to have a lesser effect on the level of funding for structures maintenance. For structures and other assets the reduction in maintenance may impact on **route security** (i.e. the level of risk of keeping a route open to road traffic and other users) caused by environmental (e.g. flood defences), safety (e.g. increased accidents), quantifiable economic issues (e.g. disrupted journeys) or social issues (e.g. community severance). The study showed evidence of the costs of repair and economic impacts of closures and failures on road networks but it was not possible to adopt a traditional cost benefit analysis methodology to predict the change in whole life economic cost of different funding scenarios.

A brief analysis of the likely effects on levels of **street lighting** following maintenance budget reductions assessed the changes in the number of night-time accidents on the road network. The analysis assumed the reductions to the lighting budgets would be smaller than the 20 percent and 40 percent reductions to the overall budget. Nevertheless, the reductions in Authority costs were expected to exceed the cost of the increased number of accidents. It was also recognised that street lighting also provides benefits of security and accessibility but these were not quantified in this study.

The outcome from the quantified analysis in this study was that with the overall deterioration in network condition the **undiscounted total non-works costs were predicted to increase** by between £1,335m and £1,390m per year by 2030 for the three funding scenarios. These showed the cumulative effect was that the undiscounted non-works costs, compared with the constant level of funding Scenario, were predicted to be £1,976m and £3,976m for the 20 percent and 40 percent overall maintenance funding reductions respectively. When discounted back to the base year, the increases were £1,212m and £2,423m for the two Scenarios respectively. Those increases exceeded the savings to Local Authorities from reduced maintenance costs over the analysis period so the net effect of reduced maintenance budgets was an increase in the total transport costs of £524m and £974m for the two Scenarios with overall maintenance funding reductions.

Condition data from Local Authority databases was used in an asset valuation model to estimate the change in value of the local road network over the analysis period for the three funding scenarios. That analysis showed that at the end of the analysis period, compared to the value when the 2010 level of spend was retained, the **reduction in the asset value** was predicted to be £118m for the 20 percent reduction in overall maintenance funding and a reduction of £234m in the undiscounted asset value with the 40 percent overall maintenance funding reduction. With the 40 percent overall maintenance funding reduction, the decrease in undiscounted asset value in 2030, compared with 2010, was predicted to be more than £960m but the decreases in asset value for the two reduced budget scenarios were less than the savings in maintenance budgets over the analysis period, compared with the constant funding scenario.

The analysis showed the different contributions made to the wider effects examined and the importance of vehicle operating costs as road network condition deteriorates. Also, for this study, to assess the effect of maintenance funding reductions, the impacts were considered for 8 sample Local Authorities and the results from that sample were scaled to represent to effect for the whole local road network. The key assumptions in these two aspects of the study were examined to **assess the sensitivity** of the overall results to assumptions made. The results of the sensitivity tests did not change the overall conclusions from the study but did show the potential for variability in the results from the analyses.

1 Introduction

This study was commissioned on behalf of the Wider Economic Issues, Impacts, Costs and Benefits Working Group, as part of the National Road Maintenance Review for Scotland, to carry out an analysis of the Scottish Local Authority road network. The purpose of the analysis was to determine the economic, environmental and social impacts of 3 different road maintenance budget scenarios over a 20 year analysis period. The analysis included assessment of vehicle operating costs, user costs, emissions costs and a range of wider factors aligned with the Scottish Transport Appraisal Guidance (STAG) criteria (Transport Scotland, 2011a).

The analysis used projected road pavement (i.e. carriageway) network condition data from 8 sample Local Authorities, chosen to be representative of the different types of Local Authority in Scotland. The study also included a literature review, focused on determining the wider socio-economic impacts of changes in the road transport service provision (e.g. the forced closure of a bridge) which may be an increased risk with reduced maintenance budgets.

1.1 Context

Scotland’s road network, at approximately 56,000km, is the largest and most valuable community asset in Scotland of which 52,000km are the responsibility of Local Authorities. It plays a vital role in supporting Scotland’s economy, facilitating the movement of people, goods and services throughout the country and connecting people with economic and social opportunities.

The Audit Scotland Report – Maintaining Scotland’s Roads (Audit Scotland, 2011) highlighted that the overall maintenance backlog on Scotland's roads is £2.25 billion. Of this, £1.54 billion relates to the maintenance backlog on Local Authority roads and £0.713 billion relates to trunk roads, including bridges. The report included a central recommendation for the Scottish Government to take forward a national review of “how the road network is managed and maintained, with a view to stimulating service redesign and increasing the pace of examining the potential for shared services.”

The Government accepted the central recommendations in the report and announced on 25 February 2011 that a national Road Maintenance Review would be undertaken looking at how the road network in Scotland is managed and maintained.

The Review was taken forward by Transport Scotland in partnership with the Convention of Scottish Local Authorities (CoSLA), the Society of Local Authority Chief Executives (SOLACE), Society of Chief Officers of Transportation in Scotland (SCOTS) and the Scottish Road Works Commissioner under the guidance of a Steering Group. The Review commenced in March 2011 with a timetable to report to Ministers and Council Leaders in early autumn 2011 in time to inform a Road Maintenance Summit. The Summit was held on 2nd November 2011.

The Steering Group is supported by four Working Groups drawn from Steering Group member organisations as well as invited stakeholders. This study and associated reports has been commissioned by Transport Scotland on behalf of the Wider Economic Issues, Impacts, Costs and Benefits Working Group (WG4). This Working Group monitored and assessed the work in this study as it progressed.

1.2 Study for the trunk road network

Transport Scotland commissioned an associated study on the economic, environmental and society effects of different levels of maintenance funding for the Transport Scotland trunk road network. The aim of the study was to investigate the effects of changes in road maintenance funding between 2010 and 2020 and used three scenarios to examine different levels of maintenance funding:

- Scenario 1 (Base case): Constant annual level of spend (2010/11 funding level continues) for 20 years
- Scenario 2: Reduction in the annual spend in Scenario 1 by 20% (starting 2010/11) for the first 10 years. Return the annual spend to current 2010/11 levels using annual uniform increases, between 2020 and 2025. From 2026, increase annual funding by 2.5% per year
- Scenario 3: Reduction in the annual spend in Scenario 1 by 40% (starting 2010/11) for the first 10 years. Return the maintenance budget to current 2010/11 levels using annual uniform increases, between 2020 and 2025. From 2026, increase annual funding by 2.5% per year

The study reviewed the current internationally available evidence, analysed potential changes in the amount of maintenance that would be undertaken on the trunk road network and where possible estimated the monetised costs and benefits arising from:

- Changes in Transport Scotland maintenance budget;
- Changes in accident rates;
- Vehicle operating costs and depreciation;
- Changes in journey time;
- Global (i.e. CO_2) emissions; and
- Customer satisfaction.

A full technical report has been provided in 2011 (Transport Scotland, 2011b).

1.3 Study for the local road network

The Working Group (WG4) considered the trunk road study when collating evidence for the Review and identified the following work to feed into the Review:

- A study similar to that completed for the trunk road network in Scotland for the local road network, considering similar scenarios to the earlier trunk road study;
- Consideration of evidence for the full range of issues (qualitative or quantitative as appropriate) that might be applicable to local roads under the different funding scenarios; and
- Exploration of the sensitivity of the results of the analyses for local and trunk roads for those variables seen to have a key impact on the results of the changes in maintenance funding.

This report addresses all of these issues and provides detailed background on the analyses and review that has been undertaken. A Summary Report (Transport Scotland, 2011c) (Transport Scotland, 2011c) combines the results from this report and the trunk road study to provide an overview of the impact for the entire Scottish road network.

For the 20 year analysis period, the scenarios considered were:

- Scenario 1 (Base case): Constant annual level of spend (2010/11[1] funding level continues) for 20 years
- Scenario 2: Reduction in the annual spend in Scenario 1 by 20% (starting 2010/11) for the first 10 years. Return the annual spend to current 2010/11 levels using annual uniform increases, between 2020 and 2025. From 2026, increase annual funding by 2.5% per year
- Scenario 3: Reduction in the annual spend in Scenario 1 by 40% (starting 2010/11) for the first 10 years. Return the maintenance budget to current 2010/11 levels using annual uniform increases, between 2020 and 2025. From 2026, increase annual funding by 2.5% per year

In line with the Scottish Transport Appraisal Guidance (STAG) (Transport Scotland, 2011a) (Transport Scotland, 2011a) requirements, the results of all the analyses given in this report are given in 2002 prices to enable comparison with different studies over time.

1.4 Layout of report

The report describes the separate activities in the study and the conclusions drawn. The main body of the report includes descriptions of the analysis methodology, an overview of Scotland's local road network and sample results of the analysis using data for one Local Authority. The main body of the report also includes discussion of the broader impacts and qualitative assessments of the different budget scenarios and culminates with conclusions and recommendations based on the results of the analysis.

The results of the analyses were derived for each year of the analysis period. To aid the clarity of presentation the results have generally been shown graphically as points with a line joining the points for each Scenario.

The results of the literature review are reported in Section 3 with a bibliography in Section 16 and more detailed information provided in Appendix A and Appendix B.

Section 4 describes the local road network in Scotland and provides key data that forms the basis of the analyses up to 2030.

The methodology and results for refining the funding scenarios are described in Section 5. Sections 6 to 10 describe the methodologies and results of each effect and impact that has been studied and, where relevant, notes whether the analysis has been based on a sample of Authorities or the full network.

Section 12 describes how the sample analyses have been scaled up to estimate the full network impact.

Section 13 examines the effects on depreciation of the road network asset value for each of the funding scenarios.

[1] At the time of undertaking the study, 2010/11 budgets had not been finalised. Refer to Appendix A.10 for further details.

Section 14 reviews the analyses undertaken and summarises both the qualitative and quantitative impacts that have been identified. The impacts are described in terms of the STAG criteria for transport project appraisals.

Section 15 provides the conclusions and recommendations from the qualitative and quantitative analyses.

Appendices are provided for each Section containing more detailed information, as appropriate, for more detailed descriptions of the analysis methodologies adopted and results from all the analyses as well as further information on the literature review and the key assumptions and data used in the analyses.

2 Methodology

The analyses were intended to provide an indication of the magnitude of the impacts due to potential reductions in maintenance spending. As with any such strategic study of network level impacts, key assumptions had to be made to account for the extent of data and resources available. The analyses have been carried out in accordance with the Scottish Transport Appraisal Guidance (STAG) (Transport Scotland, 2011a) (Transport Scotland, 2011a) and where relevant the UK Department for Transport, Transport Appraisal webTAG Guidance (Department for Transport, 2011a). Where this has not been possible, the report notes the assumptions that have been adopted.

A comprehensive literature review was conducted to identify as much relevant available evidence as possible. The review also took account of various published or unpublished evidence supplied by WG4 members. The review enabled a qualitative analysis to be completed which identified the potential impacts of the funding scenarios.

2.1 Local Authority road networks

For the quantitative analyses, two initial steps were needed before undertaking a detailed assessment of the impacts of the funding reductions:

- The scenarios are broadly defined (i.e. a base case assuming current funding levels and two alternatives assuming 20% and 40% reductions), but they do not describe the practical implications on changes in actual road maintenance activity. For example, for the 20% reduction in funding, a Local Authority might choose to maintain its current expenditure on street lighting and winter maintenance, but make more significant cuts (i.e. greater than 20%) to the carriageway surfacing budget, to achieve an overall 20% reduction.
- To assess many of the impacts, it was not feasible to conduct the same analysis for each of the 32 Local Authorities. Instead, a sample of Authorities was, therefore, selected for detailed analysis. These Authorities were considered reasonably representative of the whole local road network. The results from the sample Authorities could then be scaled to represent the impact on all the local road network.

The network varies from remote rural roads to major city networks. SCOTS has adopted a referencing approach which classifies each Local Authority network into one of five categories (city, urban, semi-urban, rural and island). For most of the analyses described in later Sections, eight Local Authorities have been analysed in detail:

- City – Glasgow City
- City – City of Edinburgh
- Rural – Aberdeenshire
- Rural - Highland
- Rural – Dumfries and Galloway
- Semi-urban – Fife
- Semi-urban – South Ayrshire
- Urban – North Lanarkshire

The full list of 32 Authorities and the associated categories is given in Appendix D. For the scaling of the sample results to the full network, Island Authorities have been considered as rural Authorities where necessary. Results for individual Authorities, excluding the 8 sample Authorities, are not provided. Authorities are identified only by the Authority category.

To examine the effects on different types of Authority, the sample Authorities were selected to include rural, urban, semi-urban and city Authorities. Within each Authority, where appropriate, the network was analysed by road class (A, B, C and U) and urban/rural.

To assess the impacts related to traffic, the vehicles have been considered in terms of cars, light goods vehicles (LGVs), buses and heavy goods vehicles (HGVs).

All analyses have taken into account the expected growth in the level of traffic through the analysis period, changes in economic parameters (e.g. values of time and accidents) and improvements in engine efficiency for vehicle operating costs.

For the analyses, the maintenance budget assumed for 2010/11 for each of the Local Authorities was that agreed for the Spending Review 2010 analyses of maintenance funding. The budgets are given in Appendix C.

In practice, since the 2010/11 budgets were set, these have been reduced so the effects of reduced budgets are already being seen. This study has been restricted to examining the effects of the reductions to the Spending Review 2010 budgets.

2.2 Network condition analyses

To assess the effect of the funding levels in each of the sample Local Authorities, WDM Ltd was contracted to run the road condition prediction model to predict the condition of each road type in each Authority (the analyses were run separately for each Authority and each Scenario). The model uses data for 2009/10 collected from SCANNER surface condition surveys to predict the condition of the network in each year of the analysis period (i.e. between 2010/11 and 2029/30) using the appropriate budget in each year. To limit the volume of results produced from these analyses, the outputs from the condition predictions only for the years 2010, 2013, 2017, 2020, 2025 and 2030 were stored at the end of the analyses. The results included:

- Predicted carriageway condition parameters including longitudinal profile variance for each 10m carriageway length in an asset database for the 8 Authorities
- Treatment types, lengths and areas for each of the time intervals used in the model (i.e. 2010 to 2012, 2013 to 2016, 2017 to 2019, 2020 to 2024 and 2025 to 2029).

To obtain the annual values for the results, the results for each time step (e.g. between 2010 and 2013) were divided equally between the years in the time-step. This can lead to apparent jumps in the results between time steps but was considered sufficiently reliable for overall network analyses of this type.

Using a separate asset valuation, condition analysis model, WDM also produced estimates of the cumulative depreciation for each road type in each sample Authority.

Both the condition prediction model and the valuation model have been used for Local Authorities in Scotland for several years. It was agreed that this study would take the results from the runs of the models and not be concerned with changing the analysis method, input data or results produced.

The predicted condition for each of the road types in the sample Authorities when combined with other data (e.g. traffic) formed the basis of the further analysis of the wider economic costs and benefits (e.g. vehicle operating costs).

3 Evidence of the Impacts of Reductions in Road Maintenance

3.1 Overview

A literature review has been completed to underpin the quantitative analyses and is described in the report for the trunk roads study (Transport Scotland, 2011b) (Transport Scotland, 2011b). Specifically, the impacts investigated included:

- Travel time impacts due to roadworks and deteriorating road conditions
- Accident costs due to deteriorating road conditions and reduced lighting
- Vehicle operating costs due to deteriorating road conditions
- CO_2 emissions associated with the above impacts

For this study for local roads, a further literature review has been undertaken to focus on the wider associated impacts of potential reductions in maintenance expenditure. The review has been undertaken also to consider any specific issues related to a local (non-trunk) road context. For example, road maintenance cuts may have a more significant impact on pedestrians and local communities in an urban Local Authority context. The review focused on the following impacts as defined by STAG:

- Environmental
  - Noise and vibration
  - Global and local air quality
  - Biodiversity
  - Visual amenity
  - Cultural
  - Landscape
  - Physical fitness
- Safety
  - Accidents including vehicle accidents directly related to road condition
  - Security
- Economy (transport economic efficiency)
  - Vehicle operating costs, including those already captured quantitatively
- Integration
  - Policy integration
- Accessibility and social inclusion
  - Community accessibility
  - Comparative accessibility

The report also identifies other impacts of maintenance funding which were uncovered as part of the review and which were considered as part of a workshop, organised by the Wider Economic Issues Working Group as part of the National Road Maintenance Review for Scotland, held during the study. The workshop identified impacts on the consequences of maintenance which could not currently be quantified. The outcome from the workshop has been recorded in Appendix M.

3.2 Results of the review

3.2.1 Relevance and value

The literature searches produced a total of 131 documents (32 from the Working Group) covering findings from mostly the UK and Europe. Of the 131 documents, 66 have been assessed as relevant (see Appendix B for more details on the literature screening).

3.2.2 Coverage

The evidence was assessed against a coverage matrix of impacts (from the STAG criteria) and activities or assets associated with road maintenance on which this aspect of the study focused. The coverage matrix is given in Table 3.1.

Table 3.1 Document relevance and coverage matrix

Activity/ Assets		Impacts											
		Environment							*Safety*		*Economy (transport economic efficiency)*	*Accessibility and social inclusion*	
		Noise and vibration	*Global air quality*	*Biodiversity*	*Visual amenity*	*Cultural*	*Landscape*	*Physical fitness*	*Accidents*	*Security*	*Vehicle operating cost*	*Community accessibility*	*Comparative accessibility*
		1	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*	*11*	*12*
A	*Pavement*	A1	A2	A3	A4	A5	A6	A7	A8	A9	A10	A11	A12
B	*Structures*	B1	B2	B3	B4	B5	B6	B7	B8	B9	B10	B11	B12
C	*Footway*	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11	C12
D	*Cycleway*	D1	D2	D3	D4	D5	D6	D7	D8	D9	D10	D11	D12
E	*Lighting*	E1	E2	E3	E4	E5	E6	E7	E8	E9	E10	E11	E12
F	*Drainage*	F1	F2	F3	F4	F5	F6	F7	F8	F9	F10	F11	F12
G	*Pedestrians*	G1	G2	G3	G4	G5	G6	G7	G8	G9	G10	G11	G12
H	*Cyclists*	H1	H2	H3	H4	H5	H6	H7	H8	H9	H10	H11	H12
J	*Street cleaning*	J1	J2	J3	J4	J5	J6	J7	J8	J9	J10	J11	J12

Notes: Number of references (≥5) — Number of references (2 to 4) — Number of references (1) — White cell = no reference

3.2.3 Conclusions

There is a considerable amount of published material on the various potential benefits and impacts of transport investment. However, when the search is narrowed to the more specific impacts of road maintenance and potential funding scenarios, there is much less literature available. In particular, availability of any quantified evidence is extremely limited. Of 66 documents that were classified as relevant, only 12 contained direct evidence about the economic and social impacts of shortfalls in road maintenance.

The key evidence has been collated from the review and categorised according the STAG criteria as shown in Appendix B. This shows where the key gaps are terms of the areas noted in Table 3.1. It was also noted that benefits were identified that do not fit the current STAG criteria (e.g. changes in retail activity and increases in house prices). The following summary conclusions have been drawn:

- The coverage of the relevant papers is concentrated around the safety, economic and accessibility and social inclusion impacts. There is little evidence in the literature of the environmental impacts of the reduction in maintenance
- Based on the literature review, it could be concluded that the user group most affected by a reduction in road maintenance would be pedestrians, especially those with mobility and visual impairments. Pedestrians would be affected in many aspects including noise and vibration, global air quality, visual amenity, cultural and landscape, physical fitness, accidents, security, community and comparative accessibility.
- There is a lack of quantified evidence in the literature on the impacts for cycle-tracks and drainage
- Road maintenance supports other Government initiatives (e.g. Cycling Action Plan for Scotland (Scottish Government, 2010a))
- Reviewing the information by asset types such as carriageway, structures, footways and cycle-tracks, the evidence shows that the impacts are mainly related to safety, economy and accessibility and social inclusion.
- Lighting provides benefits from reduced crime and improved mobility.
- There have been initiatives to reduce long-term costs of maintenance by innovative funding arrangements (e.g. using health service budgets for winter maintenance of footways) and by work planning (e.g. coordination of maintenance and utilities works) to reduce the number of future interventions at the same site. These are examples of preventive spend which aim to reduce longer term costs which is in line with the Christie Commission (Scottish Government, 2011) principles.
- Evidence has shown improved street-scene leads to higher commercial activity (and increased retail rents) and higher house prices (e.g. increases of approximately 5% in attractive areas).

The following Sections of the report describe the specific analyses and reviews of the Scottish local road context undertaken during this study. Key issues from the literature review and the analyses have been drawn together into the overall study conclusions in Section 14.

4 Local Road Network in Scotland

4.1 Extent and nature of network

Table 4.1 shows the length of the local road network in Scotland as used for the analyses.

Table 4.1 Scottish local roads network length

Local Authority Road Class	Network length (Carriageway km)
A Class roads	7,611
B Class roads	7,486
C Class roads	10,619
Unclassified roads	25,907
Total	**51,623**

Source: RCI condition reports

The Scottish local road network[2] carries less than 65% of all traffic and less than 40% of all Heavy Goods Vehicle (HGV) traffic in Scotland, whilst being more than 90% of the total length of the Scottish road network.

4.2 Amount of travel

The most recent traffic data for Local Authority roads in Scotland (for 2009) was obtained from Scottish Transport Statistics[2] and used to derive the total distance travelled on the network, summarised by road type, used in this study (shown in Appendix C). Table 4.2 shows the 2010 levels of traffic on local roads in Scotland[2]. For the 20 years represented in this study (2010 - 2030) traffic growth rates from the National Road Traffic Forecasts (NRTF) have been used. These growth rates (shown in Appendix C) are for each vehicle type (Cars, Light Goods Vehicles, Heavy Goods Vehicles and Buses) and vary through the 20 years analysis period.

For the economic analysis the traffic count for heavy vehicles has been assumed to be for articulated commercial vehicles.

4.3 Accident trends

Accident data was extracted from the STATS19 database for the period 2005 to 2009 was extracted. The data in STATS19 is populated from police reports taken at the scene of road accidents. From 2005 the data has included contributory factors for each accident recorded in the database. This data has been analysed to determine the number of accidents on the Scottish Local Authority road network, resulting in death or serious injury, by contributory factors that may be influenced by changes in road maintenance spend. The results of this analysis are shown in Figure 4.1. Note that

[2] Further details on the road network are available at http://www.transportscotland.gov.uk/strategy-and-research/publications-and-consultations/j205779-00.htm

accidents can have more than one contributory factor associated with them so this data should not be aggregated to determine the total number of accidents in any given year.

The data shows that the single largest contributory factor to serious and fatal injuries is slippery road conditions (due to weather), with deposits on the road being the second largest and a poor or defective road surface being the third largest contributory factor.

Table 4.2 Traffic on Scottish local roads by vehicle type (2010)

Road Type	Traffic (Million vehicle kilometres)					
	Cars	2 wheel motor vehicles	Buses	Light Goods Vehicles (LGV)	Heavy Goods Vehicles (HGV)	All motor vehicles
Major local roads						
Non-trunk A roads – urban[1]	3,722	19	96	509	153	4,499
Non-trunk A roads – rural[1]	6,033	65	107	1,080	450	7,735
All major local roads	**9,755**	**84**	**203**	**1,589**	**603**	**12,234**
Minor roads (B, C and Unclassified)						
Urban roads[1]	6,400	59	215	1,054	126	7,854
Rural roads[1]	5,193	50	82	1,352	207	6,884
All minor local roads	**11,593**	**109**	**297**	**2,406**	**333**	**14,738**
All roads						
Urban roads[1]	10,122	78	311	1,563	279	12,353
Rural roads[1]	11,226	115	189	2,432	657	14,619
All local roads	**21,348**	**193**	**500**	**3,995**	**936**	**26,972**

Note: 1. Source: Scottish Transport Statistics.
Scottish Transport Statistics uses the Department for Transport classification of urban and rural roads which is based on population. The classification used here is based on built up/non-built up areas.

Similarly the data for fatal accidents on the Scottish Local Authority road network was investigated to determine the number of accidents by the prevailing lighting conditions. This data is shown in Figure 4.2. Note that most accidents occur during daylight hours, since traffic flows are higher compared to night time.

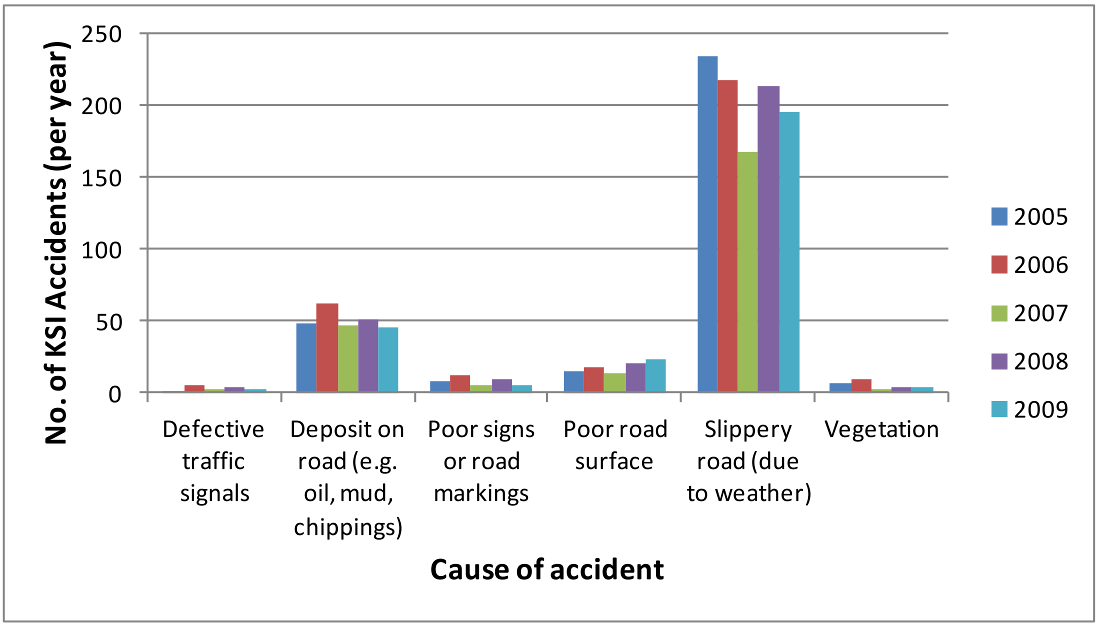

Figure 4.1 Accidents causing death or serious injury by contributory factor

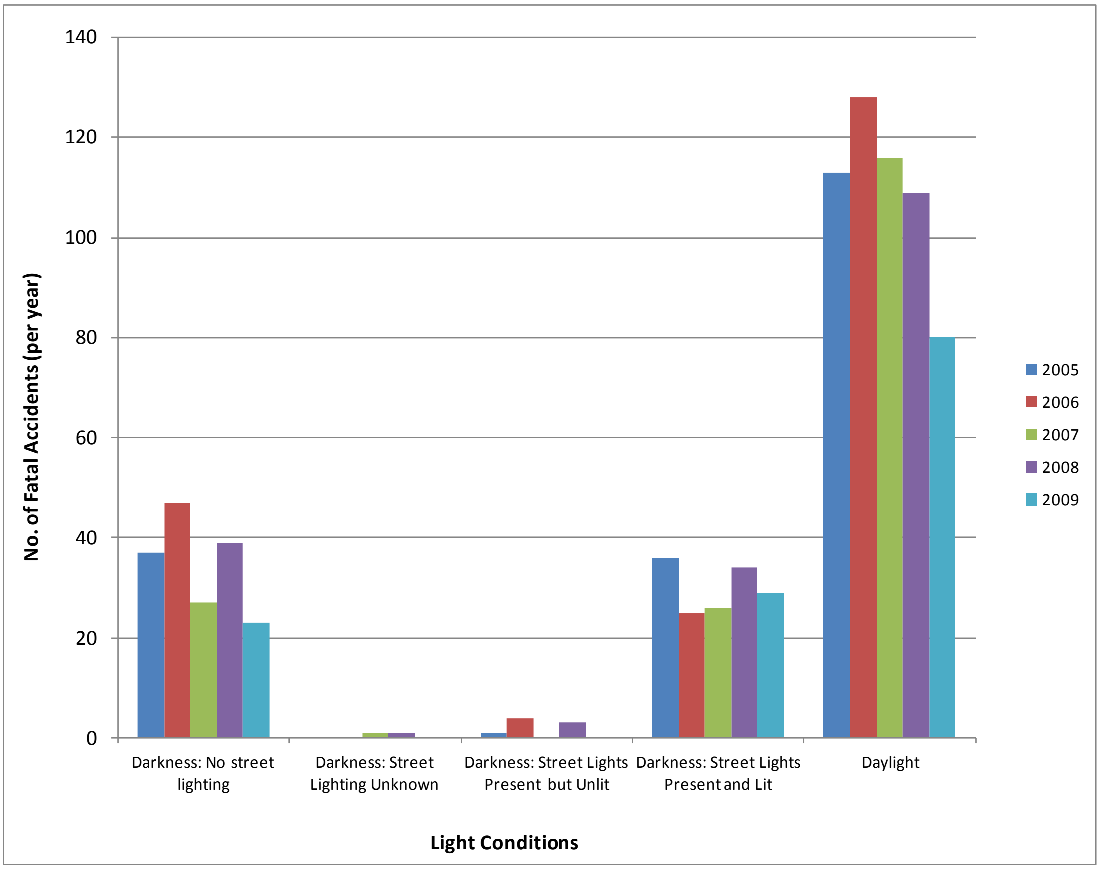

Figure 4.2 Numbers of fatal accidents by lighting levels

4.4 Budgets

The most recent expenditure data available for this study is the 2009/10 outturn costs (Audit Scotland, 2011). Table 4.3 shows the costs for all local roads and Appendix C shows the results for the 8 Local Authorities considered in the detailed analysis in this study.

Table 4.3 Expenditure on local roads in Scotland (2009/10)

Item	Cost (£m)
Capital	
Traffic Calming	2,987
Road Safety	8,521
New Road Schemes	11,757
Lighting	20,629
Structural Maintenance	109,906
Other	34,477
Total capital	**188,277**
Revenue	
Road Construction	1,370
Structural Maintenance	65,432
Environmental Maintenance	13,950
Winter Maintenance	92,261
Lighting	53,449
Safety Maintenance and Emergency Patching	33,880
Routine repairs	42,895
Total revenue	**303,236**
TOTAL	**491,513**

Key points made by Audit Scotland (Audit Scotland, 2011) are:

- The figures translate to an average cost per kilometre of £9,400. This compares with an average cost per kilometre on the Scottish trunk road network of £47,500.
- Road maintenance expenditure has increased by £54m since 2005, taking account of general inflation. However, when the higher specific rates of road construction inflation are considered, road maintenance expenditure on local roads has fallen by £76m.

- Structural maintenance might be funded from capital or revenue expenditure. There has been a trend towards it being funded from capital expenditure in recent years.
- Different Authorities adopt different cost accounting systems to define activities and record costs. For example, costs for repairs to structures might be captured in structural maintenance (capital or revenue) or 'other' in Table 4.3.

4.5 Network condition

The Scottish Road Maintenance Condition Survey (SRMCS) is a survey of the local roads in Scotland (SCOTS, 2010). The machine-based (SCANNER) surveys measure the surface condition in terms of:

- Rutting (average of near-side and off-side wheelpaths)
- Roughness (Longitudinal Profile Variance – 3m and 10m wavelengths)
- Texture (near-side wheelpath)
- Whole carriageway cracking

These condition measurements are combined into a Road Condition Index (RCI) and the RCI values are assigned to show poor ('Red') condition, in need of investigation ('Amber') condition and good ('Green') condition. Figure 4.3 and Figure 4.4 summarise the condition of local roads in Scotland in 2009.

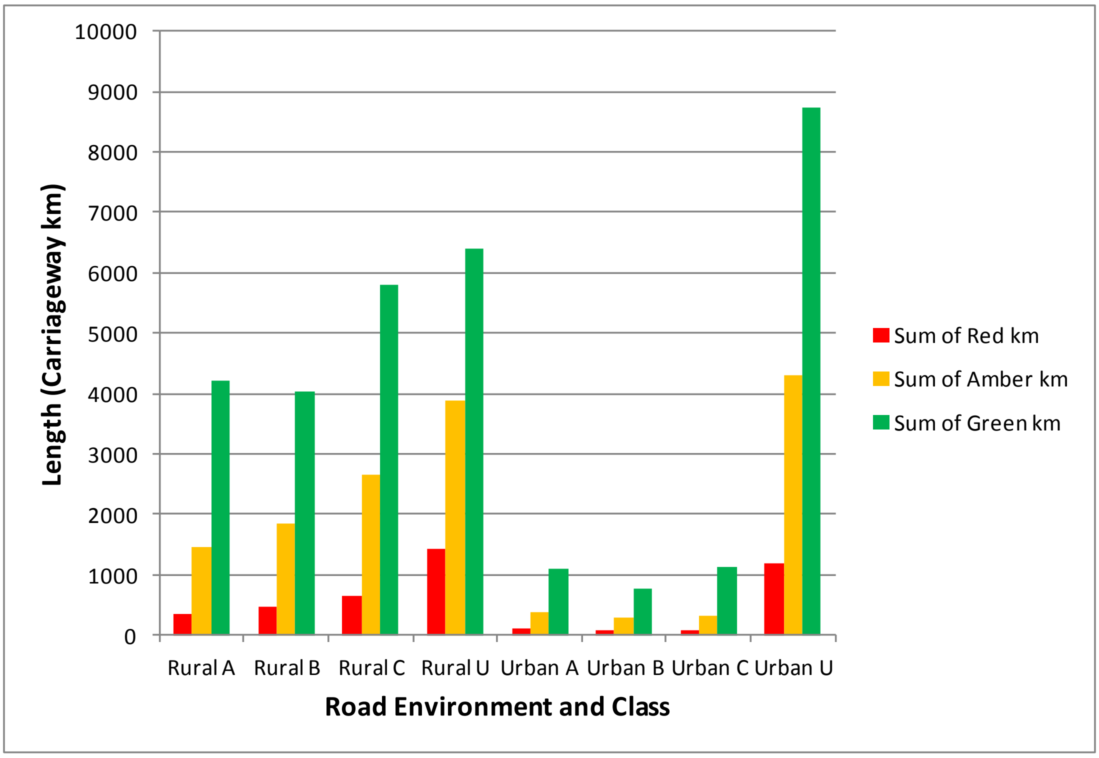

Figure 4.3 RCI by road length for Scottish local roads (2009)

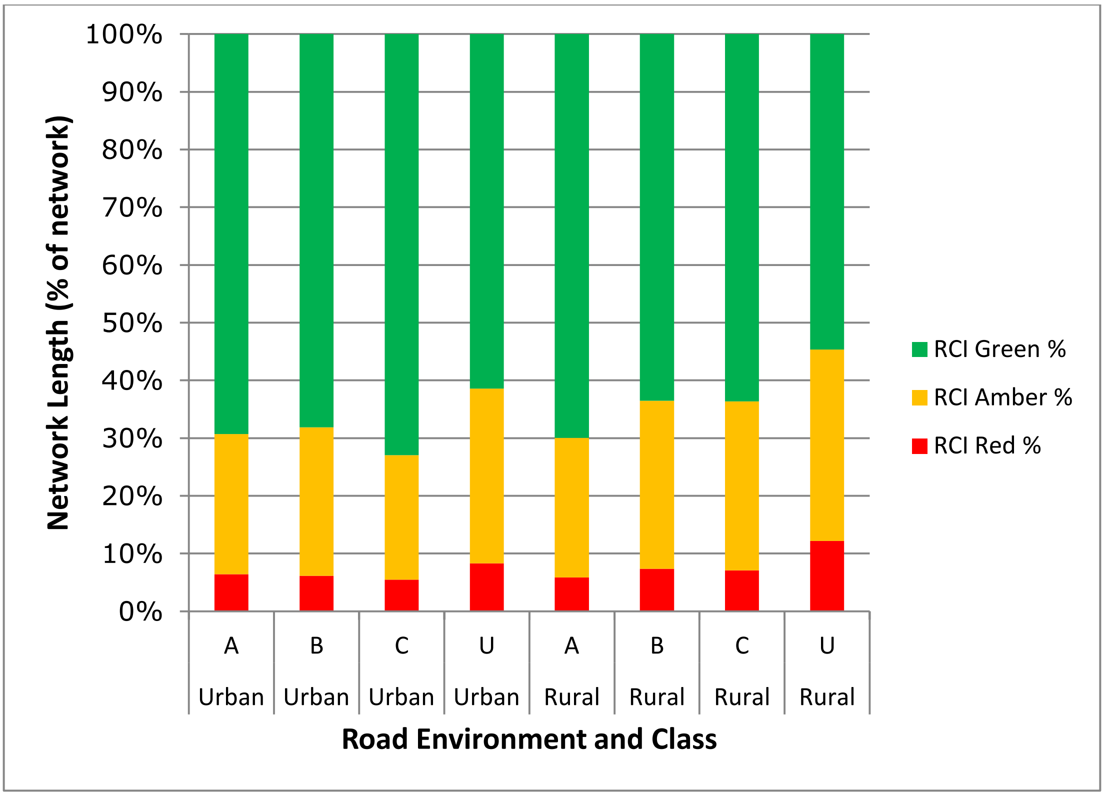

Figure 4.4 RCI by network percentage for Scottish local roads (2009)

5 Funding Scenarios

5.1 Budgets

Section 1.3 defined the funding scenarios considered in this study. Scenario 1 represents continuation of the 2010/11 maintenance funding for all of the 20 years analysis period, Scenarios 2 and 3 represent budget reductions for 10 years followed by restoration of the budgets to the 2010/11 level over 5 years in equal annual steps. For these 2 scenarios there is an annual 2.5 percent increase in the budgets for the last 5 years of the period. These are illustrated in Figure 5.1.

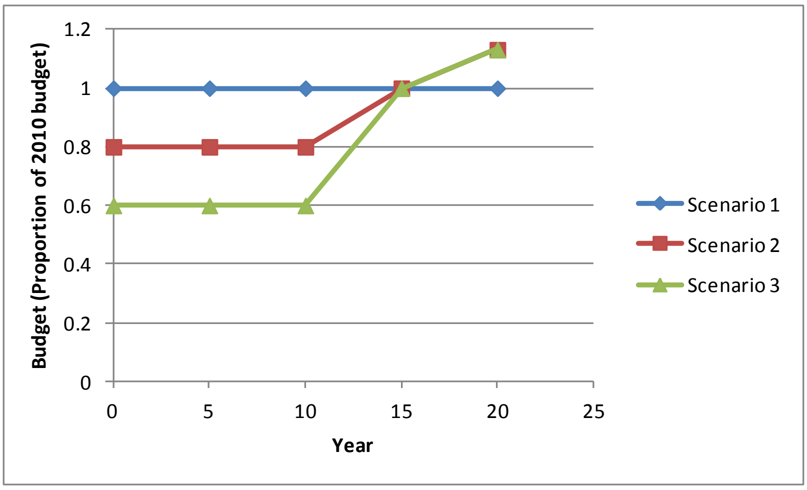

Figure 5.1 Scenario budgets

The effect of Scenario 3 is to suffer a bigger cut in maintenance budget for 10 years and therefore, in the following 5 years, to have a higher rate of funding increase than Scenario 2, so the budget is restored to the 2010/11 level in year 15 for both Scenarios 2 and 3. The annual budgets for Scenarios 2 and 3 in the last 5 years of the analysis period are the same but the network condition is different because of the pattern of funding in the first 10 years.

Over the first 10 years the effect was more deterioration in network condition with Scenario 3 than with Scenario 2. Although the rate of increase in budget was higher in the next 5 years, the budget was still lower with Scenario 3 than with the other scenarios and network condition remains worse for Scenario 3 than Scenario 1 or 2 in year 15 (i.e. 2025).

5.2 Applying funding constraints in practice

A road Local Authority has to consider numerous aspects when considering how to apply budget cuts across its range of activities. As well as any overall strategic aims, consideration also needs to be given to legislative requirements, contractual obligations and the need to react to unforeseen circumstances. It is not possible to account for all such issues in a study of this type and scope, and given the focus on long term impacts, the approach adopted in the study has been to apply spending reductions in a way which will minimise the impact on typical long term aims of a road Local Authority.

The nature and extent of the economic impact of reductions in the total maintenance budget depend on how the funding reduction is allocated across the various maintenance activities. Each activity has a different focus in terms of its relative contribution to overall corporate objectives and economic impacts. For example, the objective of maintaining directional road signs is primarily to enable reliable and predictable travel for the road user, whereas the objective of maintaining road barriers is to enable safe travel for road users, including pedestrians.

Identifying how best to minimise the impacts of road maintenance budget reductions requires a view on the relative importance of each of the various objectives and the contribution made to those objectives by the different maintenance activities.

For the trunk road study, use was made of the Transport Scotland Road Asset Management Plan (RAMP) to identify the key objectives which drive road maintenance activities (Transport Scotland, 2007). The corporate objectives are stated in the form of a number of asset management drivers: *safety*, *accessibility*, *reliability*, *condition*, *sustainability*, *value for money* and *customer care*. Whilst each local road Local Authority will have different specific local needs, it is reasonable to assume that the objectives of each Local Authority can broadly be described in terms of the six objectives in the RAMP. In order to achieve consistency for the trunk road and local road analyses, it was therefore decided to make use of the same six objectives in the analysis for local roads.

For each funding Scenario, the revised budget was allocated across the different activities, depending on the contribution to the asset management drivers:

- For each activity in the road maintenance budget, a subjective assessment was made of which driver(s) the activity contributes towards, and the relative balance of the contribution. For example, it was assumed that the safety maintenance and emergency patching activity is carried out 90% for *safety* and 10% for *customer care*;
- The activity spend was proportioned by each of the drivers. In the above example, 90% of the current safety maintenance and emergency patching budget would be allocated to *safety* and 10% would be allocated to *customer care*;
- After allocations to the activities, the total current budget was shown as a summation of notional allocations to each of the asset management drivers;
- For each scenario, the notional allocations were reduced based on their perceived relative priority. For example, for Scenario 2 (a 20% overall budget cut), 13% of the reduction is attributed to the *condition* driver notional allocation, 2% to the *sustainability* driver notional allocation and 5% to the *customer care* notional allocation;
- The proportional reduction required from the notional allocation for each driver was assessed. For example, the 13% of the overall budget being taken out of the *condition* driver represents a significantly higher proportional reduction on the condition driver allocation in itself (in this case, the proportion is 15/28 or 54% - see Table 5.1);
- Reductions were then apportioned through each activity and the new budgets available for each activity determined for the reduced budget.

In reality, as the effect of spending cuts is realised over time, a Local Authority might adjust its strategy for managing its allocation. For example, it may choose to invest spending in a number of customer care focused activities after a long period of reduced spending on such work, at the expense of another corporate driver. However, this effect has not been considered and the proportioning of spending reductions across different notional allocations has been assumed consistent over time.

5.3 Predicted activities under different scenarios

The allocations derived for Scenario 1 (current expenditure) and Scenarios 2 and 3 for reduced funding across all local roads are shown in Table 5.1.

Table 5.1 Scenario allocations by asset management driver

	Contribution to overall budget by asset management driver						
Scenario	**Safety**	**Access**	**Reliability**	**Condition**	**Sustainability**	**Customer care**	**Total**
Scenario 1	32%	7%	10%	28%	9%	15%	100%
Scenario 2	32%	7%	10%	16%	6%	9%	80%
Scenario 3	32%	7%	10%	4%	4%	4%	60%

Note: The value for money driver was excluded from the analysis as it was assumed this would apply equally across all activities.

The rationale for the above reductions was that:

- *Safety*, *accessibility* and *reliability* are all primary impacts that would be protected from cuts as long as possible
- Minimising long term whole of life costs (through the *condition* and *sustainability* objectives) and softer *customer care* outcomes (e.g. appearance of the network maintained by landscaping or graffiti removal) would be sacrificed first in order to maintain the funding for the primary impacts
- In practice, no driver would receive no funding so a minimum apportionment (4%) was used if necessary.

The process provided more immediate clarity on where the real impacts would occur when budget reductions are applied (see Table 5.2). The analysis fits with experience of how a Local Authority might be forced to reduce activity, in that:

- As budgets reduce, capital expenditure is reduced by a greater extent compared to revenue expenditure. This reflects the need to prioritise operations for the users before considering longer term capital outlay
- Activity focused on safety is most protected

- Winter operations are targeted as a key priority
- Experience of most Local Authorities is that when faced with budget cuts, spend on carriageway maintenance is where most of the reduction inevitably has to be focused.

The process was applied to the total local road budget, and also to each of the 8 individual sample Local Authorities considered in this study. Further details are included in Appendix E. The results for each Authority varied. For example, in the case of Scenario 3 (40% reduction), structural maintenance reductions varied between 58% and 63%[3].

The analysis was based on one budget year only and when disaggregated to each individual Authority, in some cases this resulted in relatively small budgets. At such levels, it was expected that there might be considerable year to year variation in specific budget heads. As the purpose of the study was to assess long term impacts it was possible to undertake the overall local road analysis for all of the 8 sample Authorities applying the same results of the subjective analysis to each Authority.

For this study, it was assumed a 20 percent reduction in the overall maintenance budget would result in a 35 percent reduction in the pavement maintenance budget (Scenario 2) and a 40 percent reduction in the overall maintenance budget (Scenario 3) would result in a 69[4] percent reduction in the pavement maintenance budget. The same budget reductions were assumed for all the Local Authorities in this study.

[3] This result shows that other Authorities which are not included in the study sample of 8 Authorities would show some reductions for structural maintenance in excess of the 69% derived for all local roads.

[4] Note that structural maintenance might include carriageway and non-carriageway work. Non-carriageway structural maintenance is probably considered higher priority (safety impacts) and so proportional spend on carriageway structural maintenance might be reduced even further than these figures.

Table 5.2 Budget reductions based on asset management drivers

Budget Head	Activity spend as % of current activity spend	
	Scenario 2: Overall 20% cut	Scenario 3: Overall 40% cut
Capital	**75**	**50**
Traffic Calming	96	92
Road Safety	96	92
New Road Schemes	89	77
Lighting	92	85
Structural Maintenance	65	31
Other	81	63
Revenue	**83**	**66**
Road Construction	89	77
Structural Maintenance	65	31
Environmental Maintenance	73	47
Winter Maintenance	96	92
Lighting	89	77
Safety Maintenance and Emergency Patching	96	92
Routine Repairs	67	33
Total Overall Budget (%)	**80**	**60**

6 Impacts of Carriageway Conditions

6.1 Overview of methodology

This Section provides an overview of the methodologies adopted for evaluating the economic impacts arising from changes in the Local Authority carriageway condition under the different budget scenarios.

If carriageway conditions deteriorate due to reduced funding, the following impacts may be experienced by the user:

- ***Vehicle operating costs increase.*** For example, cars consume more fuel on rougher roads and might need more repairs due to increased damage (e.g. from potholes). The effect has been well documented and is the basis of such models as the World Bank's HDM-4 model (Watanada, Harral, Paterson, Dhareshwar, Bhandari, & Tsunokawa, 1987) and standard UK cost benefit analysis as defined by STAG (Transport Scotland, 2011a) (Transport Scotland, 2011a) and DfT (Department for Transport, 2011b).
- ***Travel times increase.*** As the road surface condition deteriorates, it has been noted that vehicle speeds reduce (Cooper, Jordan, & Young, 1980). The effect will vary depending on the original design speed of a road. Evidence from the UK has been used to determine the significance of the effect on the Scottish local road network.
- ***Accidents increase if the skid resistance of road surfaces deteriorates*** Most national highway Authorities in the developed world, including Transport Scotland and the other UK national road agencies, and some local road Authorities monitor skid resistance and implement skid resistance management strategies. The justification of such strategies is documented evidence of increased skidding accidents on lower quality road surfaces in wet conditions (Wilde & Viner, 2001). Evidence from the UK has been used to assess if this effect might apply an issue on the Scottish local road network.

Further details of the literature and the detailed background to the above effects are provided in the detailed report on the associated trunk road study (Transport Scotland, 2011b) (Transport Scotland, 2011b).

SCOTS has previously commissioned analyses for predicting road condition based on different budget scenarios for the Scottish local road network (SCOTS, 2010). These predictions were used with other information (e.g. traffic volumes across the network) to assess the impact on vehicle operating costs and travel time.

The analysis used data from 8 of the 32 Scottish Local Authorities. Detailed results from the analysis of these 8 Authorities can be found in Appendix F, Appendix G and Appendix H. To illustrate the analysis methodology are given and issues of interpretation, results from a single Local Authority (Fife) are described in this Section. Where appropriate, comments are also provided on key differences between the results for Fife and the results for any of the other Authorities in the sample.

The impact of accidents due to skid resistance was assessed using a separate methodology as described in Section 6.4 using skid resistance information from three Local Authorities (not included in the sample of 8 Authorities used for the economic analyses).

The final stage of the analysis included the scaling-up of the results from the 8 Local Authorities to provide results representative of the entire Scottish Local Authority network. The scaling-up methodology is described in Section 12 and Appendix L.

6.2 Surface conditions and vehicle operating costs

Road surface roughness has an impact on vehicle operating costs. Increasing roughness causes additional wear and tear to vehicle suspensions and tyres and affects vehicle fuel consumption and vehicle depreciation. HDM-4 (Watanada, Harral, Paterson, Dhareshwar, Bhandari, & Tsunokawa, 1987) models the relationships between road roughness, vehicle operating costs (VOCs), fuel consumption and vehicle emissions.

In most studies, the cost of vehicle depreciation is subsumed within the overall vehicle operating costs as it is usually considered a relatively small contribution to total vehicle operating costs. In the ISOHDM study on road user effects (Bennett & Greenwood, 2004) included the development of models specifically for depreciation, based on various international studies and supplementing these with realistic assumptions where the appropriate research data did not exist. The models showed that up to roughness levels of 5 IRI (equivalent to 5.5 mm^2 3m LPV) there is no significant change in vehicle depreciation for any vehicle type.

Based on the projected road conditions predicted in this study for all the proposed budget levels, it was concluded that any changes in vehicle depreciation due to changes in investment levels on the network are negligible. The analysis was therefore concerned mainly with the change in fuel consumption of vehicles as road condition changes.

For this study HDM-4 was used to determine the economic costs of individual vehicle travelling over 1km of road in different conditions. This data was used together with the traffic data for the road networks (in vehicle kilometres travelled) and the distribution of the network in different roughness conditions for each of the modelled years in the analysis under the 3 budget scenarios, to determine the total VOCs for each of the 8 sample Authorities.

The HDM-4 analyses took no account of improvements in engine efficiency through the analysis period. The efficiency improvement factors given by the Department for Transport (Department for Transport, 2010) have been applied to the results from the HDM-4 analyses.

Full details of this analysis are given in Appendix F, which includes results from all 8 sample Authorities. The results from the analysis for Fife are shown in Figure 6.1.

Figure 6.1 shows how the increase in road surface roughness due to bigger reductions in funding (e.g. 40% reduction) leads to increased VOCs and as maintenance funding increases after 2020, the differences between the Scenarios reduces. The growth in traffic flow is a major contributor to the overall increase in VOCs through the analysis period for all 3 Scenarios.

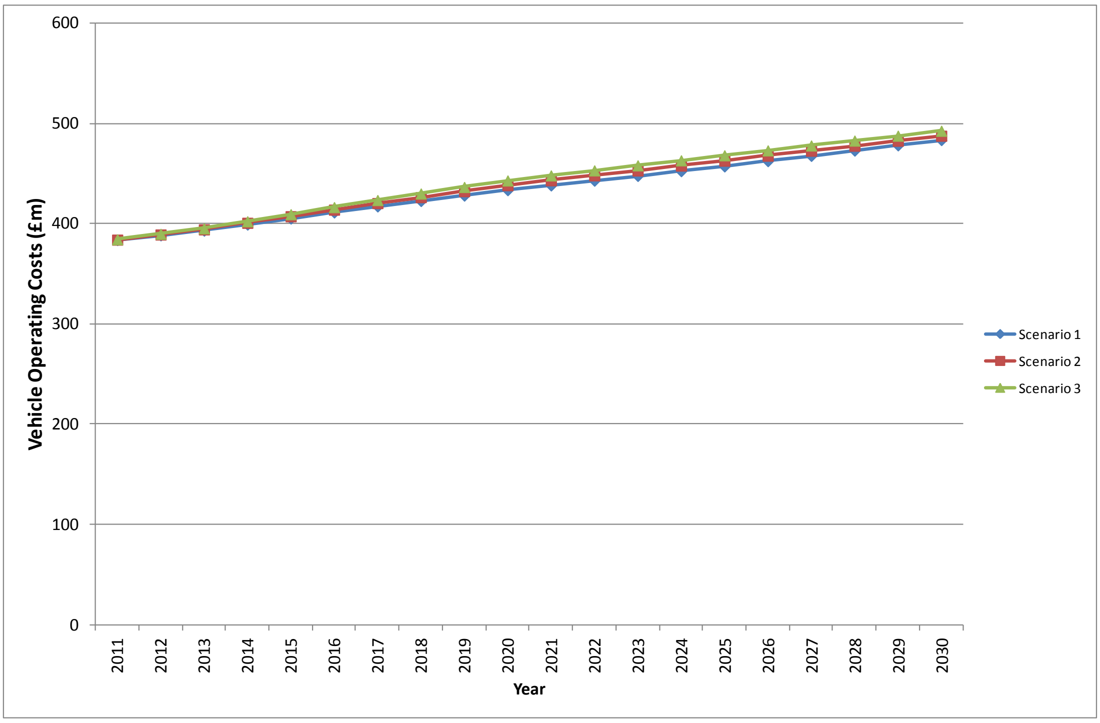

Figure 6.1 Vehicle Operating Costs - Fife
(2002 prices undiscounted)

6.3 Surface conditions and travel time costs

In the analysis of the Scottish trunk road network one of the economic impacts evaluated was the travel time costs incurred due to small changes in vehicle speed as a consequence of differences in carriageway condition.

At the 1987 World Road Congress, the World Road Association (PIARC) (World Road Association, 1987) reported the effect of pavement surface condition on vehicle speeds as:

- An increase in macrotexture and the lower orders of megatexture generally induces the driver to reduce speed; and
- Increases in megatexture and greater roughness, or the incidence of loose gravel or deep snow or mud, frequently have the effect of inducing the driver to reduce speed to below 50 km/h.

Studies in Sweden by (Linderoth, 1981), (Wretling, 1996) and (Anund, 1992) investigated the relationship between road surface condition and travel speed using a sample of resurfaced roads and a control group. Linderoth and Wretling concluded that there was no evidence of reduced speed due to roughness. Anund showed that there was a statistically significant speed reduction of 1.6 km/h for passenger cars travelling in the evening and at night if the rut depth increased by 10 mm, and a reduction of 2.2 km/h for an increase of 1 IRI. The corresponding figures during day time were 1.9 km/h and 3.0 km/h. For trucks with and without trailers, no significant speed reduction with increased roughness or rut depth was found. The results of those studies support a significant reduction in vehicle speed only when road condition deteriorates beyond some critical level.

For both the trunk and local roads analyses the results of research carried out by TRL was used (Cooper, Jordan, & Young, 1980). That study concluded that following the resurfacing of a trunk road, under free flowing traffic conditions, there is a small, but measurable, increase in the speed of vehicles of between 2 and 2.6km/h depending on vehicle type.

In extending this analysis to the Local Authority road network where road alignment, the number of junctions and lower speed limits have increased influences on vehicle speeds compared to trunk roads, the application of the methodology used for the trunk road analysis has been considered to be inappropriate for B, C and U class roads. Therefore the methodology is restricted in scope to consideration of A class local roads only.

The HDM-4 model also includes a vehicle speed road condition relationship and allows for the input of crew cost data to calculate the costs arising from speed changes due to changes in road condition. To avoid double counting the speed effects within the HDM-4 analysis the crew costs for all vehicle types used in HDM-4 were set to zero.

Full details of this analysis can be found in Appendix G, which includes results from all 8 sample Authorities. The results from Fife are shown in Figure 6.2.

Comparing the results from the 8 Authorities it is evident that Fife and Edinburgh show a bigger change in travel time for budget Scenarios 2 and 3 compared to the base scenario (Scenario 1).

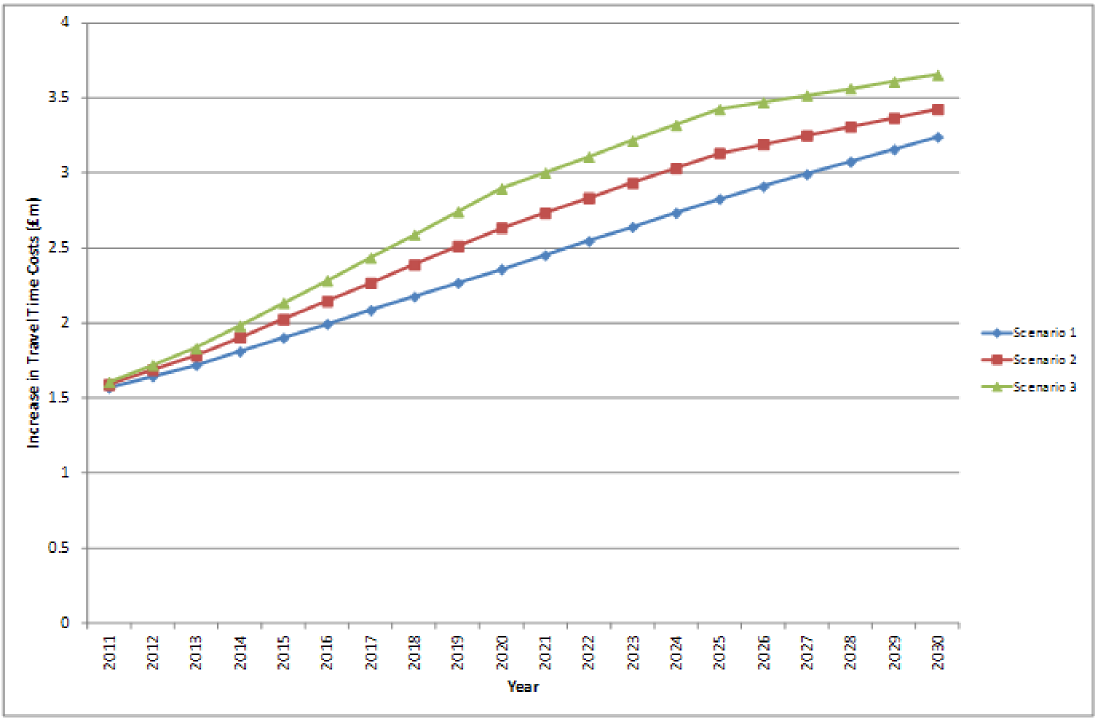

Figure 6.2 Travel time costs for Fife
(2002 prices undiscounted)

The shapes of the curves for the 3 Scenarios again show how the bigger budget reductions have a clear impact up to 2020 but in the period 2020-2030 when funding recovers to the 2010/11 level and above, the differences in cost due to increased travel time are reduced. Although funding levels in Scenarios 2 and 3 return to the level of

Scenario 1 by 2025 and exceed Scenario 1 funding for the last 5 years of the analysis period, the travel time costs for Scenarios 2 and 3 remain significantly higher than those for Scenario 1.

6.4 Skid resistance and accident costs

The relationship between skid resistance, site accident risk rating and skidding accident rates has been well established in the UK and shows lower skid resistance tends to correlate with an increased accident rates. Many factors influence the rate or risk of accidents, including skid resistance/texture depth, and other road condition factors such as unevenness and ruts (Wilde & Viner, 2001).

Comparative friction data over a wide range of surfaces, with a range of skid resistance and texture characteristics shows that higher risk sites have higher proportions of accidents above a skid friction coefficient (SFC) of 0.35 than is the case for risk category 1 sites.

The research also confirmed the necessity of maintaining an adequate level of texture depth to ensure good high-speed friction and the data showed that a texture of at least 0.7mm Standardised Mean Texture Depth (SMTD) was desirable. The results also demonstrated the declining benefits of continuing to increase the texture depth above an adequate level of approximately 1.25mm SMTD.

A large-scale study of the link between skid resistance and personal injury accidents, based on 1000km of the trunk road network in England (Rogers & Gargett, 1991) confirmed the different levels of accident risk for different types of road site and the increase in risk for sites with lower skid resistance.

Earlier studies, (Parry & Viner, 2005) and (Viner, Sinhal, & Parry, 2005), summarised the current position for Motorways in which the overall trend with skid resistance is very flat except for the lowest levels of skid resistance. For dual carriageways the results showed there is a statistically significant trend for accident risk to increase at locations with lower skid resistance. For single carriageway non-event lengths, the trend was both stronger and more significant and the trend was stronger when considering only wet or skidding accidents. The trend for single carriageway non-event lengths showed a continuous increase in accident risk with decreasing skid resistance. For local roads, the network is predominantly single carriageway roads.

6.4.1 Summary of trunk road methodology for skid resistance

Transport Scotland has monitored skid resistance on a routine basis for a number of years on trunk roads. In the earlier trunk road study, data analysis showed that:

- Skid resistance significantly improved between 2001 and 2005, since when it has shown little change and no further significant trends
- Average annual road surfacing budgets (in real terms) were higher in the early half of the 2000s than the latter half

Using the available evidence on the risk of accident occurrence on roads with differing skid conditions (Coyle & Viner, 2009) and data on the total number of wet road accidents in recent years on the trunk road network, a broad estimate of potential accident costs under different future funding scenarios was produced. A similar approach was sought for the local road network.

6.4.2 Assessment of local road skid resistance data

The measurement of skidding resistance by SCRIM is not a routine survey on the Local Authority network. After canvassing the Local Authorities for available data, SCRIM data was provided from three Scottish Local Authorities (Aberdeenshire, Fife and Angus) and used to assess the effects of changes in skid resistance. A summary of the data available is given in Table 6.1.

Table 6.1 Summary of available SCRIM data

Year	Available SCRIM data by road class		
	Aberdeenshire	Fife	Angus
2005	A, B, C and U		
2006	A, B, C and U	A, B and U	
2007	A, B, C and U		A and U
2008	A, B and C		A and U
2009	A, B, C and U	A, B C and U	A, B and U
2010	A, B, C and U	A, B C and U	A, B and U

The data for all road types was a sample of each network only. Although data was provided for U roads, the coverage was low and prevented drawing reliable conclusions. It was therefore decided that focusing on the data for the A, B and C roads was appropriate for this study. Figure 6.3 shows the trends for the three networks.

Trends in the data are less pronounced than for the trunk road network. There is some evidence of an underlying trend affecting all three networks in a similar way, which is reasonable given that skid resistance data is affected by seasonal variation and the data is from Local Authorities all on the east coast of Scotland with similar climatic conditions. However, overall the pattern of behaviour is not robust and it is not considered that any significant conclusions can be drawn on any increasing or decreasing trends.

It was therefore concluded that no quantitative analysis or conclusions can be drawn from the limited skid resistance data available for this study.

In terms of qualitative conclusions, it is still reasonable to assume that experience of other Authorities (that targeting poor skid resistance reduces the number of accidents due to wet road skid resistance) will be the same for the local road network. Reductions in maintenance budgets will therefore strain the ability of Authorities to manage skid resistance (even if the reduced maintenance funding is targeted to address safety as the highest priority) and, therefore, the reductions represent a lost opportunity for improvements in road safety.

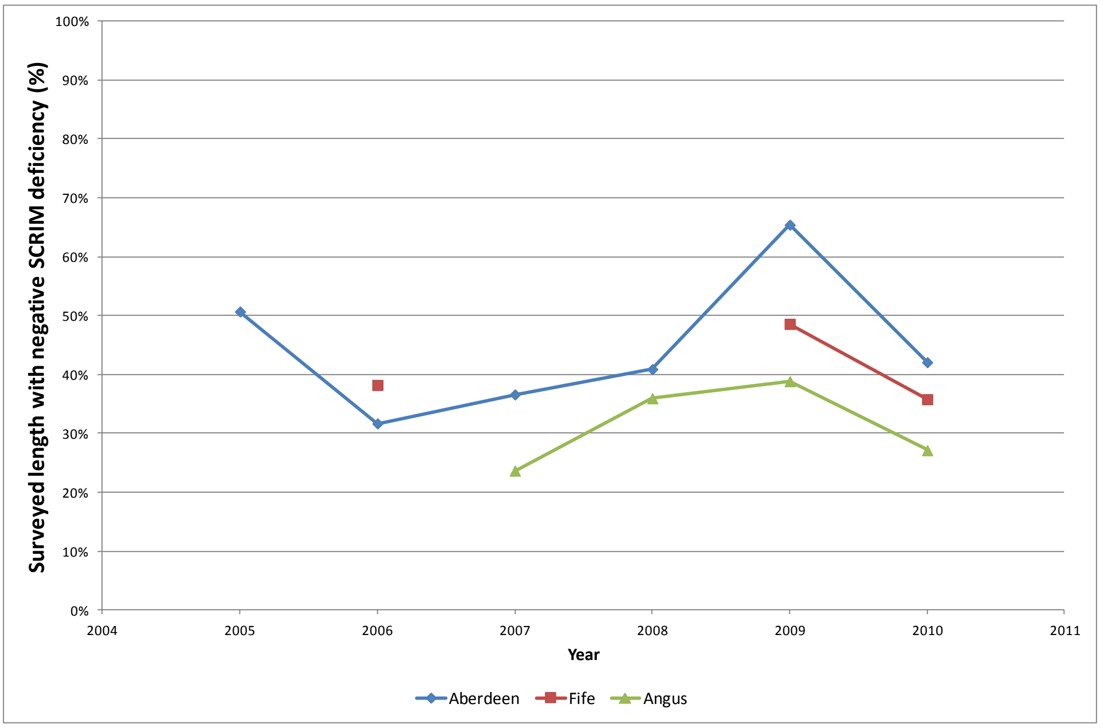

Figure 6.3 Trends in deficient skid resistance for 3 Local Authorities

6.5 Ride quality

As road condition deteriorates, the vehicle ride quality may also reduce. Poor ride quality is not currently a major factor with road users for current levels of network condition. However, studies have been undertaken into the effect of poor ride quality on professional drivers.

In addition to road condition and ride quality, these studies have considered other factors that may affect drivers such as prolonged use of poor quality seats and exposure to noise. It is recognised that vibrations affect drivers but no information could be found on the incremental effect of surface unevenness (e.g. potholes) on drivers.

The European Agency for Safety and Health at Work (EU-OSHA) (European Agency for Safety and Health at Work (EU-OSHA), 2011) recognises the potential effects on long-distance professional drivers and includes the effect of exposure to vibrations (ride quality) in the list of main physical hazards and risks. It was considered that the levels of road condition predicted for the scenarios in this study will not lead to severe changes in ride quality, particularly for HGVs, and therefore little change in risk to drivers from overall levels of condition. With reductions in maintenance funding it is, however, likely that there will be an increase in the occurrence of small areas of rapid deterioration (e.g. potholes) and these may increase the levels of vibration for drivers if the defects are not repaired quickly.

7 Impacts from Carriageway Operations

7.1 Overview

Road carriageway pavement maintenance interventions on the road network require traffic management during the maintenance works. Traffic management causes delays to vehicles using the network with a corresponding economic cost to road users. The amount of delay is related to the traffic flow on the road, the works length, closure speed and the type of traffic management used.

Therefore, the amount and type of maintenance carried out on the network has an impact on the costs of delays to road users. More maintenance treatments require more lane closures and generate more traffic delays. The expectation is that as maintenance budgets are cut and the amount of scheduled works is reduced, the costs of delays to road users will decrease. The counterpoint to this is that increased deterioration of carriageway condition may lead to an increase in accidents (e.g. skidding related accidents). However for the purposes of this analysis these 'rebound' effects have been considered separately in Section 6.4.

7.2 Roadworks and user delay costs

To calculate the user delays caused by roadworks the QUADRO (Queues and Delays at Roadworks) model (Highways Agency, 2009b) was used. Traffic levels based on the network traffic data were used with the extent of maintenance works in each of the analysis years estimated from the outputs (treatment lengths) from the WDM analysis. The WDM model applied treatments based on the network condition and available budget. Details of the analysis methodology and results from all 8 sample Authorities is given in Appendix H. Results for Fife are shown in Figure 7.1.

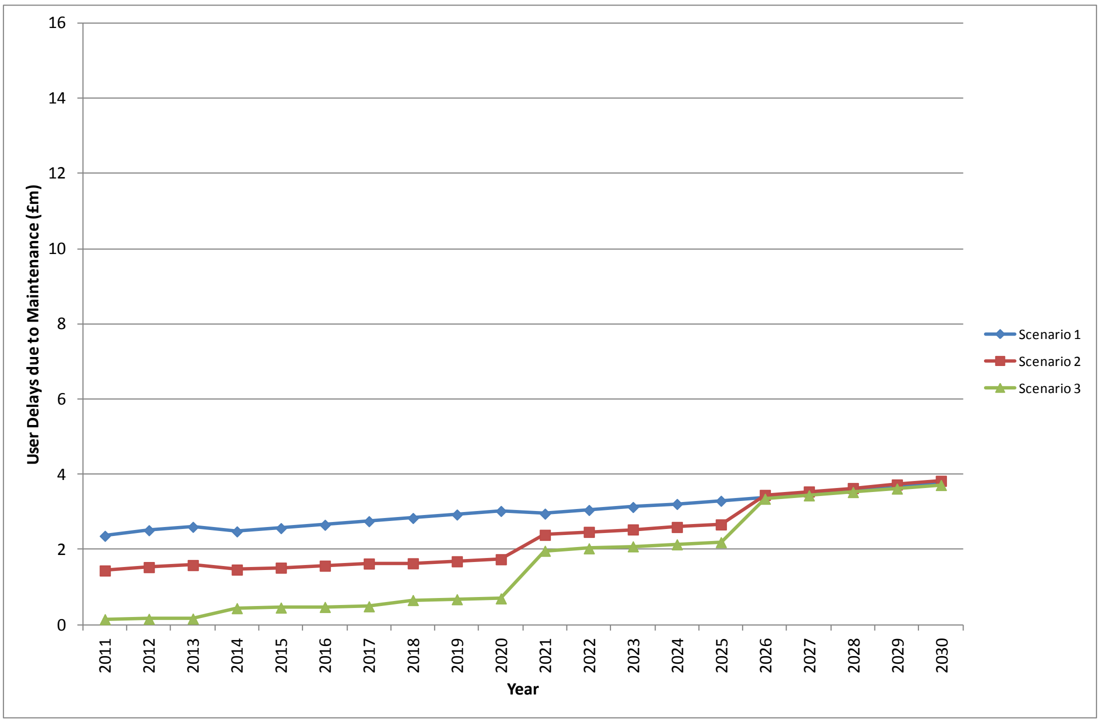

Figure 7.1 User delay costs at roadworks - Fife
(2002 prices undiscounted)

The reduced funding in Scenarios 2 and 3 clearly show the effect of less maintenance work up to 2020. As the funding for the Scenarios increases, the delays to road users increase until, from 2025, there is little difference between the 'in-year' costs for the 3 Scenarios. The increase in traffic flow contributes to the overall gradual trend increase in delay cost for all 3 Scenarios (e.g. in Scenario 1 with constant maintenance funding, there is an increase in the costs of user delays through the analysis period).

8 Impacts Related to Route Security

8.1 Overview

Route security refers to the level of risk being carried to keep a route open to road traffic and other users. Insecurity might be caused by a number of factors:

- ***Inadequate maintenance regimes.*** For example, if major structures such as tunnels or bridges are not inspected on a sufficiently frequent basis, or if funding is unavailable to replace ageing culverts or retaining walls at risk of collapse, the risk of the route being (partially) closed for safety reasons and repairs increases.
- ***Environmental issues.*** For example, roads in mountainous terrain or unstable geological areas are at risk of slips and subsistence. Whilst investment might be able to mitigate some of the risk, it is not possible to remove the risk.
- ***Extreme events.*** Similar to environmental issues, extreme events such as unexpectedly heavy snowfall or rain might lead to closure of links or entire areas of a road network. Again, whilst design and maintenance processes aim to mitigate the effects to some degree, it is not possible to remove the risk.

The level of maintenance funding will impact on the ability of an Authority to maintain an appropriate level of route security. Activities to mitigate the risk include structural inspections, repairs and replacement, drainage cleaning and maintenance, embankment protection and river training works and winter maintenance. Winter maintenance has been excluded from this review and so the study has focused on other factors that may affect security.

The impacts of increasingly insecure networks might be related to the environment (e.g. flood defences), safety (e.g. increased accidents), quantifiable economic issues (e.g. disrupted journeys) or social issues (e.g. community severance). The qualitative risks of route security have been identified during the literature review and, where appropriate, are summarised in Section 14.1, with further details in Appendix B. The analysis reported in this Section has sought to quantify the risk of route security based on evidence from Scotland and elsewhere.

8.2 Evidence

8.2.1 International and national evidence

Failure of the road network infrastructure can cause significant disruption and may reach the news headlines. In recent years in North America, there have been various high profile cases of collapsing or partially collapsing structures on major routes, where questions have been raised over the adequacy of initial designs and road maintenance strategies and funding. Examples include the Minnesota bridge collapse in 2007 which caused 13 fatalities and many more injuries, as well as other longer term impacts (National Transport Safety Board, 2007). More recently, a partially collapsed tunnel in Montreal has caused disruption and it has been reported that engineers have questioned the adequacy of the long term maintenance plans (The Canadian Press, 2011).

In the UK, weather events have also caused major disruption in recent years. For example, extreme flooding in 2009 in the Lake District caused numerous bridge closures and meant that many journeys faced major diversions (BBC News, 2009).

The impact of such events might be immediate, as noted in the above examples but there is often a longer term impact. No Authority can avoid the need to address such significant hazards to the travelling public, and so in the aftermath, funds are diverted to repairs and replacement strategies at the expense of other items in the road maintenance budget.

Whilst immediate repairs and operations due to major weather events and other such environmental impacts are usually funded from discretionary budgets, again, the longer term and less visible impacts often have to be funded out of core road maintenance budgets.

No evidence has been found of any Authority which has yet managed to objectively quantify the risk of such failures and consider the quantitative trade-offs due to the potential impacts. All evidence suggests that road Local Authorities:

- Develop inspection and maintenance regimes based on engineering experience;
- Expect to manage the risk of route security with such processes and find little opportunity for reducing such strategies when funding is constrained;
- Accept that if funding for road maintenance is constrained, significant reductions will have to be made elsewhere in the budget with only marginal savings being possible when related to route security.

8.2.2 Scottish trunk roads

A good example of route security issues was experienced on the Scottish trunk road network in Scotland in October 2007 on the A83 at Rest and Be Thankful Pass in Argyll and Bute (Transport Scotland, 2009c). A landslide occurred which closed the route for 12 days. There were no accidents and the economic impacts were assessed based only on a quantified analysis of road user disruptions (i.e. the extra time taken by road users to complete their journeys). Other economic effects on the local economy (e.g. from loss of trade) have not been assessed. Key statistics include:

- The average daily traffic at the site was around 2,250 with approximately 4% heavy vehicles
- The route was closed and only opened partially late in the 12 day period
- The diversion route was estimated to be an additional 41km with an average additional journey time of 34 minutes
- The economic impact has been estimated (at 2008 prices) as £320,000 which is the central estimate of a range which might vary between £180,000 and £620,000 depending on assumptions of how many trips were actually diverted rather than cancelled or deferred until the road re-opened
- If the event had happened during the peak tourist season (summer), the central estimate would increase to £540,000 due to increased traffic levels.

At 2002 prices the central estimate of the impact is £272,000. Table 8.1 shows the impact if some of the key assumptions are varied.

Note that the data makes no assumptions around the impact of different maintenance regimes as the event was an unforeseen environmental impact. If consideration was being given to the effect of different maintenance regimes (i.e. funding more maintenance to reduce the potential occurrence of an event) then the agency costs for prevention would increase but could be offset against the anticipated reduction in economic impact.

Table 8.1 Scenarios for route security (2002 prices)

Title	Description	Impact
Base	Low traffic rural road (ADT 2,250) with significant diversion (34 minutes) for a reasonable period of time (12 days) (e.g. landslide)	£270,000
High traffic short delay[1]	High traffic rural road (ADT 20,000) with medium diversion (15 minutes) for a longer period of time (30 days) (e.g. large geotechnical failure)	£2,700,000
Low traffic long delay[1]	Low traffic rural road (AADF 2,250) with significant diversion (34 minutes) for a long period of time (1 year) (e.g. bridge failure)	£8,300,000
Medium traffic long delay[1]	Medium traffic rural road (AADF 10,000) with medium diversion (15 minutes) for reasonable period of time (12 days)	£500,000

Note: 1. These impacts assume durations of disturbance but, in practice, temporary alternative routes may be put in place to reduce the impact (e.g. temporary bridge erected when a bridge was destroyed by flooding in Cumbria, in 2009).
Source: A83 Rest and Be Thankful closure

8.2.3 Scottish local roads

The trunk road network represents the strategic arterial routes and is therefore designed to be most resilient of the road networks in Scotland. Local roads receive less funding per kilometre and are designed to be fit for purpose routes which in most cases mean they are less resilient than the trunk road network. The risk of significant events causing closure is therefore higher, but this is offset by the, generally, lower impacts.

There are various examples of the nature of impacts on local roads in recent years. A typical example Authority is Perth and Kinross Council (Perth and Kinross Council, 2011) which experiences at least one infrastructure failure on a major route each year. Other examples are:

- Major flooding events in 2002 caused significant disruption across part of the network. Repair costs at the time were estimated to be £230,000 of capital works, £400,000 of repair work and the longer term cost impacts (e.g. the potential shorter expected lifetimes of some drainage assets due to intensive wear and tear) are unknown. However, it was noted that even if the drainage system at the time had been built in accordance with up to date standards, the intensity of the event would still have caused failures and disruption.

- Severe weather caused landslips and partial collapse of a bridge on the Dunkeld to Rotwell Road at Toll Bridge in 2004. The route was closed to traffic, caused major disruption to local communities and the environment and the estimated cost of the preferred repair (which would enable full re-opening of the road) was estimated to be £403,000 at 2005 prices.

- In July 2010, a landslip on the B846 at Aberfeldy due to wet weather on an increasingly unstable embankment required repair at an estimated cost of

£190,000. This example provides a good example of the way in which maintenance and operations can reduce such risks: part of the reason for the slip was assessed as possibly due to an overgrown tree on the embankment. Such risks are inherent across all similar networks and require the asset owner to prioritise budgets and assign expenditure to those areas at most risk. If funding is reduced, the number of 'at risk' sites therefore increases.

Local roads are also more vulnerable to failures of utilities under the road surface. The costs of these repairs fall to the utility companies but, nevertheless, cause major disruption to road users and, often, local residents. Although these are not a direct consequence of reduced maintenance funding, the reduction in maintenance work lessens the opportunity to coordinate utility works and road maintenance.

8.3 Conclusions

Whilst there is evidence of the costs of repair and economic impacts of closures and failures on road networks, it is not possible to adopt a traditional cost benefit analysis methodology to evaluate the whole of life economic cost of different funding scenarios.

The example of the failure at Rest and Be Thankful can be used as an indication of the range of impacts that might be expected in given situations. Assuming there is currently 1 route security impact of the same scale as rest and Be Thankful, in every year of the analysis period:

- It would need an increase in cost of approximately 7 times (per year) to generate the same quantified economic impact to road users as that expected from a 20% reduction in expenditure on carriageways;
- It would need an increase in cost of approximately 4 times (per year) to redress the savings in maintenance spend (works costs) from a 20% reduction in expenditure on carriageways.

Note that the above examples assume no safety risk of increased accidents (which would have a very significant impact if fatalities are involved) nor does it account for the qualitative impacts of community severance and accessibility discussed in Section 14.

9 Impacts Related to Wider Operations

9.1 Footways and cycle-tracks

9.1.1 Summary of issues

The Scottish Government report on Designing Streets (Scot Govt 2010) and Designing Places (Scot Govt 2001) both recognise that road maintenance is not a single issue and there are many other policies and influences to what and how maintenance is undertaken.

As a proportion of their assets, Local Authorities have more 'off-road' responsibility than Transport Scotland has in managing the trunk road network. For example, Local Authorities manage a significant network of footpaths and cycle-tracks which support local trips by pedestrians and cyclists. The perception of local road management is, therefore, not only related to the road assets.

The significance of footways and cycle-tracks in terms of impacts has been highlighted in the literature review (see Appendix B). The disbenefits of a network of footpaths and cycle-tracks in poor condition fall into various areas:

- ***Safety.*** The risk of trips and accidents increases if conditions deteriorate.
- ***Security.*** Residents and visitors perceive that the neighbourhood is less secure if the condition of assets is poor.
- ***Amenity value.*** Neighbourhoods in poor condition are less highly valued.
- ***Health.*** If the network is in poor condition, this acts as a disincentive to pedestrians and cyclists.

The disbenefits are unevenly distributed across various groups. Often, with budget constraints, funding for such assets may take a lower priority than for roads and so cyclists and pedestrians are disproportionately affected; older people are more concerned about the risk of slips, trips and security than the general population; people with disabilities are more affected by surfaces in poor and inconsistent condition. Footways near residential homes may receive higher priority and be less affected by maintenance funding restrictions.

9.1.2 Local road information on footways and cycle-tracks

There is less data available for footways and cycle-tracks than for the main carriageways, as they are lower value assets and so traditionally receive lower funding for monitoring and management. The current SCOTS project[5] has only just started collating information on such assets. Data is currently being collated on condition and asset value, but is as yet incomplete and there is no historical data for comparison. However, a brief review of available data has been undertaken, and information on public claims against a sample of Local Authorities was also collated as part of this study with the aim of identifying any conclusions that can be drawn from the information.

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[5] SCOTS embarked on a four year project in 2008 to implement improvements in asset management planning across Local Authorities.

Information on claims for the last 5 years was provided by 13 Authorities. Due to the fact that there is a time lag between claims being notified, and subsequent settlement, the value of settled claims (which would be the most useful figure to assess in the long term) in the most recent years is not necessarily reliable (as further settlements might yet be made). For this reason, the most useful information for this study was considered to be total number of claims made and the trends are shown in Figure 9.1. Although this does not solely represent the effects of changing footway condition, it does show an overall effect of public attitude to footway and cycle-track condition and claims for compensation. It is recognised that as well as network condition, public attitude to willingness to make claims and the perceived likelihood of success with claims may have changed over the time period.

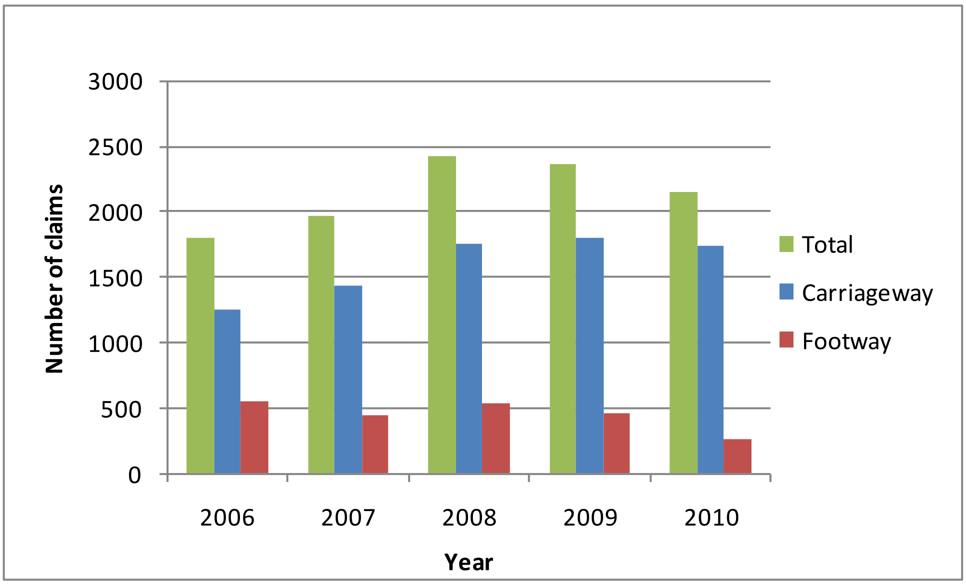

Figure 9.1 Number of claims received by a sample of Scottish Local Authorities

Whilst there is an overall upward trend in claims made against Local Authorities, the number of claims for footways appears to be relatively constant, or even decreasing.

Data from the SCOTS project was available from 9 Authorities[6] (four rural, three semi-urban and two urban). There are many factors (e.g. weather and access by utility companies) that affect the change in the value of infrastructure assets, including footways, but following figures have been derived for the sample Authorities:

- Total gross replacement cost of footways and cycle-tracks £1.2 billion
- Total depreciated replacement cost of £820m
- Total annual depreciation of £20m
- Ratio of depreciated replacement cost to gross replacement cost of 64% which is a measure of the average 'state' of the asset with a ratio of 100% being as new

[6] The data has been provided without naming Local Authorities and so it is not possible to relate the information to other published information.

and 0% as end of life. The ratio varies from 40% to 80% showing the range in conditions for different Authorities

If a linear scaling is applied to the annual depreciation of the 9 Authorities to estimate the value for 32 Authorities[7], then the total annual depreciation is between £60m and £80m. If this figure is of the correct order, then a similar annual amount will need to be invested in the assets to maintain them at their current condition and a greater investment would be needed to improve the condition and increase the asset value.

In 2009/10, from Table 4.3, the combined expenditure on structural maintenance, safety maintenance and emergency patching, routine repairs and other was around £280m. The above calculation suggests that 25% of this allocation would need to be spent on footways and cycle-tracks to maintain current conditions. It is considered unlikely that such levels would be devoted to these assets with any of the Scenarios, and so it is likely the conditions will deteriorate over the analysis period for Scenario 1 and this would be exacerbated with any further reductions in expenditure (Scenarios 2 and 3).

In recent years much effort has been used to improve the identification and design of accessibility features (e.g. tactile paving) and guidance on their implementation in the street-scene. Any reduction in adopting that guidance will have a negative effect on pedestrian users.

9.2 Street lighting

9.2.1 Summary of issues

The drive for reduced energy consumption as well as any more general on-going drive for efficiency savings has been identified in the literature review (see Appendix B). Street lighting is implemented to minimise the risk of accidents and, particularly in the local road context, has associated wider benefits for local residents of improved security and general amenity value. Recent years have seen the development of improved technology to deliver better lighting outcomes (e.g. use of dimmers for low traffic levels, lower energy consumption bulbs etc).

The traditional basis for evaluating new street lighting benefits was to assume a 30% reduction in night-time road accidents. Based on conclusions from more recent research (Crabb, Crinson, Beaumont, & Walter, 2009), the figure now adopted by the Highways Agency for lighting schemes on trunk roads in England is 10%. The research also showed that in order to implement new energy saving technology, some upfront cost is required but this is balanced by an overall saving in a 30 year whole of life agency cost analysis. It was also noted that as electricity prices increase, returns would be achieved over a shorter timeframe.

The balance of evidence from the literature (e.g. (Fox, 2007)) is still that lighting provides a safety benefit and also that it has beneficial impacts on community well-being according to integration and social accessibility criteria.

[7] Probably not a reliable measure but all that is possible with data available

9.2.2 Local road assessment

A simple scenario assessment was undertaken of the safety impact of providing reduced street lighting. The converse of the approach for assessing new lighting schemes was adopted (i.e. if lights are removed, there will be a 10% increase in night-time road accidents). The analysis also assumed:

- A specified percentage reduction in the lighting budget (revenue) translates to the same percentage reduction in the amount of available lighting on the network
- Current night-time road accidents are evenly distributed across the lit network

Both of these assumptions are clearly tenuous. However, to argue anything more detailed with the data available and in order to generate an assessment of potential orders of magnitude, it was considered an appropriate first step.

Section 5 has identified that for Scenario 2, there will be a reduction in the lighting (revenue) budget of 11% and for Scenario 3 the reduction will be 23%. Section 9.2.1 has identified that between 2005 and 2010 the average number of all accidents on lit streets after dark was around 2000 and of these around 30 were fatal. The analysis was carried out on all accidents and fatal accidents only, and the worst case (all accidents) results are shown in Table 9.1.

Table 9.1 Summary of scenario analyses for street lighting

Item	Scenario 2	Scenario 3
Agency cost saving (£m)	37	87
Increase in annual accidents (All)	22	46
Increase in accident costs (£m)	18	37

Notes. 20 year analysis period, 2002 prices, discounted costs.
Increase shown for Years 1 to 10. Assumed to gradually return to current rate in Years 10 to 20 due to return of budgets to existing levels.

This coarse analysis shows that there is a benefit to reducing lighting on the existing network, when considering accident impacts only. However, it assumes that a given percentage reduction in lighting budget translates to the same given percentage reduction in lighting. In reality, there are some base fixed costs and decommissioning costs that would be required so this would not be achievable.

The analysis also assumes that existing lights that are turned off will only increase the risk of accidents by 10%, the current figure for justifying lighting installation. However, if it were assumed that lighting already installed on the network was implemented and achieved 30% accident reductions (the earlier Department for Transport figure adopted) then the results would be very different and show a significant disbenefit to any reduction in lighting costs. Recent trials by the Highways Agency on trunk roads in England (introduced to reduce the carbon footprint) suggest little change in the number of accidents when lighting is switched off for part of the hours of darkness.

There is evidence that reduced lighting will lead to higher costs associated with security and accessibility that will also off-set any of the apparent savings. A study by Painter and Farrington and Welsh (Farrington & Welsh, 2002) reported a fall of 41% in crime in

Dudley, West Midlands, due to improved lighting. Similar results were obtained from a study for Stoke-on-Trent.

9.3 Other operations

The literature review showed neighbourhoods place a value on good condition in terms of no graffiti, no broken walkways, frequent street cleaning and vegetation cutting etc. Public perception will be reduced if less is spent on these. This has not been quantified but it is clear there are benefits from keeping up the amenity value.

Studies by Transport for London have valued the increase in residential prices and retail rents achieved by roadspace improvements or close proximity to open space (e.g. parks). Transport for London has demonstrated benefit-cost ratios of between 2.5 and 5.5, without indirect benefits, from improvements in the public realm. Other studies have shown improvements to footfall for retailers after carriageway and footway improvements. As well as showing the benefits of maintenance and improvements these valuations provide measures to use in attracting private sector funding for maintenance and improvements in local areas.

Poor walking environments and transport links can leave areas isolated and damage community cohesion. Increases in cat and dog mess, litter, broken glass, vandalism and uneven footways all represent disincentives to the use of pedestrian footways and reduction in visual amenity. These negative impacts will be increased with reductions in maintenance funding for footways.

9.4 Conclusion

Based on the analysis of the depreciated replacement cost of footways from 9 Authorities the condition of the footway and cycle-track assets is likely to be deteriorating at current levels of expenditure and these assets will be subject to increased deterioration under reduced budgets.

Reducing the lighting budget will likely result in fewer lit street lights (since lower cost lighting technologies have an initial investment cost). Reducing street lighting has an effect on amenity and a measurable effect on accidents (increases of between 10% and 30%) on accidents. With a 10% increase in accidents, a reduction in lighting costs is economically beneficial, but if the increase in accidents is 30% then the converse argument stands.

10 Environmental Impacts

10.1 Carbon emissions

Under each of the budget scenarios there are differences in the amount of maintenance carried out on the network. Changing the amount of maintenance carried out has an impact on the network CO_2 emissions in a number of ways:

- Reducing the amount of maintenance activity or the invasiveness of maintenance treatments reduces the amount of CO_2 emitted in carrying out the work and the CO_2 embodied in the materials used (e.g. asphalt).
- Reducing the amount of maintenance reduces the number of planned road closures on the network. This has an impact on vehicle delays which also has an impact in terms of CO_2 emissions from vehicles which are delayed through roadwork sites.
- The HDM-4 model (Watanada, Harral, Paterson, Dhareshwar, Bhandari, & Tsunokawa, 1987), which was used in the VOC analysis also includes an emissions model, which is sensitive to the surface condition of the carriageway. Therefore changes in the carriageway surface condition (e.g. roughness) have an effect on the CO_2 emissions from vehicles under normal operation.

It is important to note that vehicle efficiency is speed dependent, with optimal efficiency being achieved at the mid-speed range (around 80km/h or 50miles/h). On trunk roads reducing vehicle speeds (either as an effect of poorer carriageway condition or speed restrictions through maintenance sites) had the effect of producing a reduction in vehicle emissions. However, on the lower speed local road network delayed or slowed vehicles will generally emit more CO_2.

No account was taken of improvements in engine efficiency through the analysis period. The efficiency improvement factors given by the Department for Transport (Department for Transport, 2011a) have been applied to the results from the HDM-4 analyses.

Further details of the emissions analysis are given in Appendix I, including results from the 8 sample Authorities. The results from Fife are shown in Figure 10.1 and Figure 10.2 for illustration.

The results for the analysis of emissions due to maintenance appear to follow a stepped relationship. This is a consequence of the availability of results for maintenance works in 3 or 4 year time steps preventing the presentation of a smoother year by year transition.

10.2 Local air quality

Local air quality is measured at various sites using specialised sampling equipment. The 'quality' of the air is determined by the concentrations of pollutants many of which are derived from the combustion of fossil fuels. Roadside air quality is site specific and predicting the change in air quality at any given site due to changes in maintenance funding is complex and outside the scope of a network level analysis. However, using the results of the network carbon emissions output from this study it has been possible, based on the typical combustion characteristics of the vehicle fleet, to determine the approximate increase in the mass of the combustion products which affect air quality. The full results of this analysis can be found in Appendix I and are summarised in Table 10.1.

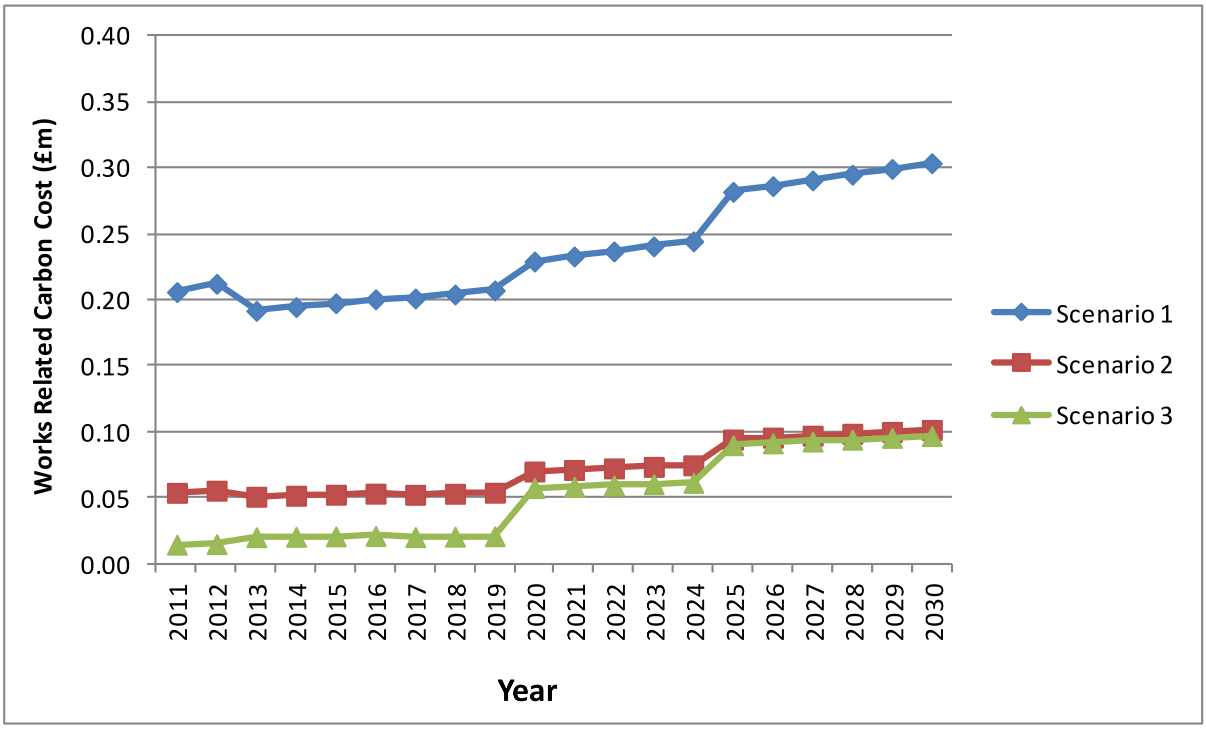

Figure 10.1 Costs of emissions due to maintenance works - Fife

Embodied CO_2 and vehicle emissions through roadwork sites. (2002 prices undiscounted)

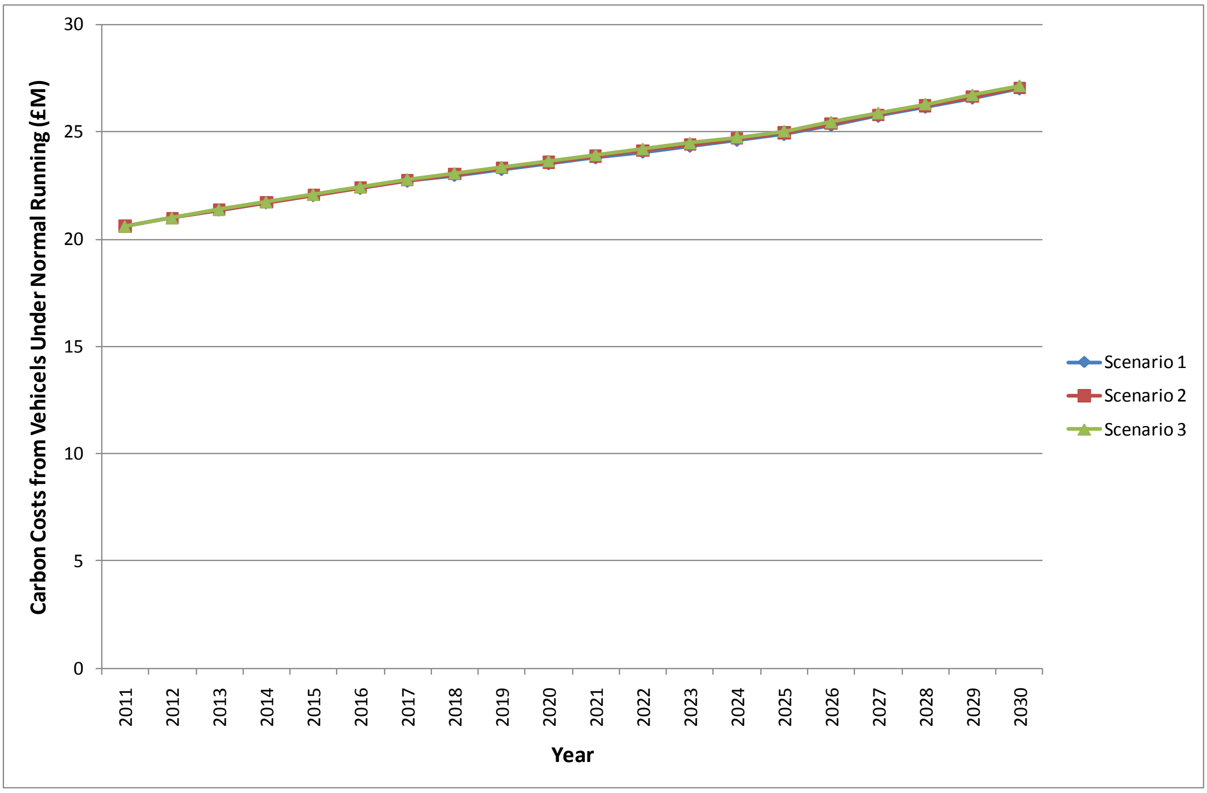

Figure 10.2 Costs of emissions from vehicles due to road roughness – Fife

(2002 prices undiscounted)

Table 10.1 Emissions for all the Scottish local road network

Emission	Scenario 1 (kg)	Scenario 2 (kg)	Scenario 3 (kg)
Nitric Oxide and Nitrogen Dioxide (NOx)	992.3	991.5	991.6
Particulate Matter < 10 µm (PM10)	85.4	85.3	85.3
Particulate Matter < 2.5 µm (PM2.5)	58.3	58.2	58.2
Hydrocarbons (HC)	188.9	188.8	188.8

There is little change in the emissions between the 3 Scenarios based on the assumptions made and the predicted changes in vehicle speeds.

10.3 Impacts of noise

10.3.1 Issues

Noise annoyance is defined by the World Health Organisation (WHO) as 'a feeling of displeasure evoked by noise'. The UK has well established procedures for assessing the nuisance to people caused by road and rail traffic-related noise and vibration. These procedures have been developed from surveys of the impacts of noise from transport on people, including dissatisfaction, annoyance and disturbance. More recently the Department for Transport commissioned a research study aimed at putting a monetary value on the impact of noise which is now captured in the analysis guidance (Department for Transport, 2011a).

According to Living Streets (Sinnett D. W., 2011) noise pollution particularly in towns and cities, can make conditions for walkers unpleasant at best and a health issue for some people. It can be a disincentive to walk close to or along main roads or in areas of stationary vehicles. It also states that noise makes casual conversation much more difficult. Thus, an increase in noise and vibration through a reduction in maintenance could have an impact on choices made by pedestrians and their way of life.

New road projects adopt the latest standards and often provide for noise mitigation measures such as noise barriers on urban freeways. These are not funded from the maintenance budget so the effects of changing the procedures for installing noise barriers have not been considered in this study.

The key area of expenditure in road maintenance which can have an impact on long term noise is road surfacings. The reduction in maintenance funding will reduce the amount of resurfacing and will lead to older surfacings lasting longer and pressure to adopt cheaper surfacing at the time of maintenance. After an initial settling in period (a few months), surfacings generally generate more noise with trafficking as they age. This may lead to a marginal impact on noise due to an ageing network. The difference in levels of noise from different surfacings has been explored for the Scottish local roads.

10.3.2 Assessment of Scottish context

Limited experience on Scottish local roads of potentially lower noise surfacings has been that they are of a similar final outturn cost and do not perform as well as other more traditional surfacings. This evidence from a recent TRL study for Scotland (Abbott, Morgan, & McKell, 2010) has again been confirmed with informal feedback during this study. Abbott looked at the experience of use of different surfacings and the potential benefits due to use of lower noise surfacings.

Key points derived from that study were:

- Lower noise surfacings have the same initial costs or possibly slightly lower costs than more traditional surfacings. However, due to the shorter lives experienced to date, the whole of life costs for both options are similar
- The extent of use of low noise surfacing on local roads is not accurately known and varies across Authorities. Some Authorities have used quieter surfacings extensively while others have had limited experience. Some Authorities have moved away from their use after poor experiences of performance
- Low noise surfacings are now used reasonably extensively (around 25%) on the trunk road network

The study considered the whole of life economic costs of the two surfacing options, in both a rural and urban environment, and summary results of the comparison are shown in Table 10.2.

Table 10.2 Impacts of noise from different surfacings

Item	Rural		Urban	
	HRA[1]	TSMA[2]	HRA	TSMA
Road type	Dual 2 lane		Single 2 lane	
Traffic level (veh/day)	24,000		8,000	
Proportion heavy vehicles (%)	5		20	
Initial cost (£/m^2)	19.2	18.4	19.2	18.4
Expected life (yrs)	12	8	12	8
NPV [Works and user delay costs] (£k)	482	690	434	593
NPV [Works and user delays cf. HRA] (£k)	Base	208	Base	159
NPV [Noise benefit] (£k)	Base	-3,431	Base	-7,921

Notes: 1. HRA = Hot Rolled Asphalt – the traditional UK surfacing
2. TSMA = Thin Stone Mastic Asphalt – the most common low noise surfacing option

Source: (Abbott, Morgan, & McKell, 2010)

The results of Table 10.2 are very dependent on the input assumptions in the examples. However, in summary, it shows there might be significant benefits from implementing noise reducing surfacings but that the works costs of such surfacings are higher in whole of life terms.

Given the limited experience to date of Local Authorities with lower noise surfacings, in the case of local roads it appears that any maintenance reductions will translate to a lost opportunity for realising any noise benefit, rather than an actual disbenefit.

For trunk roads, where there is already a reasonable proportion of the network with such surfacing in place, the conclusion is different to that for local roads. There could be a significant disbenefit if Transport Scotland shifts to using lower cost traditional surfacing as part of the implementation of lower levels of maintenance funding.

11 Customer Satisfaction

No direct evidence of customer feedback for local roads in Scotland has been available, for this study but it is likely that studies have been undertaken. It was recognised in the trunk road study that, for trunk roads, users had serious concerns about deteriorating road condition and in related studies with users for other projects comments have been made for local roads. In a study for the Department for Transport (Ramdas, Thomas, Lehman, & Young, 2007) users in focus groups were very critical of the effects of lack of local road maintenance in England.

Examples of studies into customer satisfaction by Local Authorities were made available for this study but there was no additional information on specific policies adopted by the Authorities that may affect the changes in level of service reported by the surveys (e.g. a higher rate of spend applied to a particular aspect specifically to improve that service). The studies covered the full range of services provided by Local Authorities. Winter maintenance was a topic covered widely by these surveys but individual Authorities also sought customer views on other topics (e.g. general road maintenance, street lighting) relevant to the effects considered in this study. The results from the studies available show the public take a strong view of effects of levels of maintenance of the road network. The results of the surveys are presented differently but the results illustrate the views and level of interest in road maintenance shown by local residents.

The types of studies undertaken by different Authorities are shown by 3 studies on different types of Authority[8]:

11.1 Urban Authority

Two surveys had been undertaken in 2005 and 2008, with each survey categorising the customer views in 5 bands from Excellent to Very Poor. The aspects of road maintenance covered included:

- Drainage, gullies and ditches
- Footway maintenance
- Grass cutting
- Pot holes and road surface defects
- Road markings
- Road signs
- Standard of road surface

For street lighting the survey covered the speed of street lighting repairs, level of lighting and the extent of lighting.

All sample surveys are subject to random error and require large sample sizes to give narrow error bands at 90% or 95% confidence intervals. For this Authority, the changes in views between 2005 and 2008 in the level of satisfaction (expressed as the middle category or better) were between 11% (for grass cutting) and -7% (for speed of street lighting repairs). However, for the sample sizes used, none of these changes were statistically significant. The level of satisfaction for all aspects was more than 75% in 2008.

[8] The identities of the Authorities providing the example surveys have not been included.

11.2 Semi-urban Authority

Two household surveys had been undertaken in 2008 and 2010 and in addition to assessments of the general level of service provided by the Authority, included four service areas relevant to this study:

- Maintenance of roads and footways
- Quality of town centre environment
- Street lighting
- Street and pedestrian area cleanliness

Of these four service areas, 3 showed a decrease in level of satisfaction between 2008 and 2010 of between 3.7% and 9.1% with street lighting showing an improvement of 5%. No levels of significance were given for these differences.

However, it was not only the change in level of satisfaction that is of interest but also the general level which was below 20% for road maintenance compared with more than 90% for other non-road related services provided by the Authority. This level of service was achieved even though the Authority had initiated a major investment programme in roads.

Of the four aspects of maintenance related to this study, street lighting showed a level of satisfaction of more than 80% but the other three aspects were between 18% and 57%. Cleanliness of streets and pedestrian areas showed the largest fall in level of satisfaction of nearly 10% to less than 50%.

11.3 Rural Authority

This Authority had undertaken surveys of performance annually since 2007. The surveys covered six aspects of maintenance relevant to this study:

- Cycle-paths
- Flooding
- Footway maintenance
- Road repairs
- Street cleaning
- Street lighting

The surveys adopted a 5 category response scale with the results of the surveys shown as the Net Satisfaction Rate (NSR), the difference between the sum of the responses in the top two categories and the sum of the responses in the bottom two categories.

The highest NSR for a service was nearly 90%, for libraries, but road repairs, the poorest performing service, showed -55% in 2011, with little change since 2007. The NSR for cycle-paths had improved significantly in 2011, from little change between 2007 and 2010. The NSR for street cleaning and flooding had shown gradual improvements since 2007 but were still in the bottom half of the rates for the 41 aspects of the Authority's service included in the surveys. Footway maintenance had improved since 2007 but was still 36th in the order with an NSR of less than 10%. Road repairs were clearly the poorest aspect of the Authority's service, yet in related questions on the importance of the aspect, it was seen as the most important of the 41 aspects of service.

11.4 Summary

The three Authority survey reports reviewed for this study showed that the public are very aware of the level of service provided by the road network and its importance to the public well-being. Similar categories of the service were included in the surveys by all 3 Authorities but only one Authority showed any measure of the level of reliability in differences in the results between surveys.

The surveys strongly suggest that reducing the level of maintenance funding will be recognised by the public and further reduce the level of satisfaction, which is already low compared with other aspects of Local Authority services. However, it is also likely that increasing the level of maintenance will not provide immediate improvements in the level of satisfaction. The survey for the Semi-Urban Authority showed a decrease in the level of satisfaction in road maintenance even after a major investment programme in roads, although this may have been influenced by the occurrence of particularly severe winter weather in recent years.

All 3 surveys showed the high public awareness and interest in levels of street lighting but did not identify the basis of those views (i.e. security, accidents etc.). There was also a high interest in levels of footway condition.

These surveys are not sufficient to show the levels of satisfaction in aspects of road maintenance across the road network or to indicate likely changes caused by reductions in levels of maintenance funding. They do however show that the public is well aware of the level of service provided by the road network and, even with current levels of funding, recognises that an improvement in the service is needed. It is clear, therefore, that the possible reductions in maintenance funding will reduce customer satisfaction but it has not been possible to quantify the effect.

12 Scaling-up to the Full Network

12.1 Overall approach

To understand the effects of reductions in maintenance funding for local roads it was not possible in this study to analyse the whole network. The approach was therefore based on the analysis of the road networks in 8 sample Local Authorities to represent the national network. The results from the analysis of the 8 Authorities were scaled to represent the national network.

Some of the effects of changes in maintenance funding (e.g. vehicle operating costs) are driven by the condition of the road network and the traffic using the network, while others (e.g. costs of delays to traffic due to roadworks) are driven by the amount of maintenance undertaken on the network and the level of traffic. Each aspect of cost was therefore scaled independently and the scaled costs combined to show the overall costs for the network.

For all aspects of costs, the Local Authorities are considered in the groups shown in Appendix C (i.e. rural, urban, semi-urban, city). Each type of Authority is represented in the 8 sample Authorities and the results of the analyses for each Authority type were used to scale up the costs for the Authorities of that type that were not included in the sample Authorities.

Where the 8 sample Authorities included more than one Authority for an Authority type (e.g. there were 3 rural Authorities in the sample). The results from all the sample Authorities of the type were combined for use in estimating the costs for the Authorities of that type, not in the sample. The approach adopted for scaling up the results was the same for all Authority types but the analysis was carried out separately for each Authority type.

Where there was more than one sample Authority of the same type, the results from the analyses of the sample Authorities of that type were combined to create a representative factor that could be used to scale up the costs for the Authorities of that type, not included in the sample Authorities.

12.2 Representative factors

For each aspect of cost (e.g. vehicle operating cost) and the network and vehicle type considered, a representative factor for each Authority type was derived based on the sample Authorities of that type. These factors were used to convert the total costs for the sample Authorities of that type to a 'fingerprint' value for that aspect of cost to be used for all Authorities of that type not in the sample. The equivalent factor for each Authority not in the sample was then calculated and used to derive the value for each aspect of cost for each Authority.

Where the sample Authorities included more than one Authority of the same type, the results from the sample Authorities were used in the total cost for the network, not costs derived using the representative factors for that Authority type.

The relationship for the change in vehicle speed as roads deteriorate was based on a study of the change in traffic speed on trunk roads in England. This cost was therefore estimated only for urban and rural local A roads and the results from the sample

Authorities were scaled only for these road types. No costs or benefits were estimated for changes in traffic speed due to road surface condition on other road types.

12.3 Total network cost

The total cost for the network was the sum of each of the costs for all road types and vehicle types in all Authorities. A description of the calculations applied to the sample analyses for each aspect of cost is given in Appendix L. The results from the application of the scaling methodology are shown in Table 12.1 to Table 12.3 in undiscounted 2002 prices for each budget scenario. The sample Authorities are highlighted in light blue.

Table 12.1 Costs for all the network for Scenario 1

Authority	Vehicle Operating Costs (£m)	Travel Time Delay Costs (£m)	User Delay Costs (£m)	CO_2 Emissions Cost (Network Condition) (£m)	Delay Carbon Costs (£m)	Works Carbon Cost (£m)	Baselined Cumulative Depreciation (£m)
Aberdeenshire	8374	39	24	455	0	5	68
Dumfries and Galloway	3149	21	10	171	0	6	31
Edinburgh, City of	9610	47	206	513	5	3	17
Fife	8682	48	60	474	1	5	1
Glasgow City	6297	49	16	323	0	1	67
Highland	4719	29	8	258	0	4	94
North Lanarkshire	8016	33	30	423	0	2	17
South Ayrshire	2667	15	3	140	0	1	28
Rural	22775	146	198	1244	1	17	16
Rural	41175	302	59	2297	0	12	93
Rural	41398	358	92	2334	0	12	37
Rural	23823	128	23	1281	0	2	38
Rural	22489	149	110	1236	1	12	16
Urban	5570	17	27	289	0	1	3
Urban	11285	50	68	593	0	2	9
Urban	13200	44	106	687	0	1	9
Urban	7846	23	18	405	0	0	12
Urban	13929	68	75	737	0	1	6
Urban	8583	27	45	447	0	1	13
Urban	7608	20	75	395	0	2	4
Urban	10392	67	37	572	0	1	12
Semi Urban	4880	22	74	261	0	2	4
Semi Urban	6344	36	54	344	0	2	3
Semi Urban	13838	110	47	775	0	1	13
Semi Urban	6754	45	185	368	1	5	15
Semi Urban	8570	46	50	461	0	2	10
Semi Urban	8708	27	100	463	0	4	4
Semi Urban	12048	73	17	621	0	0	25
City	7624	42	110	392	1	1	9
City	24847	196	67	1396	0	10	33
Islands	6609	36	37	359	0	4	7
Islands	10215	41	42	544	0	4	12
Islands	392020	2352	2073	21258	16	124	727
Total	8374	39	24	455	0	5	68

Note: (2002 prices undiscounted)

Table 12.2 Costs for all the network for Scenario 2

Authority	Vehicle Operating Costs (£m)	Travel Time Delay Costs (£m)	User Delay Costs (£m)	CO_2 Emissions Cost (Network Condition) (£m)	Delay Carbon Costs (£m)	Works Carbon Cost (£m)	Baselined Cumulative Depreciation (£m)
Aberdeenshire	8413	40	19	455	0	1	76
Dumfries and Galloway	3173	22	8	171	0	2	45
Edinburgh, City of	9675	51	176	514	2	1	22
Fife	8760	52	47	475	0	1	9
Glasgow City	6327	50	13	323	0	0	71
Highland	4739	30	6	258	0	1	103
North Lanarkshire	8067	35	24	424	0	0	19
South Ayrshire	2676	15	3	140	0	0	30
Rural	22892	152	154	1245	1	13	18
Rural	41368	314	46	2300	0	9	109
Rural	41585	372	72	2337	0	9	42
Rural	23949	133	18	1282	0	2	45
Rural	22600	155	86	1237	0	9	18
Urban	5604	18	22	290	0	1	4
Urban	11354	53	55	594	0	1	10
Urban	13289	46	87	689	0	1	11
Urban	7891	24	14	405	0	0	13
Urban	14019	72	62	739	0	1	7
Urban	8639	28	35	448	0	1	15
Urban	7658	21	61	395	0	2	5
Semi Urban	10468	72	29	573	0	1	15
Semi Urban	4921	24	60	261	0	2	6
Semi Urban	6394	38	42	345	0	1	4
Semi Urban	13934	117	37	776	0	1	17
Semi Urban	6804	48	142	369	1	4	20
Semi Urban	8637	49	39	462	0	2	13
Semi Urban	8776	29	74	464	0	3	5
City	12130	78	14	622	0	0	27
City	7677	45	91	392	1	1	10
Islands	24958	204	53	1397	0	8	37
Islands	6642	38	29	359	0	3	8
Islands	10270	42	34	545	0	4	14
Total	394292	2469	1650	21289	9	86	845

Note: (2002 prices undiscounted)

Table 12.3 Costs for all the network for Scenario 3

Authority	Vehicle Operating Costs (£m)	Travel Time Delay Costs (£m)	User Delay Costs (£m)	CO_2 Emissions Cost (Network Condition) (£m)	Delay Carbon Costs (£m)	Works Carbon Cost (£m)	Baselined Cumulative Depreciation (£m)
Aberdeenshire	8454	42	13	456	0	1	87
Dumfries and Galloway	3195	23	6	171	0	1	54
Edinburgh, City of	9739	56	141	514	1	1	26
Fife	8835	56	32	476	0	1	18
Glasgow City	6349	52	9	324	0	0	73
Highland	4761	31	4	259	0	1	113
North Lanarkshire	8121	37	18	424	0	0	21
South Ayrshire	2686	16	2	140	0	0	32
Rural	23013	159	112	1247	1	10	21
Rural	41573	327	33	2303	0	7	121
Rural	41786	388	52	2340	0	7	46
Rural	24078	139	13	1284	0	1	50
Rural	22716	161	62	1239	0	7	21
Urban	5640	19	16	290	0	1	4
Urban	11427	55	42	595	0	1	12
Urban	13382	49	65	690	0	1	12
Urban	7937	25	11	406	0	0	15
Urban	14114	76	48	740	0	1	8
Urban	8699	30	27	449	0	0	17
Urban	7710	22	46	396	0	1	5
Semi Urban	10541	77	21	575	0	1	18
Semi Urban	4963	25	43	262	0	1	7
Semi Urban	6441	41	29	345	0	1	5
Semi Urban	14022	125	26	777	0	1	21
Semi Urban	6852	51	99	370	1	3	25
Semi Urban	8702	52	27	463	0	1	16
Semi Urban	8834	31	48	465	0	2	7
City	12203	84	11	623	0	0	29
City	7722	48	69	393	1	1	10
Islands	25077	212	38	1399	0	6	41
Islands	6677	39	22	360	0	2	9
Islands	10326	44	25	546	0	3	16
Total	396577	2592	1212	21321	7	62	961

Note: (2002 prices undiscounted)

13 Asset Valuation

13.1 Overview

The standard analysis period adopted for appraisal of transport schemes is 60 years. For such long periods, the effect of different salvage values at the end of the analysis period is generally small due to discounting. For reduced time period analyses, the effect of assumptions of salvage value becomes more important. Discussion of the basis of the calculation of the salvage value for the whole network is beyond the scope of this study.

As an asset deteriorates, the value depreciates. Local Authorities are required to show the change in the value of the road asset (i.e. the depreciation) in the annual financial accounts. The valuation methodology adopted in the UK for valuation of the local road network is based on the condition of the network and the depreciated value is the cost to return the asset to the as new condition.

The WDM network condition projection model produces an estimate of the depreciation for each length of road in the network based on the predicted future condition. This information has been used to show the overall change in the local road network for each Scenario.

The analysis included only the carriageway and did not include other parts of the infrastructure (e.g. structures, footways) and was based on the predicted carriageway condition. Other factors may impact on the condition and, therefore, the valuation as well as the predictions in the analysis (e.g. weather, utility excavations and company access from a road).

13.2 Results

An example of the results from one Authority for one road type is shown in Table 13.1 for Scenario 1 (i.e. retaining the current budget). Full details for each of the eight Local Authorities are included in Appendix K.

Table 13.1 Example asset valuation from one Authority for one road type

Year	Accumulated depreciation	
	Percent (of asset life)	Value (£m) 2009 prices
2010	52.9	81.027
2020	61.2	93.757
2030	65.6	100.424

Table 13.1 shows that maintaining the current level of spend (for this road type in this Authority) is not sufficient to prevent the further depreciation in the value of the road.

13.3 Scaling the results to the network

The results have been scaled up in accordance with the methodology described in Section 12 to derive an overall value of depreciation for the Scottish local road network during the analysis period. The results are shown at 2002 prices for the three scenarios in Table 13.2. The difference in the accumulated depreciation, compared to the base case (Scenario 1) is carried forward to the summary of the quantified impacts of reduced maintenance funding given in Section 14.2.

Table 13.2 Estimated cumulative depreciation for Scottish local roads

Year	Scenario 1	Scenario 2	Scenario 3
2010	4,105	4,105	4,105
2020	4,577	4,728	4,866
2030	4,832	4,950	5,066

Note: 2002 prices undiscounted (£m)

The undiscounted budgets for Scenarios 1, 2 and 3 over the analysis period are £7,990m, £7,043m and £6,014m. From Table 13.2, the increases in depreciation (i.e. loss in value) for the network over the analysis period with Scenarios 1, 2 and 3 are £727m, £845m and £961m respectively.

Hence, although Scenario 1 budget is £1,976m more than the budget for Scenario 3, the depreciation is only £234m more with Scenario 3. Similarly, the Scenario 1 budget is £947m more than the budget for Scenario 2 but the depreciation is only £118m more with Scenario 2.

14 Summary of Changes and Impacts

14.1 Qualitative impacts

This Section summarises the conclusions from the study against the five STAG criteria (environment, safety, economy, integration, accessibility and social inclusion).

For some sub-criteria within each criterion, there is very limited potential for road maintenance funding to have any impact and where appropriate this has been noted.

The basis for the comments is the results of the literature review (see Appendix B) and the analyses carried out in this study. References have been provided throughout the report as appropriate and are not repeated here for ease of reading.

Table 14.1 Assessment of impacts on environmental criterion

Sub-criterion	Issue	Summary
Noise and vibration	New projects	New road projects adopt the latest standards and often provide noise mitigation measures (e.g. noise barriers in urban areas). Maintenance of the barriers has not been considered in this study but it is likely that as maintenance budgets are reduced, the funding for the repair of existing barriers will be reduced.
	Road surfacings and traffic noise	The aim to minimise resurfacing costs will lead to increased lives of surfacings and pressure to adopt cheaper surfacings. After an initial settling in period, the level of noise from trafficking surfacings generally increases with surface age. Limited experience on Scottish local roads of potentially lower noise surfacings has been that the construction cost is similar to traditional surfacing but the whole of life cost is higher as they do not perform as well. The potential effect of change in noise level due to reduced maintenance expenditure is therefore considered neutral and the impact is more one of a lost opportunity. As surfaces deteriorate and funding for routine maintenance (e.g. patching) reduces, the likelihood for potholes and other sudden surface discontinuities increases. The resulting changes in ride quality lead to increased vibrations and noise in near-by buildings, particularly caused by heavy vehicles, may be a concern to local communities and might also adversely affect vehicle users, particularly those who drive for long periods (e.g. truck drivers) but these effects have not been quantified in this study.
Global air quality	Vehicle use and road maintenance	Reduced planned maintenance consumes less energy and therefore generates fewer emissions from works activity. Travel through work sites is also changed. As roads deteriorate, vehicle speeds reduce and fuel consumption changes. The effect of all these aspects has been quantified in Section 10 and the cost impact is summarised in Table 14.6. It is important to note that there might also be an increase in unplanned reactive work as the network deteriorates but no consideration of this effect has been possible.
Local air quality	Vehicle use	Local air quality due to vehicle use will be proportional to the effects of global air quality noted above. These show overall additional amounts of Nitric Oxide and Nitrogen Dioxide (jointly referred to as NOx) and Particulate Matter (PM10 and PM2.5) for the 20% and 40% scenarios respectively. However these measures should not be treated as indicative of changes in local air quality as measured at specific sites.
	Maintenance activity	Reduced road maintenance will mean less planned maintenance. Particularly at major road and bridge maintenance sites, significant dust can be generated. As maintenance funding reduces, there is likely to be fewer of these sites and this will improve the air quality, but this may be offset by an increase from the effects of unplanned maintenance (e.g. a structure collapse requiring urgent repair).

Sub-criterion	Issue	Summary
	Street cleaning	Evidence suggests that local air quality will deteriorate if streets are cleaned less.
Water quality and drainage		There is no evidence that a change in road maintenance funding will have a significant effect on drainage. However, the purpose of routine and planned drainage maintenance is to keep existing drainage functional. If such activity is reduced, the risk of local flooding will increase and outfall water quality will reduce if any drainage pollution controls are reduced. There is subjective evidence that reductions in the performance of road drainage can reduce the life of carriageways, earthworks and structures (e.g. abutments). This effect has not been quantified but would reinforce the reduction in road condition seen in this study.
Geology		The sub-criterion is unaffected by any change in road maintenance activity.
Biodiversity and habitats	Lighting	There is little evidence that biodiversity will be impacted by reduced road maintenance funding. However, there is evidence that bats will not fly in directly illuminated areas and so any reductions in street lighting due to reductions in funding might be beneficial to the bat population.
	Vegetation control	Roadside vegetation provides important grassland habitats and migration routes for many species. It has been found that a reduction in appropriate vegetation control leads to increases in noxious plants and a decline in species rich habitats. Reduced funding for appropriate vegetation control will be highly likely in each funding Scenario and therefore have a negative impact on biodiversity.
Landscape, visual amenity and cultural	Carriageways and footways	There is little evidence to suggest that differing levels of carriageway maintenance have any effect on amenity value. However, poor walking environments and transport links can leave areas isolated and damage community cohesion. Increases in cat and dog mess, litter, broken glass, vandalism, uneven footways all represent disincentives to the use of pedestrian footways and reduction in visual amenity. These negative impacts will be increased with reductions in footway maintenance.
	Street cleaning	If street cleaning is reduced, the amenity and cultural heritage of an area will decrease and levels of crime may increase. Evidence suggests that the public places importance on a clean environment such that, for example, only partial graffiti removal would still impact negatively.
Agriculture and soils		The sub-criterion is unaffected by any change in road maintenance activity.

Table 14.2 Assessment of impacts on safety criterion

Sub-criterion	Issue	Summary
Accidents	Road carriageways	Road engineering is only one of the factors which might contribute to road accidents. For the reductions in maintenance funding considered, maintenance activities related directly to safety have been protected so the effects on accidents are minimised. Poor condition of the road surface can increase the risk of accidents due to skidding and also due to road users taking evasive action to avoid hazards (e.g. potholes). A majority of Scottish Local Authorities consider current levels of maintenance funding are a threat to road safety and that the threat has increased in the last year (Asphalt Industry Alliance, 2011). This view is likely to be exacerbated with the funding cuts considered in this study. On Scottish trunk roads, a skid resistance policy has been implemented. A review of condition and accident trends suggests accidents due to skidding could increase from their current levels of around 400 to around 450 per year for the 40% funding reduction Scenario and this effect is monetised in Section 5. Only three Scottish Local Authorities that have implemented a similar policy have been identified and there is not enough evidence to draw any conclusions on the impacts in these Authorities. International evidence suggests the risk of skidding will reduce with the introduction of skid resistance policies. Introduction of a skid policy might only reprioritise existing road surfacing funds and it will inevitably require start-up and monitoring investment which may be considered unaffordable if road maintenance funding is reduced. Funding reductions potentially represent a lost opportunity to reduce road accidents due to poor skid resistance on local roads.
	Structures	Failure of a structure can be catastrophic and make headline news. Whilst maintenance funding for road safety aspects has been protected in each of the funding reduction Scenarios in this study, there will almost inevitably be an increase in the risk of failures as budgets reduce. Infrastructure failures (e.g. failures of structures) potentially result in accidents for all types of road users. The likely costs of those accidents have not been estimated in this study.
	Street lighting	Historically, one of the justifications for the introduction of street lighting has been to reduce road accidents. With recent constrained funding and an aim to reduce the carbon footprint of road network operations, some UK Authorities have reduced the level of street lighting and reported no disbenefit, but the balance of evidence still suggests lighting reduces the risk of accidents (e.g. street lighting enables pedestrians to identify and avoid defects which could cause accidents). With selective (e.g. part of the night) reductions in street lighting (i.e. targeting low risk areas first), it might be possible to avoid significant increases in the risk of accidents but for the 40% funding reduction Scenario (which assumed a

Sub-criterion	Issue	Summary
		reduction of 23% in street lighting budgets) it is likely that safety risks will increase. For example, a coarse analysis quantified in Section 5 suggests accidents (all injuries) could increase by around 45 per year (from current levels of around 2000) on the local road network following a 40% reduction in maintenance funding.
	Footways and cycle-tracks	All evidence suggests increased deterioration in footways and cycle-tracks will cause an increased safety risk to pedestrians and cyclists particularly those with mobility and visual impairments. It has not been possible to quantify the impact for the scenarios in this study.
Security	Street lighting	Poor street lighting and poorly maintained street lighting furniture increase the public's fear of crime. Funding reductions for street lighting will therefore reduce the use of streets, primarily for walking and cycling.
	Street cleaning	The issue has been discussed under landscaping and amenity in Table 14.1.
	Footways	Reduced care of footways and roadside environments (e.g. fence repairs, surface repairs, vegetation control) increase the perceived risk of crime for the public and serve as a deterrent to use. This will lead to lower social interaction in neighbourhoods which increases risks of crime. Funding reductions will exacerbate any such risks (perceived or real).

Table 14.3 Assessment of impacts on economy criterion

Sub-criterion	Item	Summary
Transport economic efficiency	Vehicle operating costs	Deterioration in road conditions will cause an increase in vehicle operating costs (fuel consumption, vehicle damage due to defects). The effect is quantified in Table 14.6. For local roads, the increased costs are carried by cars (80.3%), vans (14.4%), buses (1.8%) and trucks (3.4%). In the 40% funding reduction Scenario for local roads, in 2020 (i.e. before expenditure is assumed to increase), the undiscounted costs represent an annual additional 0.6 pence per vehicle km for cars, 1.3 pence per vehicle km for vans, 2.2 pence per vehicle km for buses and 3.6 pence per vehicle km for trucks at 2002 prices compared to the costs for the Scenario with no funding reductions.
	Journey times	Deterioration in road conditions will cause increases in travel time as vehicles travel slower on roads in poorer condition. The effect is quantified in Section 6. In the 40% funding reduction Scenario, in 2020 before maintenance expenditure is assumed to increase, the longer journey times represent an annual additional 1,349,351 hours for cars, 239,629 hours for vans, 30,998 hours for buses and 186,980 hours for trucks on all (trunk and local) roads. For local roads, the increased journey times represent an additional 988,186 hours (cars), 181,059 hours (vans), 22,596 hours (buses) and 96,435 hours (trucks). This effect is, however, more than offset by less disruption to journeys due to reduced roadworks, which have also been quantified. The effects of increases in unplanned maintenance or route diversions that might occur with reduced planned maintenance were not assessed. Infrastructure failures are likely to increase journey times for all types of road users due to travel diversions. The possible effects on road user journey times from potential breaks in network links has been demonstrated in this study by relating the effects to the experience gained from the earthworks failure at Rest and Be Thankful on the A83 (Argyll and Bute). Although the effects are relatively small, they can cause significant local issues and affect economic activity (e.g. freight diversions and loss of passing trade).
	Journey reliability	It was not possible to quantify the effects of decreased journey time reliability due to the potential increase in risk of disruptions on the network (e.g. due to failure of signs, signals, structures or other assets). Analysis of data from the closure of the A83 at Rest and Be Thankful demonstrated that if the disruption is of short duration, the costs to road users of that disruption are unlikely to outweigh savings from reduced direct maintenance costs or the changes in road user costs that occur when maintenance budgets are reduced. Nevertheless, no matter how small, the effect still serves to increase costs to society.

<table>
<tr><th>Sub-criterion</th><th>Item</th><th>Summary</th></tr>
<tr><td></td><td>Journey quality</td><td>The journey quality for all users will deteriorate under each funding Scenario. Rougher roads are more uncomfortable to drive on, reduced lighting (if applied on parts of the network) affects the ease of driving and the visual appearance of the roadway will deteriorate for the user. Customer satisfaction surveys for the trunk road network show that road users rate roads in poor condition as one of the most significant detractors on their journeys, and Local Authorities will face similar concerns.

Local Authority customer satisfaction surveys show the reduction in satisfaction with road maintenance and road condition to be the source of two of the biggest reductions in satisfaction with Local Authority services in recent years. The level of public satisfaction is expected to continue to fall under all 3 funding Scenarios considered.</td></tr>
<tr><td colspan="3">Wider economic benefits and economic activity and location impacts have not been considered further in this study. Surveys of business attraction to Scotland include the quality of transport availability such as airport connections, but do not address the more detailed issues of maintenance of road surfaces. However, there is anecdotal evidence that specific industries take into account the availability and quality of the road network when considering the locations of depots and other facilities. Similarly, tourism may be affected if road condition becomes much poorer but this is not expected to be significant for the levels of condition predicted in this study. Poor road condition can deter travel and therefore affect transport industries (e.g. buses) and local businesses. Increased travel time costs have been included in the analysis (see above) but the second order effect of deterred travel have not been considered and overall, the effects of maintenance on these aspects are considered marginal.</td></tr>
</table>

Table 14.4 Assessment of impacts on integration criterion

Sub-criterion	Item	Summary
Policy integration	Physical fitness and health	The Scottish government would like to see improved health outcomes which are in many cases strongly linked to the degree of physical fitness levels of a community. The potential for increased severance noted under the accessibility and social inclusion criterion will be a disincentive for affected communities to maintain physical fitness levels. There are strong connections between road condition and policies on health and obesity as poor carriageway and footway condition deter walking and cycling. Road condition also affects equalities since women will often view the public realm differently from men, primarily because of fear of crime and being alone in an unsafe environment. The success of Government policies (e.g. Cycling Action Plan for Scotland, (Scottish Government, 2010a), Route Map to Healthy Weight, (Scottish Government, 2010c)) is directly related to the standard of provision of carriageways, footways and cycle-tracks. Scottish Government policies for Designing Streets (Scottish Government, 2010b) and Designing Places (Scottish Government, 2001) set out the policies for streets and communities. They include Ministerial statements on the value placed on delivering healthy lifestyles and growing local economies which are closely linked to well designed and well maintained environments. Designing Streets puts people and places before the movement of vehicles: "Attractive and well-connected street networks encourage more people to walk and cycle to local destinations, improving their health while reducing motor traffic, energy use and pollution". The health benefits of increased walking (i.e. if 1 in 100 currently inactive people took adequate exercise) have been estimated to save the National Health Service in Scotland £85m per year (Scottish Government, 2003).
Transport integration and *transport and land-use integration* have not been considered further in the study. The effects of maintenance on these aspects are considered marginal.		

Table 14.5 Assessment of impacts on accessibility and social inclusion criterion

Sub-criterion	Item	Summary
Community accessibility	Remote communities	New investment may be focused on improving links with rural communities which often do not show a quantifiable economic benefit. Lifeline roads, where there is usually only one route for access, will be strongly affected if the condition of the route significantly deteriorates. Road maintenance management approaches inevitably focus funding where risks and traffic are most significant, therefore it is expected that remote communities will suffer comparative disadvantage if maintenance funding is reduced and those routes are not prioritised.
	Structures, footpaths, cycle-tracks	Potential increased risk of structural failure could have a significant effect on community accessibility. For example, a bridge spanning a river with a community on both sides of the riverbank. However, due to safety concerns it is likely that such assets will be shielded the most from the effect of budget reductions. However, if facilities such as pedestrian underpasses or footpaths are poorly maintained and suffer reduced use due to fears of crime and accidents as noted elsewhere, a similar effect of severance will be realised in the long term.
	Pedestrian	Any increase in roadside noise or deterioration in local air quality, visual amenity and appearance (graffiti etc) and street lighting will have a more comparatively significant effect on pedestrians (and cyclists) than other road users.
	Cyclists	Reduction in traffic calming measures will lead to less favourable conditions for cyclists (assuming such measures adequately address the needs of cyclists). Poorly maintained surfacing with loose material, uneven edges and potholes are a major deterrent for cyclists as they increase their risk of accidents. Such budget items are often the first carriageway items to be reduced in constrained funding environments. It is therefore likely that cyclists will experience a more comparatively significant effect than other road users for such impacts.
Comparative accessibility	Older people	Older people are more likely to be adversely affected as defects on footways increase and street lighting and other amenities and activities are reduced due to a greater fear of crime and potential accidents. They will therefore experience a bigger effect than other road users for such impacts.

Sub-criterion	Item	Summary
	People with disabilities	Under the Disability Discrimination Act: Transport Scotland Good Practice Guide for Roads (Transport Scotland, 2009a) Local Authorities must ensure that road maintenance policies do not disadvantage disabled people. Uneven footways have a bigger impact on people with disabilities (e.g. visual impairment, or mobility) so that deterioration in the quality of such assets will have a comparatively bigger effect on disabled people. The Disability Discrimination Act: Good Practice for Roads (Transport Scotland, 2009a) lays out clearly the accessibility standards needed to enable disabled people to use road environments. If carriageways and footways fall below accepted standards of accessibility then this will have a direct impact on the use of the road network by disabled people by affecting access to local businesses and facilities, and thus increasing the severance for those affected.

14.2 Quantitative impacts

Appendix J provides the detailed annual costs and benefits for the analyses undertaken. Table 14.6 and Table 14.7 summarise the overall quantified costs and benefits for each Scenario for the 20 year analysis period. It is essential to note that:

- Quantification of the impacts represents only a portion of the various impacts that have been discussed in Section 14.1.
- The analysis is an assessment using high-level summary data only and has involved a number of significant assumptions which are discussed in Appendix C.
- The effects on the pavement asset value are summarised in Table 14.8.

Notwithstanding these comments, the analysis shows that there is an increase in user costs with increasing budget cuts and the accumulated depreciation of the asset shows that the condition at the end of the asset value is diminished by the end of the analysis with increasing budget cuts (i.e. condition does not return to the same level that could be achieved by maintaining current levels of maintenance expenditure despite increasing budgets in the latter half of the analysis).

Table 14.6 Summary of quantified economic impacts over 20 years

Cumulative Discounted Costs for Local Road Network (£m)	Scenario 1	Scenario 2	Scenario 3
Financial costs			
Internal works costs	5,677	4,989	4,218
Economic impacts			
Vehicle operating costs	274,246	275,731	277,212
Travel time costs (surface condition related)	1,572	1,649	1,730
Accident costs (skid related)	N/A	N/A	N/A
Delays costs (roadworks)	1,480	1,126	768
Lighting costs (accidents)	2,155	2,173	2,192
$C0_2$ emissions	14,971	14,957	14,955
Overall impact	294,424	295,636	296,857

Note: Discount rate = 3.5%.

Table 14.7 Summary of economic impacts compared to the base case

Cumulative costs[1] (£m 2002[2] Prices)	Undiscounted[3]			Discounted[3]		
	Scenario 1 (Base Case)	Scenario 2	Scenario 3	Scenario 1 (Base Case)	Scenario 2	Scenario 3
Financial Costs to Transport Scotland						
Maintenance works	7990	-947	-1976	5877	-688	-1459
Impacts on Society						
Vehicle operating costs	392,020	+2,272	+4,558	274,246	+1,485	+2,966
Travel time (surface condition related)	2,352	+117	+240	1,572	+77	+158
Accident costs (skid related)	N/A	N/A	N/A	N/A	N/A	N/A
Delays (through roadworks)	2,073	-423	-861	1,480	-354	-712
Lighting (accidents)	2,975	+23	+47	2,155	+18	+37
$C0_2$ Emissions	21,398	-13	-8	14,971	-14	-16
Overall (non-works) impact	420,818	+1,976	+3,976	294,424	+1,212	+2,433
Economic analysis						
Works costs reduction	Base Case	947	1976	Base Case	688	1,459
Increase in non-works costs	Base Case	1,976	3,976	Base Case	1,212	2,433
Net Present Value[4]	Base Case	-1,029	-2000	Base Case	-524	-974

Notes:
1. *Annual discount rate = 3.5%.*
2. *2002 prices are 2010 prices factored by 0.81.*
3. *Scenario 2 (20% reduction) and Scenario 3 (40% reduction) figures are shown as differences compared to Scenario 1 (2010/11 funding retained).*
4. *Negative NPV shows an overall increase in cost (i.e. non-works costs increase more than the reduction in maintenance expenditure).*

Table 14.8 Summary of pavement asset depreciation

Depreciation [at 2002 prices] (Current accumulated depreciation = £4,105m)			
Accumulated depreciation at 2030	4,832	4,950	5,066
Difference compared to 2010 accumulated depreciation	Base Case	-118	-234

14.3 Sensitivity analysis

The results of the quantified analyses showed the largest contribution to the overall Net Present Value came from Vehicle Operating Costs and the changes in those costs for Scenarios 2 and 3 are sufficient to remove any potential savings achieved by reducing the maintenance budget over the analysis period.

Various assumptions were made in the estimation of the Vehicle Operating Costs but two of the key components in the total costs are the cost of fuel in the total Vehicle Operating Costs and the effect of scaling the results from the 8 sample Local Authorities to give the results for all the road network.

14.3.1 Effect of fuel costs on vehicle operating costs

From the analysis of Vehicle Operating Costs using the HDM-4 model, fuel makes up nearly half of the total cost. The other major component of cost, for all vehicle types, is the cost of labour used for vehicle maintenance. The vehicle crew costs have been removed and are considered in the costs associated with journey time. Much of the labour costs arise from regular maintenance and are less affected by changes in condition of the road network but the cost component from fuel changes more directly with change in road surface condition. The costs of spare parts also change with road condition but there is little effect on capital costs, oil or tyre costs from changes in road condition.

Table 14.9 shows the components of Vehicle Operating Cost per vehicle for different levels of road condition. The Table shows the costs over a wider range of road surface condition (IRI) than is expected to occur in any year for any of the Scenarios. For this analysis, the likely range in condition is in the band of IRI between 2.5 and 5.

The total Vehicle Operating Costs of spare parts changes only due to road surface condition but in the analysis, the component of cost arising from fuel consumption allows for a real increase in the cost of fuel over the analysis period but this is balanced, in part, by an expected improvement in vehicle engine efficiency. All cost components reflect the increase in the number of vehicles resulting from the assumed annual traffic growth rates.

The results of the analysis described in Section 14.2 show an increase in Vehicle Operating Costs as the maintenance budget is reduced (i.e. Scenarios 2 and 3) and these increases are the main contributor to the overall increase in NPV for these Scenarios. To assess the minimum increase in Vehicle Operating Costs that may result from the change in road condition, the assessment of these costs has been repeated but with no traffic growth in the analysis period and no real increase in the cost of fuel. The real improvements in vehicle fuel efficiency were retained in the assessment. Table

14.10 shows the change in Vehicle Operating Costs and the impact on the NPV resulting from the reduced Vehicle Operating Costs.

Table 14.9 Effect of road condition on vehicle operating costs

Road Condition (IRI)	Vehicle Type	Cost (pence/vehicle/km) (2002 prices)						
		Capital	Fuel	Labour	Oil	Parts	Tyres	Total
1.0	HGV	59.9	147.1	215.6	13.4	110.8	27.1	573.9
	PSV	53.4	39.5	118.7	6.6	23.1	6.6	247.9
	Car	66.4	21.8	38.7	2.0	19.2	1.2	149.4
	LGV	66.5	27.0	40.6	9.0	27.6	1.8	172.5
4.0	HGV	60.6	153.0	231.1	13.6	126.6	27.6	612.4
	PSV	54.1	40.9	133.9	6.6	29.2	6.7	271.4
	Car	66.4	22.2	41.3	2.0	21.6	1.2	154.7
	LGV	67.3	27.7	43.2	9.1	31.0	1.8	180.0
7.0	HGV	75.3	159.9	260.7	13.7	159.7	28.1	697.6
	PSV	67.2	42.3	161.9	6.7	42.1	6.7	327.0
	Car	68.1	22.6	47.8	2.0	28.2	1.2	170.0
	LGV	83.6	28.3	48.4	9.1	38.2	1.8	209.5
9.5	HGV	90.9	166.8	280.3	13.9	183.7	28.3	763.8
	PSV	81.1	43.3	178.8	6.7	51.0	6.8	367.7
	Car	70.1	22.9	52.7	2.1	33.7	1.3	182.8
	LGV	100.9	29.0	52.0	9.2	43.5	1.8	236.3

Rather than an overall increase in cost from reduced maintenance expenditure (i.e. Scenarios 2 and 3), both Scenarios show there is an overall saving when there is no traffic growth or real increase in the cost of fuel.

Therefore, between the base assumptions, for traffic growth and increase in fuel costs through the analysis period, and no growth in these parameters there is a level of growth that leads to no overall change in cost resulting from a reduced maintenance budget.

Table 14.10 Revised economic impacts from reduced vehicle operating costs

Cumulative Discounted Costs for Local Road Network (£m)	Scenario 1	Scenario 2	Scenario 3
Economic impacts – Base Analysis			
Vehicle operating costs	274,246	275,731	277,212
NPB (Works cost savings)	Base Case	688	1,459
NPB (User cost savings including emissions)	Base Case	-1,212	-2,433
Overall impact (NPV)	Base Case	-524	-974
Economic impacts – Revised Vehicle Operating Costs			
Vehicle operating costs	140,988	141,617	142,238
NPB (Works cost savings)	Base Case	688	1,459
NPB (User cost savings including emissions)	Base Case	-356	-716
Overall impact (NPV)	Base Case	332	743

Notes:
1. *Annual discount rate = 3.5%*
2. *Traffic growth included*
3. *Scenario 2 (20% reduction) and Scenario 3 (40% reduction) figures are shown as differences compared to figures for Scenario 1 (2010/11 funding retained).*
4. *Negative NPV shows an overall increase in cost (i.e. user costs increase more than the reduction in maintenance expenditure).*
5. *2002 prices are 2010 prices factored by 0.81.*

14.3.2 Revised scaling of vehicle operating costs

To calculate the costs for the whole road network based on the analyses of the 8 sample Local Authorities, the results of the analyses for the sample Authorities were scaled using the approach described in Section 12. For the sensitivity test in Section 14.3.1, because the dominant cost in the overall analysis was the Vehicle Operating Costs, the sensitivity of only that aspect of cost was considered in the analysis.

For the scaling up of results in the base analysis, the percentage of the network (for each road type) in red condition (i.e. categorised as red in the SRMCS report for 2009/10) was used for each Authority not in the sample of 8 Authorities analysed. However, an alternative assumption that may better reflect the overall condition of the network would have been to scale the results based on the percentage of the network (for each road type) in red and amber condition (i.e. as categorised in the SRMCS report for 2009/10).

To assess the potential effect on the overall results of the revised scaling approach, Vehicle Operating Costs for all of the non-sample Authorities were derived using the alternative (i.e. percentage of the network in red and amber) scaling factors. Table 14.11 shows the effect on the overall Vehicle Operating Costs and the NPV for the analyses.

The revised scaled values continue to show an increase in the overall NPV if maintenance funding is reduced but the increase in cost over the analysis period is reduced from £524m to £447m for Scenario 2 and from £974m to £806m for Scenario 3.

Table 14.11 Vehicle operating costs using red and amber parts of the network

Cumulative Discounted Costs for Local Road network (£m)	Scenario 1	Scenario 2	Scenario 3
Economic impacts – Base Analysis			
Vehicle operating costs	274,246	275,731	277,212
NPB (Works cost savings)	Base Case	688	1,459
NPB (User cost savings including emissions)	Base Case	-1,212	-2,433
Overall impact (NPV)	Base Case	-524	-974
Economic impacts – Revised Vehicle Operating Costs			
Vehicle operating costs	255,346	256,754	258,144
NPB (Works cost savings)	Base Case	688	1,459
NPB (User cost savings including emissions)	Base Case	-1,135	-2,265
Overall impact (NPV)	Base Case	-447	-806

Notes: 1. Annual discount rate = 3.5%.
2. Traffic growth included
3. Scenario 2 (20% reduction) and Scenario 3 (40% reduction) figures are shown as differences compared to figures for Scenario 1 (2010/11 funding retained).
4. Negative NPV shows an overall increase in cost (i.e. user costs increase more than the reduction in maintenance expenditure).
5. 2002 prices are 2010 prices factored by 0.81.

15 Conclusions and Recommendations

15.1 Economic analysis

The economic analysis was based on a sample of 8 Local Authorities and the results of those analyses scaled to provide the information for the whole of the Scottish Local Road network.

The effect of the maintenance funding reductions on network condition was assessed by WDM Ltd using a proprietary analysis model that had been used for similar analyses in 2010. No analysis of the sensitivity of the results from the model has been undertaken. The results from the analyses suggest there would be little benefit in increasing the sample size of Authorities until more reliable data for the analyses can be obtained.

In practice, budgets have since been further reduced for both networks compared with those used in the Scenario. The implication is that there is already a long term disbenefit to society if current investment levels continue.

A subjective analysis identified the potential reductions in road maintenance budgets of 20% and 40% would lead to reductions in carriageway structural maintenance of 34% and 68% respectively. This subjective analysis was based on limited information from individual Authorities and it is recommended that improved budget information is obtained to re-examine the likely impact of maintenance funding reductions on the funding for carriageway structural maintenance.

Network condition was predicted to deteriorate with the current level of funding (Scenario 1) and increased funding in years 11 to 20 of the analysis period, after reductions of 20% (Scenario 2) and 40% (Scenario 3) in years 1 to 10, was insufficient to achieve the condition predicted for the end of the analysis period from maintaining the current level of funding.

The results of the economic analysis show that reducing the road maintenance budget has an overall negative Net Present Value, as user costs increase more than the savings achieved in works costs. However, considerable assumptions and approximations have been made in the analyses and it cannot be assumed the overall impacts shown for the budget reductions will be fully achieved in practice.

The results of the analyses show for every £1 (undiscounted) saved by reducing maintenance budgets, there is an increase of more than £2 in non-works costs from the wider impacts of the reduced maintenance. The ratio is £1 to £1.67 for discounted costs with the 40 percent overall reduction in maintenance funding.

Furthermore even though Scenarios 2 and 3 restore the budget to current levels by 2025 and include a further 2.5% per year increase over current spend the condition of the network does not recover to the same level achieved under Scenario 1 (maintain current level of spend) at the end of the analysis period.

The non-works costs are dominated by the vehicle operating costs (which are themselves dominated by fuel costs), which account for the largest variation between the different scenarios (Scenario 3 being the most expensive and Scenario 1 being the lowest cost). However, the variation in vehicle operating costs is small, around 1%. No models of the change in vehicle operating costs for the levels of condition expected on the Scottish Local Road network were identified. The HDM-4 model was used to estimate these costs through the analysis period for 4 vehicle types and to undertake a sensitivity analysis on the effects of fuel costs over the 20 year period. Vehicle operating cost is the major cost component of the total Net present Value over the analysis period. Improved model analyses would therefore provide greater insight and reliability in the predicted consequences of the reduced maintenance funding. A sensitivity analysis of the vehicle operating costs examined the effect of removing traffic growth and the real increases in fuel costs forecast in STAG. These changes were sufficient to show an overall reduction in Net Present Value from reduced maintenance funding. The level of vehicle operating costs is approximately halved and, although the increase in vehicle operating cost between Scenarios 3 and 1 remained at approximately 1%, the actual increase was not sufficient to remove the savings achieved from the reduced maintenance budget. Further sensitivity analyses would help develop a more robust picture of the overall effects of the changes in maintenance funding.

Scaling the results of the vehicle operating cost from the analyses of the sample Local Authorities to the whole network analyses used the percentage of the network in 'red' condition, as given by the 2010 SRMCS report. A further sensitivity test on the approach adopted for scaling the results to the whole network used the percentage of the network in 'red + amber' condition. The effect was to reduce the scaled vehicle operating costs by approximately 13% but the increase in the costs caused by the maintenance reductions remained at approximately 1% for the 40% reduction in funding (Scenario 3). The change reduced the overall increase in the Net Present Value but still showed an overall increase in the Net Present Value resulting from the reduced maintenance funding.

There was insufficient skid resistance data available to assess the impact on the number of skidding accidents from reduced maintenance funding on the Local Road network.

The increase in maintenance during the last 10 years of the analysis period increases the associated delays to road users at roadworks but over the analysis period, the total costs of delays to road users for the scenarios for reduced funding are less than for the scenario that retains the 2010 level of maintenance funding.

With reduced maintenance funding there is increased risk of failure of the infrastructure. Analysis of the consequences of an earthwork failure in Scotland has suggested an increase of 7 times the costs from the reported incident would generate the same economic impact as a 20% reduction in maintenance funding. Evidence from Perth and Kinross Council suggests that infrastructure failures result in at least one main route closure per year, with the current level of maintenance funding.

Based on the analysis of the depreciated replacement cost of footways from 9 Local Authorities the condition of the footway and cycle-track assets is likely to be deteriorating at current levels of expenditure and therefore will be subject to increased deterioration under reduced budgets.

Reducing the lighting budget will likely result in fewer lit street lights (since lower cost lighting technologies have an initial investment cost). Reducing street lighting has an effect on amenity and a measurable increase of between 10% and 30% in the number of accidents. At a 10% increase in accidents, a reduction in lighting costs is economically beneficial, whereas if the increase in accidents is 30% then there is an overall increase in cost.

The literature review highlighted the related benefits of street lighting from reductions in crime, easier mobility and improved commercial viability. These will all off-set any increase in the number of accidents but there is no reliable quantification of the overall effect.

The effects of carbon emissions from vehicles under normal running and while passing roadworks, and from changes in the amount of maintenance carried out have been assessed for each Scenario. The results suggest little difference between the costs of CO_2 emissions for the 3 Scenarios.

An estimate of the cumulative depreciation cost of the local road network, by WDM Ltd, has suggested that with the current level of funding the depreciation of the network will increase by nearly 20% over the analysis period and by nearly 25% if the maintenance budget is reduced by 40% (Scenario 3).

15.2 Qualitative analysis

Based on the literature review and discussions at a stakeholder workshop (see Appendix M), the user group most affected by a reduction in road maintenance would be pedestrians, especially those with mobility and visual impairments. Pedestrians would be affected in every aspect including noise and vibration, global air quality, visual amenity, cultural and landscape, physical fitness, accidents, security, community and comparative accessibility.

The effect of maintenance budget reductions on the condition of footways and cycle-tracks was not assessed in this study. A related study, based on the valuation of the footway asset, has highlighted the investment needed for footways. It was considered unlikely that the budget needed would be allocated under any of the funding scenarios considered in this study so it is likely that the condition of footways and cycle-tracks will continue to deteriorate.

The literature review and the Workshop held during the study highlighted impacts of maintenance funding that cannot currently be quantified and do not, necessarily, fit the current STAG criteria. These include:

- Improved footway condition to encourage walking and, hence, healthier lifestyles
- Increases in the number of cyclists (e.g. this will support the Cycling Action Plan for Scotland (Scottish Government, 2010a))
- Avoidance of the 'broken windows' effect (i.e. general deterioration of the locality when the area does not appear to be looked after)
- Reduced compensation costs from lower claims following accidents
- Reduced health service costs from the reduction in accidents
- Increases in house prices and commercial activity in areas with well maintained roads
- Reduced litter on well maintained roads

Examples were identified where proactive funding could also lead to lower long-term costs (e.g. health budget used to fund winter maintenance, to help reduce the number of accidents, and streetworks planning to complete all activities at the same time and avoid re-visiting the site for a longer period of time). The study has confirmed the lack of robust quantified benefits from maintenance. It is recommended that further work is used to develop approaches that can be adopted to better quantify the consequences of alternative levels of maintenance funding.

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Glossary

AADF	Annual Average Daily Flow
AIA	Asphalt Industry Alliance
ALARM	Annual Local Authority Road Maintenance
CABE	Commission for Architecture and the Built Environment
CDT	Cycling Demonstration Town
CIMS	Cleanliness Index Monitoring System
CMH	Ceramic Metal Halide
COSLA	Convention of Scottish Local Authorities
dB(A)	A-weighted Decibel (measure of noise)
DEFRA	Department for Environment, Food and Rural Affairs
DfT	Department for Transport
DPTAC	Disabled Persons Transport Advisory Committee
ESALF	Equivalent Single Axle Load Factor
GDP	Gross Domestic Product
HA	Highways Agency
HGV	Heavy Goods Vehicle
HPS	High Pressure Sodium
HRA	Hot Rolled Asphalt
ICE	Institution of Civil Engineers
ILE	Institution of Lighting Engineers
IRF	International Road Federation
IRI	International Roughness Index
ISOHDM	International Study on Highway Development and Management (HDM-4)
KSI	Killed and Seriously Injured
LGV	Light Goods Vehicle
LPV	Longitudinal Profile Variance (mm^2) (reported at 3m, 10m or 30m wavelengths)
NOx	Nitric Oxide and Nitrogen Dioxide
NPB	Net Present Benefit
NPV	Net Present Value
NTS	National Travel Survey
OGV	Other Goods Vehicle
PET	Personal, Environmental, Trip (related)

PM10	Particulate Matter < 10 µm
PM2.5	Particulate Matter < 2.5 µm
PSV	Public Service Vehicle
PTE	Passenger Transport Executive
QUADRO	Queues and Delays at Roadworks
RAMP	Road Asset Management Plan
RCI	Road Condition Index
RPI	Retail Price Index
SCANNER	Surface Condition Assessment for the National Network of Roads
SCOTS	Society of Chief Officers of Transportation in Scotland
SCRIM	Sideway-force Coefficient Routine Investigation Machine
SEU	Social Exclusion Unit
SFC	Sideway-Force Coefficient
SMTD	Sensor Measured Texture Depth
SOLACE	Society of Local Authority Chief Executives
SRMCS	Scottish Road Maintenance Condition Survey
STAG	Scottish Transport Appraisal Guidance
SUDS	Sustainable Urban Drainage Systems
TfL	Transport for London
TRIP	A national transportation research group, Washington DC, USA
VOC	Vehicle Operating Cost

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Appendix A Literature Review

A.1 Methodology

This Annex provides the results of the literature review on the qualitative wider economic and social impacts which result from potentially worsening road conditions. It is also a follow up to the literature review prepared in the associated study for trunk roads (Transport Scotland, 2011b). In this review the following activities were undertaken:

- Review of the documents provided by the Working Group which were not covered in the literature review for the trunk roads study
- Undertake focused literature searches to cover the current gaps (biodiversity, noise and vibration, global air quality, street cleaning, drainage and landscape) identified in the trunk roads study and review the identified documents.
- Integrate all the results from the literature reviews to provide a comprehensive matrix/report on the qualitative impacts of the reduced road maintenance spend on the wider economic and social factors.

The literature searches have produced a total of 131 documents (32 from the Working Group) covering findings from mostly the UK and Europe. A full list of these documents is given in Sections A.2 and A.3.

Of the 131 documents, 65 have been assessed as relevant according to five key questions. The contents of these relevant documents have been reviewed and each document has been assigned a RAG (Red, Amber or Green) rating. The RAG classification is described in Table A.1.

Table A.1 Document relevance value rating

Colour code	Document relevance rating	Rating description	Number of documents in the category
Grey	Not relevant	Document is not relevant	66
Red	Low relevance	Document contains some general statements about the economic and social impacts of shortfalls in road maintenance but no evidence has been provided.	26
Amber	Medium relevance	Document contains some evidence about the economic and social impacts of shortfalls in road maintenance but it would be inferred.	25
Green	High relevance	Document contains direct evidence about the economic and social impacts of shortfalls in road maintenance.	14

In addition to looking at the value of the relevant documents, their content was also assessed against a coverage matrix of impacts and activities or assets. The coverage matrix is given in Table 3.1.

A list of the documents considered is given in Section A.2. The findings of all the documents identified as relevant have been collated and summarised in Section A.3.

A.2 Document List

Table A.2 lists the documents in the order of lead author and provides the item reference number for use in Section A.3.

Table A.2 Documents included in the literature review

#	Author	Title
71	Abbott, P.G., Morgan, P.A. and McKell, B.	A review of current research on road surface noise reduction techniques
1	Anastasopoulos, P.C., Florax, R.J.G.M., Labi, S. and Karlaftis, M.G.	Contracting in highway maintenance and rehabilitation: Are spatial effects important?
2	Ansved, L.	Techniques and tools for the implementation of a new Swedish Maintenance Philosophy
3	Asphalt Industry Alliance	Annual Local Authority Road Maintenance (ALARM) survey 2011
85	Asphalt Industry Alliance	The economic impact of local road condition
72	Audit Commission	Going the distance - achieving better value for money on road maintenance (Local government report)
4	Auditor General for Scotland and Accounts Commission	Maintaining Scotland's roads
5	Back, A.	Habitats by design
6	Bayar, A., Fortuna, M. and Rege, S.	Welfare impacts of road construction using a public-private partnership: a CGE analysis of a project
68	BBC News	Flood-hit areas face travel chaos
93	Beyer, F.R. and Ker, K.	Street lighting for preventing road traffic injuries (Review)
7	Borges, I.M.	The added value of accessible public transport for all in the context of demographic ageing
8	Bradbury, A., Tomlinson, P. and Branning, C.	Social and community impacts study
103	Branco, F.E.F.	International symposium on the environmental impact of road pavement unevenness
9	Breeze, J.	Impact assessment form and action table (budget cuts)
10	Brett, S.	The light fantastic
105	Brewer, S	Route canal work brings relief

#	Author	Title
11	Brown, P.	A Roads Policy for London: Challenges and opportunities for maintaining and improving road transport operations in London
61	Buchanan, C.	Valuing urban realm - business cases for public spaces (Summary Report)
12	Buchanan, P. and Gay, N.	Making a case for investment in the public realm
100	Buckinghamshire County Council	Switching off street lights to save energy trial - Second interim report
63	Burnett, A.	In the right place accessibility, local services and older people
13	CABE Space	Paved with gold - The real value of good street design
128	Cabinet Office	An analysis of urban transport
111	Campbell, S.	Deteriorating vision, falls and older people: the links
14	Campos, A. L. and Adelaja, S.	Local roads speeding and urban sprawl: An analysis of the casual relation in the Detroit Metropolitan Area
15	Chan, C., Forwood, D., Roper, H. and Sayers, C.	Public infrastructure financing: An international perspective
94	Chang, Hsin-Li. and Chang Hsin-Wen.	Exploring recreational cyclists' environmental preferences and satisfaction: experimental study in Hsinchu technopolis
73	Clegg, A.	Contribution of road and street maintenance to make better places
67	Cormany, D. L.	Small retailers struggle to survive bridge collapse
87	Crabb, G.I., Crinson, L., Beaumont, R. and Walter, L.	The impact of street lighting on night-time road casualties
16	Crick, J.	Keeping an eye on the road
17	Crick, J.	Don’t scratch the surface
97	Cycling England	A sustainable future for cycling
96	Daley, M., Rissel, C. and Lloyd, B	All dressed up and nowhere to go? A qualitative study of the barriers and enablers to cycling in inner Sydney
69	DEFRA	Code of Practice on Litter and Refuse
45	Department for Transport	Traffic Advisory Leaflet 5/08. Walking Bibliography
62	Department for Transport	Traffic Advisory Leaflet 5/03. Walking Bibliography
18	Department of Transport	Manual for Streets 2
119	Emery, M.	Effect of street lighting on bats
86	Farrington, D.P. and Welsh, C.	Effects of improved street lighting on crime: a systematic review
19	Fezzi, C., Crowe, A., Abson, D., Bateman, I., Askew, T., Munday, P., Pascual, U., Sen, A., Darnell, A. and Haines-Young, R.	Evaluating provisioning ecosystem service values: a scenario analysis for the United Kingdom

#	Author	Title
20	Forman, R.	Road ecology: a look behind the book and the field
57	Forslund, U. and Johansson, B.	Assessing road investments: Accessibility changes, cost benefit and production effects
21	Fowler, D.	Roads in an era of austerity
22	Fox, P.	Invest to save - sustainable street lighting
23	Glendinning, S., Loveridge, F., Starr-Keddle, R.E., Bransby, M.F. and Hughes, P.N.	Role of vegetation in sustainability of infrastructure slopes
110	Halcrow	Investment in lifeline rural roads - Stage two final report
112	Harding, E.	Towards lifetime neighbourhoods: designing sustainable communities for all - a discussion paper
24	Hart, J.	Driven to excess: Impacts of motor vehicle traffic on residential quality of life in Bristol, UK
91	Highways Agency	DMRB HA 103/06: Vegetated drainage systems for highway runoff
75	Hill, J. and Starrs, C.	Saving lives, saving money - The costs and benefits of achieving safe roads
25	ICE Scotland	Scotland infrastructure special 2011
74	Institute for Environmental Studies	Environmental economics. The economic benefits of environmental policy
89	Institution of Lighting Engineers	Save money and keep the lights on
120	Institution of Lighting Professionals	Lighting against crime - a guide for crime reduction professionals
26	IRF Research Council	The socio-economic benefits of roads in Europe
27	James, E., Harper, H., Reid, S., McColl-Grubb, V. and Tomlinson, P.	Community severance research: Final review report
28	James, E., Millington, A. and Tomlinson, P.	Understanding community severance Part 1: Views of practitioners and communities
108	Johansson, S and Johansson, K.	Road condition management policies for low volume roads - tests and development of proposals
29	Johansson, S.	Socio-economic impacts of road condition on low volume roads
30	Jones, C.	Budgets, buttercups and biodiversity (presentation)
66	Keizer, K., Lindenberg, S. and Steg, L.	The spreading of disorder
104	Kuennen, T	Making edge drains work
31	Lavery, I. and Davey, S.	The pedestrian environment - the Achillies' heel of travel by low floor bus
114	Living Streets	WALKIPEDIA

#	Author	Title
115	Living Streets	Creating healthy environments - Practical tools for increasing walking in the built environment: Cleanliness Index Monitoring System (CIMS)
32	London Borough of Greenwich	Local Implementation Plan
33	Lopez, R.P. and Hynes, H. P.	Obesity, physical activity, and the urban environment: public health research needs
76	Lothian & Borders Emergency Planning Strategic Co-ordinating Group	Community risk register
107	Maas, G.A., Maas F.K., Maas, S.P. and Claughton, D.	Dynamic measurement of tyre/road noise
70	Marsden, G., Jopson, A., Cattan, M. and Woodward, J.	Transport and older people: Integrating transport planning tools with user needs
102	McClintock, H. and Russell, T.	Cycling solutions
109	McDowall, E and Adams, C.	Locally significant roads: An investment strategy
34	McRobert, J. and Sheridan, G.	Road runoff and drainage: Environmental impacts and management options
35	Morris, J. and Camino, M.	Economic assessment of freshwater, wetland and floodplain (FWF) ecosystem services
36	Mourato, S, Atkinson, G., Collins, M, Gibbons, S., MacKerron, G. and Resende, G.	Economic analysis of cultural services
124	MTRU	Road maintenance costs to local authorities - Potential changes from transfers of goods between rail and road, and a methodology for assessing the impact of transfers from road to rail
130	National Transport Safety Board	Collapse of I-35W Highway Bridge Minneapolis, Minnesota
77	Nellthorp, J., Chintakayala, P. and Wardman, M.	Valuation of townscape improvements using a two-level stated preference and priority ranking approach
64	Organisation for Economic Cooperation and Development	Ageing and transport. Mobility needs and safety issues
37	Pakrashi, V., Kelly, J. and Ghosh, B.	Sustainable prioritization of bridge rehabilitation considering road users
90	Parkman, C.C. and Bradbury, T.	Economic assessment of the impacts of changes in maintenance spend on the Scottish trunk road network
58	Perrels, A.	The basic service quality level of transportation infrastructure in peripheral areas
98	Pitt, R.	Demonstration of nonpoint pollution abatement through improved street cleaning practices
84	Pittner, C. and Allerton, G.	SUDS for roads
38	Powell, J., Dalton, A., Brand, C. and Ogilvie, D.	The health economic case for infrastructure to promote active travel: A critical review

#	Author	Title
88	Ramdas, V., Thomas, C., Lehman, C. and Young, D.	Highway service levels
39	Reid, S.	Pedestrian environments: a systematic review process
83	Reid, S. and Shore, F.	Seeing issues clearly - valuing urban realm
131	Road Surface Dressing Association	Guidance note on quieter road dressings
122	Roads Liaison Group	Well-lit highways - code of practice for highway lighting management
123	Roads Liaison Group	Well-lit highways - code of practice for highway lighting management complementary guidance
121	Scotland TranServ Environment Team	A82: Allt Chonoghlais bridge replacement: Environmental review report and proposed mitigation
78	Scottish Enterprise	Briefing paper - opportunities and influence, globally competitive business environment
118	Scottish Executive	Controlling light pollution and reducing lighting energy consumption
79	Scottish Government	Scottish noise mapping
80	Scottish Government	Aligning noise action planning
113	Scottish Government	Scottish household survey - Annual report
40	Sen, A., Darnell, A., Crowe, A., Bateman, I., Munday, P. and Foden, J.	Economic assessment of recreational value of ecosystems in Great Britain
101	Sinclair, D., Swan, A. and Pearson, A.	Social inclusion and older people - a call for action
59	Sinnett, D., Williams, K., Chatterjee, K. and Cavill, N.	Making the Case for Investment in the Walking Environment: A Review of the Evidence (Summary Report)
60	Sinnett, D., Williams, K., Chatterjee, K. and Cavill, N.	Making the Case for Investment in the Walking Environment: A Review of the Evidence (Full Report)
41	Social Exclusion Unit	Making the Connections: Final Report on Transport and Social Exclusion
106	Stidger, R.W.	The pros and cons of municipal street sweeping
125	Sustrans	Cycling in the city regions
127	Sustrans	Creating your own DIY street
43	Swedish National Council for Crime Prevention	Improved street lighting and crime prevention - a systematic review
99	Tarry, N	Safety Fears as the Lights go out
42	TfL Investment Programme Management Office	Business case development manual
44	Tomlinson, P. and James, E.	Understanding community severance Part 2: Monetisation of severance impacts
46	Transport Analysis Guidance (TAG)	Guidance on the appraisal of walking and cycling schemes

#	Author	Title
47	Transport Analysis Guidance (TAG)	The townscape sub-objective
48	Transport for London	Highway asset management survey - Footways
49	Transport for London	Topic overview: Understanding our streets
50	Transport for London	Exploring attitudes to road maintenance
51	Transport for London	Road Network Management Stated Preference Survey - Customers' priorities for maintenance service levels
52	Transport Scotland	Strategic transport projects review Report 1: Review of current and future network Performance Report 2: Report on gaps and shortfalls Report 3: Option generation and appraisal Report 4: Final report Strategic Environmental assessment
117	Transport Scotland	Disability Discrimination Act - Good practice guide for roads
118	Transport Scotland	Forth replacement crossing: Managed crossing scheme: scheme definition report
129	Transport Scotland	Trunk road network audit report
53	TRIP	Future mobility in Oklahoma: Meeting the State's need for safe and efficient mobility
82	Vainio, M. and Paque, G.	Highlights of the workshop on the "state-of-the-art in noise valuation". Final report
54	Valatin, G. and Starling, J.	Valuation of ecosystem services provided by UK woodlands
81	Vibrock Limited	Results of traffic induced vibration surveys, pre and post repair, A82 Stirling Road, Dumbarton
55	Wardman, M. and Bristow, A.	Valuation of aircraft noise: experiments in stated preference
126	Warren, J.	Towards a healthier economy
65	West Midlands Local Transport Plan	West Midlands Local Transport Plan: Bridge maintenance
56	Zachariadis, T.	Roads to nowhere: An assessment of social costs for the use of cars in Cypriot cities
95	Zhang, C.	Delivering sustainable bridges to help tackle climate change
92	Zuman, N.	The case for improved street lighting

A.3 Document reviews

#	Author	Date	Title	Source	Relevant based on the 5 key questions?	Relevance matrix code
1	Anastasopoulos, P.C., Florax, R.J.G.M., Labi, S. and Karlaftis, M.G.	2010	Contracting in highway maintenance and rehabilitation: Are spatial effects important?	Transportation Research Part A 44 (2010) p136–146	No	
	Summary/Comment	Relationship between cost savings and contract characteristics of maintenance services				
	Useful extracts					
2	Ansved, L.	1986	Techniques and tools for the implementation of a new Swedish Maintenance Philosophy	6th IRF African Highway conference. Cairo, 21-26 September 1986. 6 Vols: Road financing, Road maintenance, Urban transport, Equipment and materials, Road planning and construction, Development of large scale Transafrican road projects and intercontinental links		
	Summary/Comment	Use of GALANT (software) for assessing costs, effectiveness, and socio-economic impact of alternative maintenance plans and strategies				
	Useful extracts					
3	Asphalt Industry Alliance.	2011	Annual Local Authority Road Maintenance (ALARM) Survey 2011	Asphalt Industry Alliance	Yes	A5, A8, A9
	Summary/Comment	Survey investigating levels of maintenance activity and funding, and the impact on planned maintenance.				
	Useful extracts	Overall, 90% of Authorities responding say they believe that the under-funding of the highway maintenance programme creates a threat to road users' safety: nearly a third feel it is a major threat. Just over half (52%) believe that the threat to road users' safety has increased, whilst 41% feel it is unchanged (p10). According to a recent survey, poor local road condition is costing small and medium sized businesses in England and Wales over £4 billion a year (p11).				

<table>
<tr><th>#</th><th>Author</th><th>Date</th><th>Title</th><th>Source</th><th>Relevant based on the 5 key questions?</th><th>Relevance matrix code</th></tr>
<tr><td rowspan="3">4</td><td>Auditor General for Scotland and Accounts Commission.</td><td>2011</td><td>Maintaining Scotland's Roads</td><td>Auditor General for Scotland and Accounts Commission</td><td>Yes</td><td>A10, A8, H8, A5</td></tr>
<tr><td>Summary/Comment</td><td colspan="5">Report on progress on implementing the recommendations contained in Maintaining Scotland's Roads report including cost of maintenance, user satisfaction.</td></tr>
<tr><td>Useful extracts</td><td colspan="5">Scotland's roads are vital for economic prosperity and for the quality of life of its people (point 8).
Poor road condition can result in motorists incurring expensive repair bills, and Local Authorities face claims from road users who have had their vehicle damaged by potholes and similar defects (point 22).
In 2010, a survey estimated that over a third of Scottish motorists have suffered car damage because of potholes. The average cost of repairing damage to their vehicles is thought to be £133 per driver. Another survey of 3000 drivers estimated that an average of £220 per motorist was being spent each year on pothole-related car repairs such as suspension problems, burst tyres, chipped windscreens and paintwork damage (point 23).
Road safety is also affected by poor road condition. A recent survey estimated that over 30,000 Scottish drivers had experienced a near miss with another vehicle or pedestrian due to either hitting a pothole or swerving to avoid one, while one in four reported tyre damage caused by potholes, itself a risk to road safety (point 24).
The consequence of not spending at this level is forecast to result in a £1 billion decline in the value and a ten per cent reduction in the condition, of the local road network (point 37).</td></tr>
<tr><td rowspan="3">5</td><td>Back, A.</td><td>2005</td><td>Habitats by design</td><td>Highways, March 2005, p17-21</td><td>Yes</td><td>A3, A9, A6, F5</td></tr>
<tr><td>Summary/Comment</td><td colspan="5">Impact of not maintaining the road ecology.</td></tr>
<tr><td>Useful extracts</td><td colspan="5">Road safety remains the priority, so well managed embankments provide reasonable safe areas for vehicles that run off the road, and for vehicle occupants to easily reach a position of safety. If poorly managed, risk is substantially increased for the road user.
Mowind roadside verges and the base of embankments help drainage and allow access and increased sight lines for traffic, and reduce risk of verge fires possibly caused by accidents.</td></tr>
<tr><td rowspan="3">6</td><td>Bayar, A., Fortuna, M. and Rege, S.</td><td>2009</td><td>Welfare Impacts of Road Construction Using a Public-Private Partnership: a CGE Analysis of a Project</td><td>Centro de Estudos de Economia Aplicada do Atlantico</td><td>No</td><td></td></tr>
<tr><td>Summary/Comment</td><td colspan="5"></td></tr>
<tr><td>Useful extracts</td><td colspan="5"></td></tr>
</table>

#	Author	Date	Title	Source	Relevant based on the 5 key questions?	Relevance matrix code
7	Borges, I.M.	2011	The added value of accessible public transport for all in the context of demographic ageing	AGE Presentation at XXIII World Road Congress, Paris, France, September 2007		
	Summary/Comment	Planners need to consider safety planning a route and not create isolated bus stops with bad lighting, no shelter etc. The paper seeks to outline the specific mobility difficulties faced by an ageing population in Europe, and presents a case to ensure that future transport systems take into consideration measures which can assist to make public transport more accessible, attractive, affordable and safe to older people. The paper discusses the role of the built environment in terms of the accessibility and perceptions of safety, but predominately focuses on public transport and its accessibility, affordability, availability and attitudes towards public transport amongst older people. It also outlines the role of the European Union in terms of policy and regulation for accessible public transport vehicles and the future uptake of Intelligent Transport Systems (ITS) to assist this particular demographic group.				
	Useful extracts	"Many participants who felt threatened in a certain environment did not put themselves in that situation again" (p5). It is estimated that 10 to 20 percent of European citizens, including people with disabilities and older people, are still experiencing barriers and reduced accessibility to transportation. These barriers can lead to a lack of opportunities and limited possibilities for employment, social and leisure integration and full participation in society. The largest barriers to older people's mobility are psychophysical related impairments associated with walking and accessing public transport such as uneven and narrow footways. There is ample evidence of "distance decay" amongst older people (i.e. people are put off from using services if the journey seems too far, too time-consuming, too costly, too dangerous or too difficult) (Burnett, 2005). In general, older people worry about their safety and are reluctant to take public transport due to factors such as fear of crime, or falling over and becoming injured. Many of the participants who... felt threatened in a certain environment did not put themselves in that situation again (Marsden, Jopson, Cattan, & Woodward, March 2007). Improvements in accessibility...and the availability of public transport that take into account meeting the needs of an ageing population is essential for greater social inclusion Older people (aged over 75) tend to use public transport only if they live close to a route, especially where disability and health issues are involved (Davey & Nimmo, 2003).				

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<tr><td rowspan="3">8</td><td>Bradbury, A., Tomlinson, P. and Branning, C.</td><td>2008</td><td>Social and community impacts study</td><td>HA Environmental Support Services – West Task</td><td>Yes</td><td>G11, G12</td></tr>
<tr><td>Summary/Comment</td><td colspan="5">Community severance caused by physical and psychological barriers can create trip suppression, resulting in an individual being completely deterred from making a journey due to factors associated with the transport infrastructure (p12).
No attention is given in the guidance about severance caused by removal of an asset either through structural failure or lack of maintenance.</td></tr>
<tr><td>Useful extracts</td><td colspan="5">"There is no evidence to support the claim in Volume 11 of the Design Manual for Roads and Bridges (DMRB) (Highways Agency, 2009) that residents adjust to severance over a period of years" (p12).</td></tr>
<tr><td rowspan="3">9</td><td>Breeze, J.</td><td>2011</td><td>Impact assessment form and action table (budget cuts)</td><td>Somerset County Council</td><td>Yes</td><td>A10, F12, B11, E9</td></tr>
<tr><td>Summary/Comment</td><td colspan="5">Focus on impact of maintenance cost on disabled and older road users.</td></tr>
<tr><td>Useful extracts</td><td colspan="5">All highway users, in particular those with wheelchairs and motorised scooters, will be affected by a reduction in the frequency of surface dressing and resurfacing. This capital shortfall will lead to a spiralling increase in potholes (it is estimated that there could be an additional 90,000 potholes in 3 years costing an additional £4 million/year to repair).
A reduction in drainage maintenance means a greater likelihood of flooding on roads, footways and subways which affects all highway users. Those with disabilities are more likely to be adversely affected by surface water flooding.
A reduction in bridge maintenance including Rights of Way non-vehicular bridges will result in potential long closures of bridges which lead to long diversions, congestion and low public satisfaction for all highway users, in particular users who live in rural areas who will have to find alternative routes.
A reduction in street light replacement will affect those who suffer from a fear of crime (all groups within scope of equality impact assessment) as the amount of time the lighting is off, due to failure, will increase.
A reduction in traffic signal replacement will affect all highway users, but in particular the ‘age’ and ‘disability’ equality groups who are potentially in greater danger due to the reduced budgets on traffic signals.
There will be reduced upgrading of pedestrian crossings with ‘tactile’ paving which helps visually impaired people move around the pedestrian environment. Visually impaired people will actively seek and make use of tactile information underfoot, particularly detectable contrasts in surface texture.
Reduced installation of specific warning signs, for example outside nursing homes/hospitals and heavy goods vehicles signing will have a negative impact on the general population, but there are specific impacts on the disabled and elderly who are potentially in greater danger due to the reduced budgets on warning signs.
Frequency of gully emptying has already been reduced from 12 months to 18 months in urban areas, and no significant increase in flooding has been observed. More enforcement of landowners to fulfil their responsibility for ditching has led to improved drainage maintenance.</td></tr>
</table>

#	Author	Date	Title	Source	Relevant based on the 5 key questions?	Relevance matrix code
10	Brett, S.	2006	The light fantastic	Lighting, Sept 2006, Issue 246, p24-26	No	
	Summary/Comment	Management of on-street and car park lighting				
	Useful extracts					
11	Brown, P.	2009	A Roads Policy for London: Challenges and opportunities for maintaining and improving road transport operations in London	Royal Automobile Club Foundation for Motoring	No	
	Summary/Comment	Road transport operations				
	Useful extracts					
12	Buchanan, P. and Gay, N.	2009	Making a case for investment in the public realm	Proceedings of the Institution of Civil Engineers, Urban Design and Planning 162, March 2009, p29-34	Yes	C4, G4, C5, G5, C6, G6, C7, G7
	Summary/Comment	Valuation of benefits from high quality urban realm				
	Useful extracts	Description of two methodologies (Stated and Revealed Preference) to value the benefits of urban realm schemes.				
13	CABE Space.	2007	Paved with gold – The real value of good street design	Commission for Architecture and the Built Environment (CABE)	Yes	C5, G5, C11, G11
	Summary/Comment	Study to investigate the value of design. Well-designed buildings, spaces and places contribute to a wide diversity of values and benefits. Related to PERS work.				
	Useful extracts	The results show direct links between street quality and both retail and residential prices. In the case study of homes on high streets, improvements in street quality were associated with increases in prices. Specifically, for each single point increase in the PERS street quality scale, a corresponding increase of £13,600 in residential price could be calculated. This equates to a 5.2 per cent increase in the price of a flat for each PERS point. The analysis also showed direct links between zone A (the the most valuable space closest to the shop front) retail rents and street quality. For each point increase on the PERS street quality scale, a corresponding increase of £25 per square metre in rent per year could be calculated. This equates to a 4.9% increase in shop rents for each PERS point.				

#	Author	Date	Title	Source	Relevant based on the 5 key questions?	Relevance matrix code
14	Campos, A. L. and Adelaja, S.	-	Local roads spending and urban sprawl: An analysis of the causal relation in Detroit Metropolitan Area	Land Policy Institute	No	
	Summary/Comment	The causal relationship between local road spending and community growth. Study to determine whether or not spending on local roads is a growth promoting or deterring factor to local communities especially with regards to sprawl.				
	Useful extracts					
15	Chan, C., Forwood, D., Roper, H. and Sayers, C.	2009	Public infrastructure financing: An international Perspective	Australian Government Productivity Commission	No	
	Summary/Comment	Public financing trends for maintenance				
	Useful extracts					
16	Crick, J.	2003	Keeping an eye on the road	Surveyor, Vol 190, p18-20	No	
	Summary/Comment	General background to the ALARM survey (Asphalt Industry Alliance, 2011).				
	Useful extracts					
17	Crick, J.	2005	Don't scratch the surface	Highways, May 2005, p22-25	Yes	A10, A8
	Summary/Comment	State of the road network under budget constraints.				
	Useful extracts	Shortfall is taking its toll on the condition of the roads with a more than doubling of the number of visual defects, including potholes and cracks, over the past 10 years. In addition, engineers claim the need for structural maintenance has more than doubled over the past 10 years. All these indicators of the state of our road surfaces have serious implications for road users - particularly vulnerable road users such as two wheelers. Potholes, defects and cracks can result in serious, if not fatal accidents for this group of users. According to Highways Departments in Wales the knock-on effect of the lack of maintenance is a 50% increase in the amount of money paid out by Local Authorities in Wales last year in compensation claims.				
18	Department of Transport	2007	Manual for Streets 2	Department of Transport	No	
	Summary/Comment					
	Useful extracts					

#	Author	Date	Title	Source	Relevant based on the 5 key questions?	Relevance matrix code
19	Fezzi, C., Crowe, A., Abson, D., Bateman, I. Askew, T., Munday, P., Pascual, U., Sen, A., Darnell, A. and Haines-Young, R.	2011	Evaluating provisioning ecosystem service values: a scenario analysis for the United Kingdom	Economics Team of the UK National Ecosystem Assessment	No	
	Summary/Comment	Study to provide an estimate of the contribution of the ecosystem to the value of provisioning services from agriculture by the change in value generated by a marginal alteration in ecosystem inputs.				
	Useful extracts					
20	Forman, R.	2003	Road ecology: a look behind the book and the field	Road Ecology Center, John Muir Institute of the Environment, UC Davis	No	
	Summary/Comment	Book review on road ecology - relationship between the natural environment and the road system.				
	Useful extracts					
21	Fowler, D.	2010	Roads in an era of austerity	Transport Times, July 2010, Issue 74, p26-28	No	
	Summary/Comment	Privatisation of road usage.				
	Useful extracts					
22	Fox, P.	2007	Invest to save – sustainable street lighting	County Surveyors' Society	No	
	Summary/Comment	Report to enable Authorities to develop sustainable lighting policies.				
	Useful extracts					
23	Glendinning, S., Loveridge, F., Starr-Keddle, R.E., Bransby, M.F. and Hughes, P.N.	2009	Role of vegetation in sustainability of infrastructure slopes	Proceedings of the Institution of Civil Engineers, Engineering Sustainability 162, June 2009 Issue ES2, p101–110	Yes	A3
	Summary/Comment	Importance of roadside vegetation on verges and vegetation management.				
	Useful extracts	It appears that vegetation maintenance on infrastructure slopes is required for both engineering maintenance and to ensure biodiversity (p108).				
24	Hart, J.	2008	Driven to excess: Impacts of motor vehicle traffic on residential quality of life in Bristol, UK	MSc Transport Planning. University of West England, Bristol	No	
	Summary/Comment	Study investigating the specific impacts of traffic on quality of life in Bristol				
	Useful extracts					

<table>
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<tr><td rowspan="3">25</td><td>ICE Scotland.</td><td>2011</td><td>Scotland Infrastructure Special 2011</td><td>ICE Scotland</td><td>No</td><td></td></tr>
<tr><td>Summary/Comment</td><td colspan="5">Scotland's State of the Nation 2011 assessment.</td></tr>
<tr><td>Useful extracts</td><td colspan="5"></td></tr>
<tr><td rowspan="3">26</td><td>IRF Research Council.</td><td>2007</td><td>The socio-economic benefits of roads in Europe</td><td>IRF Research Council</td><td>Yes</td><td>A2, A8</td></tr>
<tr><td>Summary/Comment</td><td colspan="5">A study conducted by SINTEF in Norway (2007) found 'conclusive evidence that road realignments and upgrades reduce car emissions' (p16).</td></tr>
<tr><td>Useful extracts</td><td colspan="5">"For much of the past decade, spending on roads in the EU has been consistently declining - the relative lack of investment has come at the cost of increased congestion and lower safety due to poor maintenance" (p17).</td></tr>
<tr><td rowspan="3">27</td><td>James, E., Harper, H., Reid, S., McColl-Grubb, V. and Tomlinson, P.</td><td>2004</td><td>Community Severance Research: Final Review Report</td><td>TRL Unpublished Report: UPR/SE/075/04</td><td>Yes</td><td>G1, G2, G4, G7, G8, G9, G11, G12, H1, H2, H4, H7, H8, H9, H11, H12, B9, B11, B12, C11, C12, D11, D12, E9</td></tr>
<tr><td>Summary/Comment</td><td colspan="5">Barriers to accessibility include 'Omission Barriers' (failure to provide footways and suitable crossing facilities where needed) and 'Quality Barriers' where surfaces are poorly maintained, lack of lighting, facilities feel unsafe, networks are not fit for purpose (p50).
The report highlights areas where there is an evidence gap related to severance, such as delays caused to pedestrians on existing routes compared to the effect of a new route (exacerbated where the route is not maintained) (p27).</td></tr>
<tr><td>Useful extracts</td><td colspan="5"></td></tr>
</table>

#	Author	Date	Title	Source	Relevant based on the 5 key questions?	Relevance matrix code
28	James, E., Millington, A. and Tomlinson, P.	2005	Understanding Community Severance Part 1: Views of Practitioners and Communities	TRL Unpublished Report	Yes	G1, G2, G4, G7, G8, G9, G11, G12, H1, H2, H4, H7, H8, H9, H11, H12, B9, B11, B12, C11, C12, D11, D12, E9
	Summary/Comment	Reduced community interaction caused by reduced air quality, increased traffic noise, increased likelihood of road traffic accidents, can contribute to community severance (psychological or perceived barriers) (p14). Community severance comprises: 1. Physical barriers: introduction of new traffic infrastructure 2. Psychological or perceived barriers: traffic noise or road safety fears 3. Social impacts: disruption of 'neighbourhood lifestyle' (p14). NB. Definitions of community severance do not include changes to existing infrastructure (e.g. from less maintenance). Where there is a barrier to neighbourhoods and communities, people are found to reduce their involvement with the opposite side, reducing social activity across the road (p23). Mitigation measures can be used to reduce severance impacts (e.g. subways, footbridges and surface level crossings). Such measures can cause 'secondary' severance effects whereby the mitigation measure itself creates a barrier causing people to cross the road informally (p48). Pedestrian subways can attract crime and vandalism/graffiti, poor design and lack of maintenance can create fear. When asked about 'secondary severance', practitioners agreed that the overall impact of poor maintenance of mitigation measures put in place to overcome the original physical severance barrier, deters pedestrians and increases levels of fear.				
	Useful extracts	"If a large or increasingly busy road cuts through an area it can have the effect of driving a wedge through a community. This can limit people's ability or desire to move through that area, which can reduce accessibility to key services, and can damage local social networks and community 'cohesion’" (p5). In a case study looking at the community experiences of severance in the South West of England, "many people felt that the maintenance of the subways was poor in general and that graffiti, rubbish and even vomit were not being cleared away regularly enough, which deterred people from using them". Vandalised lighting, mirrors and flooding in subways were also cited as contributing to anti-social behaviour and crime (p49).				

#	Author	Date	Title	Source	Relevant based on the 5 key questions?	Relevance matrix code
29	Johansson, S.	2004	Socio-economic impacts of road condition on low volume roads	Roadex II, Northern Periphery	Yes	A11
	Summary/Comment	Halcrow reports on the HITRANS study investigating the causal link between the condition and availability of the 'lifeline road' and the socio-economic vitality of a particular community (p57). The concept of 'lifeline rural roads' in the Scottish highlands is highlighted where "a transport link which has no substitute, or where the substitute entails a considerable increase in time or money expenditures, where any diminution in the quality, reliability or availability of the former is likely to have a significant impact on the social or economic viability of an affected community" (p57).				
	Useful extracts					
30	Jones, C.	(-)	Budgets, buttercups and biodiversity (presentation)	Telford and Wrekin Council	No	
	Summary/Comment	Alternative to up-keep of biodiversity around the road network (especially roundabouts).				
	Useful extracts					
31	Lavery, I. and Davey, S.	1996	The pedestrian environment - the Achilles' heel of travel by low floor bus	Public Transport Planning and Operations. Proceedings of Seminar F held at the PTRC European Transport Forum, Brunel University, England, 2-6 September 1996. Volume P405	Yes	C11, G11
	Summary/Comment	This paper aims to explore whether the increased use of low floor buses will have a positive effect on the travelling population, particularly older people and those who suffer from mobility impairments. In particular, the authors aim to understand travel behaviours and barriers for mobility impaired people that are more fundamental than boarding and alighting public transport vehicles – namely those related to the built environment which can prevent older and mobility impaired pedestrians from accessing the transit stops. The paper suggests that a high proportion of the most prevalent barriers to walking presented by the built environment relate to surfacing quality, some of which can be linked to surface decay such as uneven pavements and broken paving stones. The associated research project that is briefly documented involved focus groups, interviews and travel diaries amongst older people in Northern Ireland and stated barriers to walking including trip hazards and poor maintenance of footways.				
	Useful extracts	These problems [difficulties connected with travelling by public transportation] are as important to many disabled and elderly people as the problems of embarking/ disembarking the bus. There is a strong relationship between the built environment and travel. The National Travel Survey 1994 (Department of Transport, 1994) cited one of the three greatest barriers to bus travel				

#	Author	Date	Title	Source	Relevant based on the 5 key questions?	Relevance matrix code
		by those with mobility impairments is getting to the bus stop. Research by the University of Wales (Tranter, Slater, & Vaughan, 1991) indicates that four out of the six most prevalent built environment barriers are to do with surfacing: • Uneven pavements • Kerbs that don't drop smoothly • Awkward kerbs • Broken paving stones The Personal, Environmental, Trip (PET) related framework (Meadows, 1992) states typical environmental barriers which include badly paved surfaces and lighting. A simple walk to a bus stop could incorporate so many built environment barriers that the person encounters a barrier chain that suppresses trips and in turn can lead to social exclusion (extreme case). Major barrier questionnaire- response "I'm frightened of tripping on something" stated by participants. Group sessions – problems stated include: • Poor pavement maintenance • Lack of bus shelters and seating • Pavements poorly maintained				
32	London Borough of Greenwich	2004	Local Implementation Plan	http://www.greenwich.gov.uk/NR/rdonlyres/8B0CE8EA-0C26-4084-BE77-76C05FDEEE85/0/LIPchapters1to4.pdf	Yes	A11, A12, C9, E9, C8, G8
	Summary/Comment	Equality Impact Assessment in the Local Implementation Plan: • Crime and Disorder Reduction Strategy is in place to reduce crime and the fear of crime • Improved street lighting to reduce the risk of accidents and violent attack • Highway maintenance, especially to reduce foliage which may create hiding areas, or limit escape routes • - Road and footway maintenance: reducing trip hazards and removing street furniture for disabled persons				
	Useful extracts	"There is no evidence to date that policies impact in an adverse way on equality sectors. Mechanisms are in place to rectify any service shortfall in the maintenance of the infrastructure so that issues raised by elderly or disabled consumers are properly dealt with" (p4-4).				

#	Author	Date	Title	Source	Relevant based on the 5 key questions?	Relevance matrix code
33	Lopez, R.P. and Hynes, H.P.	2006	Obesity, physical activity, and the urban environment: public health research needs	Environmental Health: A Global Access Science Source 2006, 5:25	Yes	G7
	Summary/Comment	The social effect of abandonment is termed 'broken windows syndrome', with consequences such as reduced walking, physical activity and recreation in public (p4). Features of the built environment (e.g. the presence of sidewalks, streetlights, inter-connectivity of streets, population density and use mix) appear to encourage physical activity and thus reduce the risk of obesity and related health problems (p2). Many factors of the inner city environment, including built, physical and social factors, may exert a net negative influence on the health of residents. These factors and conditions include problem land use issues, such as waste sites, infrastructure maintenance and investment issues (p3). A lack of pedestrian amenities discourages walking, and a fear of crime keeps people indoors (p3). Unimproved sidewalks decay as utility crews dig up concrete, tree roots push up paved areas, and weather erodes surfaces. Urban neighbourhoods frequently have broken or impassable pedestrian sidewalks resulting in less leisure walking (p5).				
	Useful extracts	"Several features of the suburban built environment such as low densities, poor street connectivity and the lack of sidewalks are associated with decreased physical activity and an increased risk of being overweight. But compared to suburban residents, inner city populations (in America) have higher rates of obesity and inactivity despite living in neighbourhoods that are dense, have excellent street connectivity and where streets are almost universally lined with sidewalks" (p1). "In the inner city, densities may be lowered because of abandonment and disinvestment" (p1).				
34	McRobert, J. and Sheridan, G.	2000	Road runoff and drainage: Environmental impacts and management options	Austroads AP-R180	No	
	Summary/Comment	Impacts of road runoff and drainage on aquatic and terrestrial ecosystems.				
	Useful extracts					
35	Morris, J. and Camino, M.	2011	Economic assessment of freshwater, wetland and floodplain (FWF) ecosystem services	UK National Ecosystem Assessment	No	
	Summary/Comment	Valuation of ecosystem services from wetlands, freshwaters and floodplains.				
	Useful extracts					

#	Author	Date	Title	Source	Relevant based on the 5 key questions?	Relevance matrix code
36	Mourato, S, Atkinson, G., Collins, M., Gibbons, S., MacKerron, G. and Resende, G.	2011	Economic analysis of cultural services	UK National Ecosystem Assessment	No	
	Summary/Comment	Economic evaluation of key cultural benefits provided by ecosystem services in the UK.				
	Useful extracts					
37	Pakrashi, V., Kelly, J. and Ghosh, B.	2010	Sustainable prioritization of bridge rehabilitation considering road users	Transportation Research Board Annual Meeting 2011 Paper #11-2667	No	
	Summary/Comment	Road user cost for structures				
	Useful extracts					
38	Powell, J., Dalton, A., Brand, C. and Ogilvie, D.	2010	The Health Economic Case for Infrastructure to Promote Active Travel: A Critical Review	Built Environment, Vol 36, no 4, p504-518	Yes	C7, D7
	Summary/Comment	A growing body of evidence suggests that levels of physical activity in general and active travel in particular are associated with conducive neighbourhood characteristics, but there is limited evidence for the effects of interventions in the physical environment - such as constructing paths, trails or other infrastructure for walking and cycling - on levels of active travel, physical activity in general, or associated health benefits.				
	Useful extracts					
39	Reid, S.	(-)	Pedestrian environments: a systematic review process	TRL	No	
	Summary/Comment	This document reports on the result of a project commissioned by the London Borough of Bromley to develop a system that could be used to evaluate pedestrian environments within the Borough. In describing the resultant system, known as PERS (Pedestrian Environment Review System), the paper sets out its development, outputs, application, lessons learnt and areas for future exploitation of the system.				
	Useful extracts	Elements such as graffiti...are critical to the quality of environment offered to pedestrians and their consequent willingness to walk. Subjective experience can be fundamental in determining pedestrian behaviour. Afraid of attack.				

#	Author	Date	Title	Source	Relevant based on the 5 key questions?	Relevance matrix code
40	Sen, A., Darnell, A., Crowe, A., Bateman, I., Munday, P. and Foden, J.	2011	Economic assessment of recreational value of ecosystems in Great Britain	Economics Team of the UK National Ecosystem Assessment	No	
	Summary/Comment	Assessment of recreational value of ecosystems in Great Britain using a developed model.				
	Useful extracts					
41	Social Exclusion Unit.	2003	Making the Connections: Final Report on Transport and Social Exclusion	Office of the Deputy Prime Minister	Yes	G1, G2, G8, G11, G12
	Summary/Comment	Pedestrian accidents, air and noise pollution and busy roads cutting through communities disproportionately affect deprived areas and people facing social exclusion (p17) There is a clear link between pedestrian accident rates and social class, and between area deprivation and pedestrian accident rates (p18). Deprived communities suffer the worst traffic pollution (p19). Busy roads can divide and damage local communities and restrict walking, especially among children and elderly people (p20). Poor walking environments and transport links can leave areas isolated and damage community cohesion (p20). Crime and the fear of crime can deter walking, cycling and the use of public transport.				
	Useful extracts	"The building of the M32 into Bristol severed one traditional neighbourhood (Easton) into two parts" (p20). "Poor transport as a barrier to work may contribute to higher benefit payments, reduced tax contributions, missed health appointments, delays in patient discharge from hospital, course drop-outs in education. The impact of transport through pollution and pedestrian deaths has significant immediate and long-term costs" (p20).				
42	TfL Investment Programme Management Office.	2008	Business case development manual	Transport for London (TfL)	No	
	Summary/Comment	Manual for the presentation of business cases across TfL				
	Useful extracts					

#	Author	Date	Title	Source	Relevant based on the 5 key questions?	Relevance matrix code
43	Swedish National Council for Crime Prevention.	2007	Improved street lighting and crime prevention - a systematic review	The Swedish National Council for Crime Prevention	Yes	E9
	Summary/Comment	Concern for being attacked outdoors after dark prevents some people from using public spaces, and darkness can create a favourable environment for vandalism and theft. There are two theories why improved street lighting may cause a reduction in crime (p7): 1. Improved lighting leads to increased surveillance of potential offenders (by improving visibility and increasing number of people on the street) thus creating a deterrent 2. Improved lighting signals community investment leading to increased community pride, cohesiveness and informal social control. Five British evaluation studies in Bristol, Dudley, Dover, Stoke-on-Trent and Birmingham showed that improved lighting led to a 29% decrease in crime, with financial savings from reduced crimes greatly exceeding the financial costs of improved street lighting (p8). The British studies showed that night time crimes did not decrease more than daytime crimes, suggesting a 'community pride' theory may be more applicable than a 'deterrence/surveillance' theory.				
	Useful extracts	"As a highly visible sign of positive investment, improved street lighting might reduce crime if it physically improved the environment and signalled to residents that efforts were being made to invest in and improve their neighbourhood. In turn, this might lead them to have a more positive image of the area and to have increased community pride, optimism and cohesion" (p10).				
44	Tomlinson, P. and James, E.	2005	Understanding Community Severance Part 2: Monetisation of Severance Impacts	TRL Unpublished Report	No	
	Summary/Comment					
	Useful extracts					
45	Department for Transport.	2008	Traffic Advisory Leaflet 5/08. Walking Bibliography	Traffic Advisory Unit, Department for Transport	No	
	Summary/Comment	List of bibliographies on walking.				
	Useful extracts					

#	Author	Date	Title	Source	Relevant based on the 5 key questions?	Relevance matrix code
46	Transport Analysis Guidance (TAG).	2010	Guidance on the appraisal of walking and cycling schemes	TAG Unit 3.14.1, Department for Transport	No	
	Summary/Comment	This document, published by the Department for Transport, forms part of the Transport Analysis Guidance. It includes guidance on various tasks required when analysing a walking and/or cycling scheme. Guidance is included for setting objectives, appraising options, conducting an appraisal, forecasting and monitoring. Three case studies are included which illustrate the appraisal process in practice. In setting out the appraisal summary, the document briefly lists benefits that can be gained through the implementation of walking and cycling schemes, which include benefits relevant to the Scotland. However, for the purposes of the literature review, these impacts are not considered in terms of maintenance spend or reduction to maintenance budgets, and are therefore not included within the relevance matrix. References to maintenance within the TAG document are present but focus on ensuring costs of scheme maintenance have been fully monetised within the cost/ benefit appraisal process.				
	Useful extracts	The impacts (benefits) of walking and cycling are more fully explored in other publications. However, the paper does state some impacts as: • Fear of potential accidents (p5) o Perceived safety or the fear of potential accidents is mentioned by cyclists and potential cyclists as a major barrier to cycling (or cycling more) • Cycling and walking schemes may positively affect severance by reducing barriers to opportunities and destinations. This may include indirect routes, lack of provision, safety concerns or information. (p7)				
47	Transport Analysis Guidance (TAG).	2004	The townscape sub-objective	TAG Unit 3.3.8, Department for Transport	No	
	Summary/Comment	Physical characteristics of townscape.				
	Useful extracts					
48	Transport for London.	2011	Highway Asset Management Survey - Footways	Transport for London	Yes	C11, C12, G11, G12
	Summary/Comment	This research, carried out on behalf of Transport for London, gathered minimum and preferred levels of service from pedestrians in London, with regard to specific footway condition defects such as cracking, subsidence, flooding, depressions and raised or sunken ironworks. The research asked footway users to view different surfaces at various condition levels and choose if they would prefer TfL to maintain or if TfL must maintain the footway surface. More than a third of the sample had a long-term physical or mental disability (including those related to old age) which limited their daily activities or work that they could do. The priorities highlighted by the research were cracked and depressed flagged and bitumen surfaces, and raised ironwork.				

#	Author		Date	Title	Source	Relevant based on the 5 key questions?	Relevance matrix code
	Useful extracts	Those [pedestrians] without impairment were much more frequent users of the Red Route Network [in London] than those with mobility or visual impairment Those [pedestrians] with a mobility impairment were slightly more likely to say the condition of the Red Route Network was poor or very poor as well as slightly more likely to say the condition was good than those with a visual impairment or without an impairment (i.e. greater sensitivity to surface condition)? The condition of the Transport for London Road Network was most important for those with a visual impairment Lots of anecdotal quotes in Appendix D from members of the public.					
49	Transport for London.		2011	Topic Overview: Understanding Our Streets	Transport for London	Yes	C12
	Summary/Comment	In a study to prioritise improvements to highways to meet the needs of disabled people, the most important priority overall was to improve the quality of the pavement surface, with the provision of traffic islands and dropped kerbs at road crossings (p14).					
	Useful extracts						
50	Transport for London.		2008	Exploring Attitudes to Road Maintenance	Transport for London	No	
	Summary/Comment						
	Useful extracts						
51	Transport for London.		2008	Road Network Management Stated Preference Survey - Customers' Priorities for Maintenance Service Levels	Transport for London	Yes	A8, C11, C12, E8, G11, G12, J4
	Summary/Comment	The paper presents the findings of research carried out on behalf of Transport for London which aimed to gather user perceptions and preferences related to condition defects of various types, extents and severities and to seek to understand tolerances to nuisance and disruption to maintenance works required for remedy. This study aims to integrate this research with Transport for London's strategy for prioritising investment based on the UKPMS (UK Pavement Management System). The research entailed over 1,240 interviews with users of Transport for London's Road Network including pedestrians, cyclists and various road users. This paper may be valuable for Transport Scotland in terms of understanding the acceptability of various surface conditions by different road users.					
	Useful extracts	The main user priorities for both footways and carriageways are maintenance and good lighting. 84% of 450 pedestrian respondents stated the quality of the footway is important or very important The importance given to maintenance indicates that users wish footway and carriageway condition to be maintained at a good level, even if there is disruption. This applied to around 75% of respondents. Personal safety concerns may be partly driving the importance of ensuring there is good lighting					

#	Author		Date	Title	Source	Relevant based on the 5 key questions?	Relevance matrix code
		The most important condition defect on footways are raised/ sunken ironwork, large potholes and cracks/ uneven surfaces. The most important condition defects on carriageways are large potholes, bumps, raised/sunken ironwork and surface in a poor condition. About half of all respondents thought some or all condition defects get worse in rain and in the dark, principally cracks and potholes for pedestrians and potholes for carriageway users About 75% thought that condition defects could have an impact on safety About half of pedestrians preferred maintenance over good, bright, even lighting after dark or improvements to the drains About two thirds of pedestrians preferred maintenance compared to a footway free of litter or ensuring that no vegetation encroaches into the footway. Around two thirds of carriageway users preferred maintenance of the carriageway over good, bright, even lighting after dark Three quarters of carriageway users preferred maintenance over improvement to drains In practice, a poor footway or carriageway will often mean that many or all of the condition defects [categorised in the study] are present at the same time When pedestrians were asked to offer commentary on aspects not covered by the study, over 25 respondents at one site stated vegetation encroaching on to the footway was problematic. There were other maintenance issues raised in a similar way across all sites, concerning damaged railings, puddles on the footway, litter and damaged pedestrian crossing buttons as examples.					
52	Transport Scotland.		2008	Strategic Transport Projects Review Report 1: Review of Current and Future Network Performance Report 2: Report on Gaps and Shortfalls Report 3: Option Generation and Appraisal Report 4: Final Report Strategic Environmental Assessment	http://www.transportscotland.gov.uk/strategy-and-research/strategic-transport-projects-review	No	
	Summary/Comment	List of reports on Scottish Government's transport investment priorities.					
	Useful extracts						

#	Author	Date	Title	Source	Relevant based on the 5 key questions?	Relevance matrix code
53	TRIP.	2011	Future mobility in Oklahoma: Meeting the State's Need for Safe and Efficient Mobility	TRIP	Yes	A8, A10, B11
	Summary/Comment	Deteriorated bridges causing restrictions on vehicle weight may cause emergency vehicles, commercial trucks, school buses and farm equipment to use alternative routes (p17). Roads in poor condition (e.g. potholes, rutting, rough surfaces), increase Vehicle Operating Costs by $425 per motorist each year (p15).				
	Useful extracts	"Stress on the vehicle increases in proportion to the level of roughness of the pavement surface" (p16).				
54	Valatin, G. and Starling, J.	2010	Valuation of ecosystem services provided by UK woodlands	UK National Ecosystem Assessment	No	
	Summary/Comment	Valuation of ecosystem services especially woodlands in the UK				
	Useful extracts					
55	Wardman, M. and Bristow, A.	(-)	Valuation of aircraft noise: experiments in stated preference	Loughborough University	No	
	Summary/Comment	The aim of this work was to report new evidence relating to residents' valuations of aircraft noise in three countries with an emphasis on a comparison of the valuations				
	Useful extracts	Obtained using two contrasting approaches				
56	Zachariadis, T.	2008	Roads to nowhere: An assessment of social costs for the use of cars in Cypriot cities	Cyprus Economic Policy Review, Vol. 2, No. 2, p51-80 (2008)	No	
	Summary/Comment					
	Useful extracts					
57	Foruslund, U. and Johansson, B.	1995	Assessing road investments: Accessibility changes, cost benefit and production effects	Annals of Regional Science, Vol 29, No. 2, p155-174 (1995, May)	No	
	Summary/Comment	A series of alternative national road investment programmes in Sweden are examined. Each programme is assessed in terms of expected time savings and reduced accident rates.				
	Useful extracts					

#	Author	Date	Title	Source	Relevant based on the 5 key questions?	Relevance matrix code
58	Perrels, A.	2003	The basic service quality level of transportation infrastructure in peripheral areas	European RSA Conference 2003, Article 470	No	
	Summary/Comment	Study indicating the problems and trade-offs of infrastructure elements for specifying minimum service levels.				
	Useful extracts					
59	Sinnett, D., Williams, K., Chatterjee, K. and Cavill, N.	2011	Making the case for investment in the walking environment: A review of the evidence (Summary Report)	Living Streets	Yes	C4, C7, C8, C9, C11
	Summary/Comment	This report presents a review of available evidence which make a case for investing in the walking environment. It seeks to understand the benefits of investing in walking environments, including health, economic, social and economic advantages, and presents various interventions which have shown to improve the walking environment. These can include measures such as home zones, lowering speed limits, traffic calming and the reallocation of road space. The publication also presents the evidence for investing in walking environments in terms of value for money, cost/ benefit analysis and a comparison between investing in walking and other forms of transport. Several case studies are also presented.				
	Useful extracts	Specific groups such as children and older people are often more reliant on their local neighbourhoods People walk more when they feel their neighbourhood is safe, well maintained and lively. People tend to report that investments in the walking environment lead to more attractive and safe places The aesthetic quality of a place is the most consistently important factor in relationships between the public realm and recreational walking, health and well-being				
60	Sinnett, D., Williams, K., Chatterjee, K. and Cavill, N.	2011	Making the case for investment in the walking environment: A review of the evidence (Full Report)	Living Streets	Yes	C4, C7, C8, C9, C11
	Summary/Comment					
	Useful extracts	Walking friendly = high density, mixed use and connected (p13). Therefore – if a decrease to a maintenance budget reduces connectivity, for example, we can infer that a neighbourhood becomes less walking friendly and benefits of walking friendly area are reduced. A study in the UK found that the perception residents had of the quality of their neighbourhood, its level of maintenance and character were all positively associated with a sense of community and attachment to place(p14). Social interaction has been associated with lower crime rates Therefore decrease in social interaction on the street, through a lack of maintenance (e.g. causing business to support stationary activities like cafes with street tables and chairs to decrease) could have an impact on crime rates?				

#	Author	Date	Title	Source	Relevant based on the 5 key questions?	Relevance matrix code
		In Glasgow, those who felt their neighbourhoods were safe to walk in after dark were 70% more likely to walk at least five times per week than those who did not feel their neighbourhoods were safe (p15). Perceived safety, fear and mistrust have all been linked to the levels of maintenance or incivilities, for example vandalism or graffiti, in a neighbourhood. Generally, perceptions of safety are not associated with differences in walking levels or sense of community, more important is the overall safety of the neighbourhood (as affected by its appearance, crime rate and level of incivilities). Appearance and level of incivilities could be linked to maintenance levels. The elements that were most strongly associated with differences in the sale price of flats were personal security, lighting, maintenance and quality of the environment, with each having an estimated £5096 contribution to the sale price of flats (p17). The stated preference study of street users found the most important attributes were... lighting, pavement quality and maintenance... Representatives in the retail sector placed the greatest value on footway surface quality, maintenance and quality of the environment, specifically favouring decluttering, maintenance and lighting Dundee City Council has undertaken extensive works to improve their public realm and encourage new retailers into the city, through decluttering, resurfacing and improving paving and lighting (p25). Aesthetic quality has been assessed based on the presence of a number of characteristics (...) often in conjunction with management aspects, such as maintenance, to give a measure of the overall quality of a place (p34).				
61	Buchanan, C.	2006	Valuing urban realm - business cases for public spaces (Summary Report)	Accent and Transport for London	No	
	Summary/Comment	Methodology for quantitatively assessing ambience which is a measure of the improvement to the quality of environment that users experience using PERS.				
	Useful extracts					
62	Department for Transport.	2003	Traffic Advisory Leaflet 5/03: Walking Bibliography	Department for Transport	No	
	Summary/Comment	This Traffic Advisory Leaflet is a bibliography of documents which relate to providing for pedestrians, incorporating policy, strategy documents and plans, as well as functional documents relating to infrastructure provision and maintenance. The bibliography also details sources for understanding the links between walking and health, mobility, security and road safety. There are also references to documents relating to specific journeys for school children, employees and how to effectively monitor and value schemes.				
	Useful extracts					

#	Author	Date	Title	Source	Relevant based on the 5 key questions?	Relevance matrix code
63	Burnett, A.	2005	In the right place. Accessibility, local services and older people	Help the Aged	Yes	G8, G9, G12, H8, H9, H12
	Summary/Comment	Poor quality pavements, hilly terrain, inadequate street lighting, noise and pollution, threats to safety and inconsiderate behaviour towards older, vulnerable people are cited as 'tipping points' - key elements in deciding whether to go out or not, when and where.				
	Useful extracts	"There is ample evidence of 'distance decay' amongst older people - people are put off from using services if the journey seems too far, too time consuming, too costly, too dangerous or too difficult" (p11).				
64	OECD	2001	Ageing and Transport. Mobility Needs and Safety Issues	OECD	Yes	G8, G9, G12, H8, H9, H12
	Summary/Comment	Policies need to provide safer roads and roadside environments for older drivers, pedestrians, cyclists and users of powered wheelchairs and scooters. Pedestrian safety needs to address personal security concerns.				
	Useful extracts	Improved road environments will facilitate or reduce older drivers' need to make complex decisions and perform time-related tasks.				
65	West Midlands Local Transport Plan	2006	West Midlands Local Transport Plan: Bridge maintenance	West Midlands Local Transport Plan	Yes	B4, B9
	Summary/Comment	In order to fulfil statutory obligations to the road user and to ensure that traffic restrictions are not imposed on bridges that would adversely affect national and local objectives, there is a need to manage the highway structures in a way that ensures they can carry the loads required. This means they are maintained properly and improved as necessary.				
	Useful extracts	"Safety issues have been identified in connection with subways. Many subways suffer from vandalism and are used for anti-social behaviour. They are often perceived by the public as being unsafe generally due to their secluded nature, poor lighting and lack of maintenance. Many subways are being infilled and replaced by alternative facilities as part of other programmes. However, it is recognised that subways often provide the safest routes for pedestrians crossing roads and a number of authorities have a programme of works to improve them so as to encourage their use and reduce the amount of vandalism".				

#	Author	Date	Title	Source	Relevant based on the 5 key questions?	Relevance matrix code
66	Keizer, K. Lindenberg, S. and Steg, L.	2008	The spreading of disorder	Science Vol. 322 p1681-1685	Yes	G4, G9
	Summary/Comment	The University of Groningen in the Netherlands conducted experiments to discover if signs of vandalism, litter and low-level law breaking could change the way people behave, and found that such conditions doubled the number of people prepared to litter and steal.				
	Useful extracts	The researchers' conclusion is that one example of disorder, like graffiti or littering, can indeed encourage another, like stealing - hence clearing up graffiti or littering promptly could help fight the spread of crime.				
67	Cormany, D.L.	2008	Small retailers struggle to survive bridge collapse	MinnPost.com	Yes	B11
	Summary/Comment	As a result of the Interstate Highway I-35W bridge collapse on 1st August 2007, a number of small retail establishments scattered across affected areas, but most specifically the Johnson Avenue Northeast businesses, have reported revenue declines of up to 50%. The I-35W bridge collapse is costing the state $113,000 per day in lost economic output, according to an analysis by the Minnesota Department of Employment and Economic Development.				
	Useful extracts	Though the roads immediately surrounding the retail district on the 2800 block of Johnson Street Northeast are open as usual, drivers who once passed through the area to or from I-35W South seem to be finding other routes. Area merchants say traffic flow is down significantly. Another retailer located at the final exit before southbound I-35W crosses the Mississippi River reported an 80% drop in sales immediately after the bridge accident.				
68	BBC News	2009	Flood-Hit Areas Face Travel Chaos	BBC News 23 November 2009	Yes	B11
	Summary/Comment	In the week following the 2009 floods in Cumbria, 16 bridges and 25 road closures were causing travel chaos. 6 bridge crossings collapsed and Calva bridge in Workington was condemned resulting in people in Northside having to make a 40 mile detour just to reach the town centre.				
	Useful extracts	"The lack of bridges meant people were being forced to travel 90 miles for a journey that would usually take a minute and a half, and temporary structures may be needed". A teacher in Wigton said his usual journey to work is 15 miles and takes 20 minutes, but as the two main bridges out of Cockermouth are closed, he now has to take an alternative route which is 40 miles.				

#	Author	Date	Title	Source	Relevant based on the 5 key questions?	Relevance matrix code
69	Department of Environment, Food and Rural Affairs.	2006	Code of Practice on Litter and Refuse	DEFRA website	Yes	J4
	Summary/Comment	The document by the Department for Environment, Food and Rural Affairs (Defra) is a code of practice for policy makers, responsible bodies and other stakeholders, containing advisory standards on litter, refuse and graffiti and fly tipping. The Code includes the relevant legislation which bounds responsible bodies. In brief it links the presence of graffiti and fly-posting to fear of crime and lower levels of environmental quality.				
	Useful extracts	The emphasis is on the consistent and appropriate management of an area to keep it clean, not on how often it is cleaned Such defacement [as graffiti and fly posting] even if partially removed, has an adverse effect on the quality of the environment and can lead to an increase in crime. Even if all of the litter and refuse were cleaned, the public would still perceive the area to be defaced if graffiti and / or fly-posting were still present Incidents of these types of environmental crime [graffiti and fly-posting] may not be as widespread as those of litter, refuse or detritus, but their presence on the appearance of the local environment can lead to further degradation of an area and an increase in the fear of crime.				
70	Marsden, G, Jopson, A, Cattan, M and Woodward, J.	2010	Transport and Older People: Integrating Transport Planning Tools with User Needs	11th World Conference on Transport Research, Berkeley, USA	Yes	C7, C9, C11, C12, G7, G9, G11, G12
	Summary/Comment	This research paper reports on a study which aimed to better understand older people's transport needs so that transport planning tools could better provide for this demographic group. In doing so, focus groups, interviews and assisted walks were carried out to explore how older people interact with their transport environments. One key concern for older people was the quality of footways, which in some cases cause route changes and greater distances to walk. The study also showed older people have great sensitivity to walking environments, and distance, barriers and [diminished] route choices can result in a real change in older people's participation in society. Links to health, well-being and inclusion (through older people's ability to interact with their environment) are well referenced, and the study included a literature review.				
	Useful extracts	[In terms of derived demand for transport] the study clearly found that for older people the travel itself and the feeling of freedom and purpose it engendered were often more important than the actual destination Older people's ability to get out and about was affected by environmental, social and psychological factors. These included... uneven surfaces and obstacles... a fear of being knocked or falling over. The location of bus stops within the city centre caused difficulties for those with mobility problems Whilst walking is, by definition, inherently linked to personal mobility the local environment also played a key role. A feeling that areas had not been designed to take older people's needs into account emerged from the interviews. [The study was] unable to close the gap between apparent (what the accessibility model says), actual (what older people				

#	Author	Date	Title	Source	Relevant based on the 5 key questions?	Relevance matrix code
		can and do) and perceived (where knowledge and beliefs limit actual access patterns) accessibility. The decision making environment is also changing with greater fragmentation of responsibilities for delivery and management of transport services, roadworks etc than has been the case for much of the current generation of older people's lives. Many of the issues raised by older people could be dealt with if there is sufficient will, focus and co-operation by the various agencies involved. Some of these have a resource cost but in most instances the benefits of investment will accrue to the wider community, not just older people. There is a substantial body of literature to suggest that older people suffer more than most from poor public transport and a badly maintained transport infrastructure, being more dependent on public transport, suffering from greater transport difficulties and feeling more insecure waiting for public transport (Dunbar, Holland, & Maylor, 2004) and (Disabled Persons Transport Advisory Committe (DPTAC), 2002)). The perseveration of independent mobility (..on foot..) is particularly important to the health and mental well being of older people (Maratolli, 2002) and (Harris, 2002). Inadequate pavements. Participants talked about changing their route to avoid areas with bad paving. This included them being... badly maintained... or even not being where they wanted to walk. Steps or extremely contorted journeys. Long deviations, often with steps, were noted; one example was trying to reach a supermarket by the ring road that involved many steps and bridges. It was felt that such routes had been designed for only the most agile walkers.				
71	Abbott, P.G., Morgan, P.A. and McKell, B.	2010	A review of current research on road surface noise reduction techniques	TRL	Yes	A1
	Summary/Comment	The Scottish Government commissioned TRL to undertake a review of the different low-noise road surfaces currently available and comment on their relevance and suitability for use in Scotland.				
	Useful extracts	After a period of stabilization some surfaces can exhibit significant increases in noise, particularly as the surface reaches the end of its life (p35). Bituminous surfaces which exhibit surface fretting (loss of stone) after long periods of heavy traffic, the appearance of cracks and the hardening of the bitumen due to long-term exposure, can all contribute to higher levels of tyre/road noise (p35).				
72	Audit Commission	2011	Going the distance - achieving better value for money on road maintenance	Audit Commission	No	
	Summary/Comment	Achieving better value for money in road maintenance				
	Useful extracts					

#	Author	Date	Title	Source	Relevant based on the 5 key questions?	Relevance matrix code
73	Clegg, A.	2011	Contribution of road and street maintenance to make better places	Public Space Management, the Environment Service, Perth and Kinross Council	Yes	A5, A8, A9, A4
	Summary/Comment	Benefits of road design and management in Scotland				
	Useful extracts	Research by CABE states that achievable improvement in street design quality can add an average of 5.2 per cent to residential prices on the case study high streets and an average of 4.9 per cent to retail rents. Maintenance of the network has a crucial role to play in making this asset accessible and inappropriate use of materials and infrastructure can have a detrimental effect on the perception of an area. Maintenance is critical to the long term success and benefits of streets to communities. Poorly maintained surfacing and infrastructure discourages use of the street and looks poor. Unaddressed this can contribute to increased cost through liability for damage caused by the physical condition of the asset and social and economic decline of the area. Dilapidated structures, potholes, dark lamps and heavy patching can all detract from the perceived quality of the public realm in an area. This can lead to low esteem and a lack of pride and respect for the area people live in and the consequential antisocial behaviour including graffiti, vandalism, and other more serious crime. As the economic, social and environmental spiral of decline erodes the wellbeing of the community, so the physical costs and difficulties in addressing it increase as well as the added burdens on the social health care and law and order agencies. Reductions in maintenance budgets could have very serious and far reaching consequences for the places in which we live.				
74	Institute for Environmental Studies	2009	Environmental economics. The economic benefits of environmental policy	Institute for Environmental Studies, Amsterdam	No	
	Summary/Comment	Various reports on the economics of environmental policy				
	Useful extracts					
75	Hill, J. and Starrs, C.	2011	Saving lives, saving money - The costs and benefits of achieving safe roads	Road Safety Foundation and RAC Foundation	Yes	A8, A9
	Summary/Comment	Assessing the cost of road crashes to the economy and where the cost falls but no mention of maintenance				
	Useful extracts					
76	Lothian & Borders Emergency Planning Strategic Co-ordinating Group.	2010	Community risk register	Lothian & Borders Emergency Planning Strategic Co-ordinating Group (version 5.0)	Yes	A11
	Summary/Comment	Risk register to inform communities of disruptive events but does not include evidence on effects of maintenance.				
	Useful extracts					

#	Author	Date	Title	Source	Relevant based on the 5 key questions?	Relevance matrix code
77	Nellthorp, J., Chintakayala, P. and Wardman, M.	2011	Valuation of townscape improvements using a two-level stated preference and priority ranking approach	International Choice Modelling Conference, Oulton Hall, Leeds, 4-6 July 2011	No	
	Summary/Comment	Study to establish how much citizens are willing to pay for pedestrian environment. All aspects relate to capital investment not maintenance.				
	Useful extracts					
78	Scottish Enterprise.	2011	Briefing paper - opportunities and influence, globally competitive business environment	Scottish Enterprise	No	
	Summary/Comment	Physical connectivity focus on rail and air.				
	Useful extracts					
79	Scottish Government.	(-)	Scottish noise mapping	http://scottishnoisemapping.org/	Yes	A1
	Summary/Comment	Strategic noise maps for major roads, rail, airports and industries. Probably limited applicability.				
	Useful extracts					
80	Scottish Government.	(-)	Aligning noise action planning	http://www.scotland.gov.uk/Publications/2007/08/24141743/0	No	
	Summary/Comment					
	Useful extracts					
81	Vainio, M. and Paque, G.	2002	Highlights of the workshop on the "Start-of-the-art in noise valuation" final report	Workshop on the "Start-of-the-art in noise valuation", Brussels, 14 December 2001	No	
	Summary/Comment	Methodology for noise valuation. Not closely relevant.				
	Useful extracts					
82	Vibrock Ltd.	2007	Results of traffic induced vibration surveys, pre and post repair, A82 Stirling Road, Dumbarton	WA Fairhurst and Partners, Report number R07.4787/AF	No	
	Summary/Comment	Residents of properties fronting the A82 Stirling Road, Dumbarton, located close to the junction with Glenpath, had complained that surface irregularities on the carriageway were creating traffic induced vibration resulting in damage to the structure of their premises. Not closely relevant.				
	Useful extracts					

#	Author	Date	Title	Source	Relevant based on the 5 key questions?	Relevance matrix code
83	Reid, S. and Shore, F.	2008	Seeing issues clearly - valuing urban realm	MVA consultancy and design for London	Yes	C4, C9, C11, E9, G4, G9, G11
	Summary/Comment	The study was undertaken to inform Transport for London and Design for London of the relationship between street quality and property values. In doing so, a mixed methodology was used which sought to investigate the quality of streets (as measured by PERS audits) against variations in rental values, and stated preference surveys of businesses to understand whether private businesses would be prepared to pay for improvements to the street environment.				
	Useful extracts	The experience of a place largely results from the quality of its streets and public spaces Members of the public value high quality streets and places and are willing to pay for improvements We have found there is positive, significant and consistent value added to private business by maintaining and improving the public realm The elements of streets which most clearly add value to private property are: • Personal security • Lighting • Quality of the environment • Maintenance Retailers generally acknowledged the importance of the public realm, particularly "the basics" such as cleanliness, lighting and good footway surfaces. The study found that on average businesses did value improvements to lighting, pavement surfaces and environmental quality and were willing to make a one-off payment equivalent to around 2.5% of their current annual business rate per m^2 for each increment of improvement on the PERS scale. The strongest relationship that was found between PERS scores and property values was for a combination of the four PERS criteria: • Personal Security • Lighting • Quality of the Environment • Maintenance This finding is interesting as it suggests that the most cost-effective way to add value to properties is to focus on getting these basics right.				

<table>
<tr><th>#</th><th>Author</th><th>Date</th><th>Title</th><th>Source</th><th>Relevant based on the 5 key questions?</th><th>Relevance matrix code</th></tr>
<tr><td rowspan="3">84</td><td>Pittner, C. and Allerton, G.</td><td>2009</td><td>SUDS for Roads</td><td>WSP Development and Transportation</td><td>No</td><td></td></tr>
<tr><td>Summary/Comment</td><td colspan="5">Document provides guidance on the design, construction, adoption, maintenance, performance, applicability and whole life cost of Sustainable Urban Drainage Systems (SUDS) associated with the treatment and attenuation of surface water runoff from roads and footways linked with the local authority road hierarchy.</td></tr>
<tr><td>Useful extracts</td><td colspan="5"></td></tr>
<tr><td rowspan="3">85</td><td>Asphalt Industry Alliance</td><td>2010</td><td>The economic impact of local road condition</td><td>Asphalt Industry Alliance</td><td>Yes</td><td>A10, G8</td></tr>
<tr><td>Summary/Comment</td><td colspan="5">The impact of poorly maintained local roads on the public and on small and medium sized businesses through interviews.</td></tr>
<tr><td>Useful extracts</td><td colspan="5">Quantitative assessment of cost of poorly maintained road to businesses and the public.
Businesses that incurred costs in the last 6 months estimate that it cost £4,300 on average due to damage and increased fuel cost. On average those affected by damage to their vehicles spent £340 on repairing them.
The impact of any personal injury in relation to poorly maintained roads is 20 days off on average.
The research has shown that poorly maintained roads have a negative impact upon productivity and competitiveness and on personal injury and the costs of running a vehicle.</td></tr>
<tr><td rowspan="3">86</td><td>Farrington, D.P. and Welsh, B.C.</td><td>2002</td><td>Effects of improved street lighting on crime: a systematic review</td><td>Home Office Research</td><td>No</td><td></td></tr>
<tr><td>Summary/Comment</td><td colspan="5">Report presents the findings of a systematic review of the effects of improved street lighting on crime.</td></tr>
<tr><td>Useful extracts</td><td colspan="5"></td></tr>
<tr><td rowspan="3">87</td><td>Crabb, G.I., Crinson, L., Beaumont, R. and Walter, L.</td><td>2009</td><td>The impact of street lighting on night-time road casualties</td><td>TRL</td><td>Yes</td><td>E8</td></tr>
<tr><td>Summary/Comment</td><td colspan="5">Statistically robust evidence for the contribution of street lighting to road casualty reduction using STATS19 casualty data and a literature review (p1).
The literature review found that accident severity is reduced by road lighting and road lighting appears to have a bigger effect on reducing accidents involving pedestrian casualties than vehicle occupants (p15).</td></tr>
<tr><td>Useful extracts</td><td colspan="5">The analysis of all data revealed that, taking day and night together, 'all accident' densities where street lighting is present were 7 to 17 times higher than where there is no lighting. This reflects traffic flow and that street lighting may have been installed at sites with a high accident density (p58).
In the 5 year study period 21% of accidents occurred in darkness where there was street lighting, while less than 6% of all accidents occurred where there is no street lighting. Lighting appears to have a larger effect on reducing the number of fatal accidents than the number of serious and slight accidents (p58).</td></tr>
</table>

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88	Ramdas, V., Thomas, C, Lehman, C. and Young, D.	2007	Highway service levels	TRL	Yes	A8, C11, D11, G11, H11
	Summary/Comment	TRL and Ipsos MORI research report, for the Department of Transport, aimed to integrate the perceptions of road surface conditions amongst different types of users with the parameters used by Local Authorities to measure and report on network condition. This is so that public satisfaction levels (and their drivers) can feature in how roads are maintained and how money is spent, so that better value for money can be gained from ongoing investment in the road network.				
	Useful extracts	The type of road user is a key driver of perceptions of road surface condition. The elderly and disabled (whether pedestrians, private motorists or passengers) notice road surfaces more than any other group. Trip hazard (trip >10mm) was the main aspect that concerned the participants [of the study]. The cyclists were mainly concerned about step changes (step >20mm) in their line of travel caused by potholes, sunken or raised ironwork, failed potholes and debris in the carriageway. They generally cycle on the left-hand side of the road and as such edge deterioration and raised ironworks are of particular concern. Cyclists' perceptions of road surfaces were also coloured by their view on the condition of cycle lanes. ...Cycle lanes are often too narrow and covered in "debris". Poor surfaces at the edge of the road and in cycle lanes mean that cyclists can be forced to alter their route. For some, this may mean getting off their bicycle and walking. For others, this may involve swerving into other parts of the road to avoid defects. Any deviation of the cyclists' 'line' is seen as very dangerous. Poor surfaces, especially at the edge of the road, may cause a sudden deviation that would then put the cyclist and other road users in danger. In wet weather, ruts were a concern for all road users as water collected in them and increased the amount of spray on the roads, reducing visibility. Road surfaces with loose stones were a serious concern for motorcyclists, making them feel particularly unsafe because they flew up and hit then as vehicles drove over them The condition of footways can be a barrier to mobility for older and disabled pedestrians affecting their independence and social inclusion. In an older study (Disabled Persons Transport Advisory Committe (DPTAC), 2002) visually impaired people were more likely to be dissatisfied with road and footways than other disabled users and about half (48%) of the disabled people said that they would go out more if the conditions for walking were better. In a project undertaken for the Scottish Executive (Granville, Rait, Barber, & Laid, 2001) to explore the attitudes of drivers and cyclists towards one another, conflict situations between drivers and cyclists were created by the poor state of repair on the road. A study undertaken by Newcastle City Council in 2004 to measure public opinion of the street environment found that insufficient grass cutting of verges is a top complaint in a number of counties participating in the study. Mud, dirt and rubbish on the road and the number of repaired or unrepaired potholes are perceived as major problems. Elderly and/or disabled road users are most critical of surface conditions. Unlike many other groups, they are highly				

#	Author	Date	Title	Source	Relevant based on the 5 key questions?	Relevance matrix code
		aware of surface problems. This is mainly because of fears for personal safety and discomfort. On footways, tripping or falling on raised or lowered paving slabs and potholes is a particular concern, As a result of personal safety fears on footways and severe discomfort on the roads, poor surfaces are avoided wherever possible, and there is a greater tendency to take an alternative route. ... The diversion can be a different road altogether, even if it results in a longer journey, or a deviated path (e.g. from footway and into the road) on the same road. Motorcyclists are also sensitive to uneven surfaces. The worst defects were those that were not easily visible but with the potential to disturb their balance. One defect seen as particularly unsafe for motorcyclists is "rutting"... where the rider can then be easily and suddenly thrown off. This obviously creates a serious safety concern. Like cyclists, motorcyclists often swerve and alter their "line" to avoid noticeable defects. The concern is that avoiding the defect in fact impacts on other road users and places them and the motorcyclist in danger.				
89	Institution of Lighting Engineers	2010	Save money and keep the lights on	Institution of Lighting Engineers	Yes	E8, E9
	Summary/Comment	Good lighting brings many benefits to the community (p1): 1. Reduces street crime and fear of crime 2. Reduces the number and severity of night time road accidents by up to 30% 3. Helps the emergency services carry out their roles after dark 4. Promotes the evening economy, making people confident to use public transport, walk the streets after dark in safety, offering access to evening work, education and leisure activities The Institution of Lighting Professionals (ILP) have shown that the average UK street lamp is about 70 watts and energy costs are only £30 per year at the average national tariff (p1). Recent evidence of these benefits was recently demonstrated in the case of a private finance initiative re-lighting scheme in Wakefield. The Borough re-lit its highway network during the last 5 years and the new lighting: - Helped reduce vehicle collision and damage by 50% (143 incidents in 2004, reduced to 69 in 2008) - Reduced vehicle crime by 62% between 2004-08 - Reduced night time accidents - overall accidents down by 31% from 2004-09 and night time fatalities fell from 9 to 0 in the same period. A recent report by children's charity PLAN UK highlighted that 91% of 13-18 yr old girls said better street lighting would make a big difference to whether they felt safe on the streets. Other implications of switching off lighting include: - Lighting of speed limit signs (e.g. 30mph) is often linked into street light circuits and no lighting will require new signage				

#	Author	Date	Title	Source	Relevant based on the 5 key questions?	Relevance matrix code
		- CCTV systems require street lighting - camera operation at night could be severely compromised - There are costs associated with high tariff energy use, changing lamp photo cellt to part night switching, installation of cats' eyes, and removal of electrical supply to each street lamp				
	Useful extracts	In September 2010, Louise Ellman MP, a member of the Commons Transport Select Committee was quoted as saying "I am extremely concerned that financial pressures are leading to steps which can jeopardise people's lives and increase the number of injuries" (p1). The Coroner investigating a fatality in Buckinghamshire (undergoing switching off street lights to save energy trial) directly linked the lack of lighting with the accident, saying "the driver had no chance to see the lady crossing the road without any street lights operating" (p2).				
90	Parkman, C.C. and Bradbury, T.	2011	Economic assessment of the impacts of changes in maintenance spend on the Scottish truck road network (CPR1330)	TRL	Yes	
	Summary/Comment	Use as reference to wider economic and social impact work				
	Useful extracts					
91	Highways Agency.	2006	Vegetated drainage systems for highway runoff (DMRB HA 103/06)	Highways Agency	No	
	Summary/Comment	Advice note giving guidance on how vegetated drainage system may be used to convey, store and treat highway runoff.				
	Useful extracts					
92	Zuman, C.	1980	The case for improved street lighting	The Highway Engineer, Journal of the Institution of Highway Engineers	No	E8
	Summary/Comment	Too old to be relevant				
	Useful extracts					
93	Beyer, F.R. and Ker, K.	2010	Street lighting for preventing road traffic injuries (Review)	The Cochrane Collaboration	Yes	E8
	Summary/Comment	A systematic review of 17 controlled before-after studies conducted in UK, USA, Germany and Australia to investigate the effect of newly installed street lighting and improved lighting. Street lighting may improve a driver's visual capabilities and ability to detect roadway hazards. However, street lighting could also have an adverse effect on road safety (i.e. risk compensation effect) where drivers may 'feel' safer because lighting gives them improved visibility which could result in increased speed and reduced concentration (Assum, Bjornskau, Fosser, & Sagberg, 1999). In 1976, Rockwell (Rockwell, Hingerford, & Balasubramanian, 1976) found that with improved lighting, drivers exhibited				

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		earlier detection of intersections, earlier gas pedal release and speed reduction suggesting an improvement in driver visual certainty. Street lighting can reduce the contrast between headlight glare and the environment, preventing loss of visual certainty from contrast adaptation (p3).				
	Useful extracts	In 1983, Vincent (Vincent, 1983) analysed the results of eleven previous investigations, and found that "there was not sufficient evidence to support the claim that lighting reduced road traffic crashes" (p3). The literature was re-examined by Elvik (Elvik, 1995) who concluded that street lighting may reduce night-time fatalities by as much as 65% and night-time injuries by 30% (p3). Elvik (Elvik, Hoye, Truls, & Sorensen, 2004) updated his research in 2004 to reveal that "increasing the level of lighting by up to double the previous level has a limited effect on the number of crashes, but is not so pronounced as for newly installed lighting compared to a previously unlit road" (p16).				
94	Chang, H-L. and Chang H-W.	2009	Exploring recreational cyclists' environmental preferences and satisfaction: experimental study in Hsinchu technopolis	Environment and Planning B: Planning and Design 2009, Volume 36, p318-335	No	
	Summary/Comment	This study investigates two groups of recreational cyclists' environmental preferences for, and satisfaction with, existing cycling facilities in a technopolis.				
	Useful extracts					
95	Zhang, C.	2010	Delivering sustainable bridges to help tackle climate change	Proceedings of the Institution of Civil Engineers, Engineering Sustainability 163, June 2010, Issue ES2, p89-95	Yes	E2
	Summary/Comment	Environmental impact of bridges especially carbon dioxide emission				
	Useful extracts	Maintenance of bridges uses materials, consume energy and therefore produce carbon dioxide emission. Furthermore, bridge works disrupt traffic, causing queues and detours. This leads to increased driving distances, frequent stopping and starting and long idling, all of which contribute to more fuel consumption and more carbon dioxide emissions. (p91). In order to reduce carbon dioxide emissions during the service life of bridges, maintenance works especially those that cause severe disruption of traffic - need to be minimised. (p92).				

#	Author	Date	Title	Source	Relevant based on the 5 key questions?	Relevance matrix code
96	Daley, M., Rissel, C. and Lloyd, B.	2007	All dressed up and nowhere to go? A qualitative study of the barriers and enablers to cycling in inner Sydney	Road and Transport Research	No	
	Summary/Comment	Qualitative study aimed at exploring factors that influence personal decisions to initiate and maintain cycling, or not to cycle, in inner Sydney, and to identify differences according to current cycling behaviour.				
	Useful extracts					
97	Cycling England.	2008	A sustainable future for cycling	Department of Transport	No	
	Summary/Comment	Results of investment in cycling initiatives such as Links to Schools and Cycling Demonstrations Towns				
	Useful extracts					
98	Pitt, R.	1979	Demonstration of nonpoint pollution abatement through improved street cleaning practices	Municipal Environmental Research Laboratory, US Environmental Protection Agency, Ohio	Yes	A1, C1, F1, J1
	Summary/Comment	The research report presents findings from a 1970s demonstration study of nonpoint pollution abatement through improved street cleaning practices. The study was designed to measure the range of capabilities of street cleaning equipment in removing pollutants from the street surface. The report includes the accumulation rate characteristics of the various pollutants associated with street dirt, resulting in factors which affect street cleaning equipment performance and conclusions for the design of effective street cleaning programmes.				
	Useful extracts	Paved roads should be considered as important particulate air pollutant sources. Dust from the atmosphere, soil from erosion and vehicular deposits on paved street surfaces can be disturbed by win and traffic, causing particulate emissions. Street cleaning may be an effective means of removing these particulates before they can be blown into the air. Accumulation rates vary widely in different test areas depending on street surface conditions, land use, and activities within the area. Street dirt loading was also found to increase more rapidly immediately after street cleaning, and then level off somewhat after several days. One week after street cleaning, approximately 4 to 6lb/curb mile [sic] per day of particulates were lost to the air. This rate increases for longer cleaning intervals. This loading pattern is expected to be due to wind and vehicle-caused turbulence suspending the particles in the air, thus causing increased air pollution. Areas with better quality street surfaces had more of the smaller sized particles present. The median particle size of street dirt was also found to increase with time between cleaning and decrease with cleaning. Street cleaning equipment picks up larger particles more effectively than smaller particles. As a result, the small particles tend to increase in abundance with time.				

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		Different test area conditions affected performance more than differences in equipment type. Smoother (asphalt) streets were found to be easier to keep clean than streets with oil and screens surfaces or those in poor condition. The street surface loading values after cleaning were always lower on the asphalt streets in good condition (see table 2-4, p6). Pollutant removal per unit effort decreases with increasing numbers of passes per year. The cost to remove a pound of street dirt increases with increasing numbers of cleaning passes in a year. Street cleaning has multiple benefits and can also improve air quality, aesthetic conditions and public safety.					
99	Tarry, N.		2008	Safety Fears as the Lights go out	BBC News 12 February 2008	Yes	E8, E9
	Summary/Comment	Reports on several trials being undertaken by Local Authorities: - Buckinghamshire has selected 'low risk' sites, adding solar road studs, extra signs and road markings. The 3 year trial involved switching off 287 street lights, followed by another 1,700 lights after the first phase. - Gloucestershire County Council will be turning off 36% of its lighting part time, but not on main traffic routes or areas of high crime. - Essex is carrying out 'part-night lighting' trials in Maldon District and Uttlesford. - Hampshire and Hertfordshire are also running trials. In terms of the effect on crime of turning lights off, a Home Office study from 1991 found that lighting was more likely to have a positive impact on the public's fear of crime, than on the incidence of crime itself.					
	Useful extracts	In Buckinghamshire County Council "seven sites monitored there were a total of seven collisions between August and December 2006 when lights were on, and only three in total between August and December 2007 when lights were off". AA said "Turning off street lights to save money or CO_2 may backfire in terms of increased accidents and crime". The 1991 Home Office Report states that "better lighting by itself has very little impact on crime".					
100	Buckinghamshire County Council		2010	Switching off street lights to save energy trial - Second Interim Report	Transport for Buckinghamshire	Yes	E8
	Summary/Comment	The Saving Energy Trial in Buckinghamshire County Council started in 2007 when lights at the first 7 sites were switched off (Phase 1). Lights at a further 39 sites were switched off between May and September 2008 (Phase 2). In total, 1,627 lights have been switched off at the 46 rural or semi-rural sites around the County. Three years 'before' and 'after' data is available for all Phase 1 sites and two years 'before' and 'after' data is now available for all Phase 2 sites. The trial will end when there is a complete three years 'before' and 'after' available for all 46 trial sites. The overall reported collision record at the sites where lights have been switched off shows a 31% reduction in all injury collisions and a 9% reduction in injury collisions during darkness. Customer feedback has commented on the need for lighting to be retained to highlight other highway defects including					

#	Author		Date	Title	Source	Relevant based on the 5 key questions?	Relevance matrix code
		flooding, potholes and overgrown foliage. Results across all 7 Phase 1 sites show: - 44% reduction in all injury collisions - 54% reduction in all casualties - 7% reduction in injury collisions during darkness - 21% reduction in casualties during darkness Results across all 39 Phase 2 sites show: - 27% reduction in all injury collisions - 25% reduction in all casualties - 10% reduction in injury collisions during darkness - 8% increase in casualties during darkness Data shows that collisions have increased at 3 Phase 1 sites which are all roundabouts, indicating that roundabouts are not suitable for switching off street lights.					
	Useful extracts	Results so far are encouraging with a general reduction in the overall number of collisions. When Phase 1 and Phase 2 are considered together, there has been: - 31% reduction in all injury collisions - 32% reduction in all casualties - 9% reduction in injury collisions during darkness - no change in casualties during darkness Some collisions occurring during darkness within areas where lights have been switched off have resulted in fatal injuries, however there were also fatal collisions in the 'before' period when the lights were on during darkness.					
101	Sinclair, D., Swan, A. and Pearson, A.		2007	Social inclusion and older people - a call for action	Help the Aged	Yes	G4, J2
	Summary/Comment	Findings of 6 workshops looking at older people who experience social exclusion					
	Useful extracts	According to participants, the things which made for a bad local environment were mainly three fold: rubbish (and associated mess, smells and rats); poorly maintained amenities; and neighbours' behaviour (p20) In Birmingham, the chinese group said that the pavements are uneven in places, which makes it more likely that older people will trip and fall (p18)					

#	Author	Date	Title	Source	Relevant based on the 5 key questions?	Relevance matrix code
102	McClintock, H. and Russell, T.	2002	Cycling solutions	Surveyor, Vol 189, p20-22	No	
	Summary/Comment	Findings of 2 conferences on improving the quality of infrastructure provision for cyclists.				
	Useful extracts					
103	Branco, F.E.F.	1999	International symposium on the environmental impact of road pavement unevenness	Routes/Roads, World Road Association, PIARC, Issue 304, p58-64	No	
	Summary/Comment	Analysis of environmental impacts due to road pavement unevenness				
	Useful extracts					
104	Kuennen, T.	2003	Making edge drains work	Better Roads, Vol 73, issue 1, p42-46	No	
	Summary/Comment	How to maintain edge drains in order to enhance pavement life				
	Useful extracts					
105	Brewer, S.	2005	Route canal work brings relief	Surveyor, 2nd June 2005, p16-17	No	
	Summary/Comment	A project to improve a local canal towpath in Nottingham				
	Useful extracts					
106	Stidger, R.W.	2003	The pros and cons of municipal street sweeping	Better Roads, Vol 74 issue 4, p22-25	No	
	Summary/Comment					
	Useful extracts					
107	Maas, G.A., Maas F.K., Maas, S.P. and Claughton, D.	2006	Dynamic measurement of tyre/road noise	29th Australasian Transport Research Forum	No	
	Summary/Comment	Description of methods to measure traffic noise				
	Useful extracts					
108	Johansson, S and Johansson, K.	2007	Road condition management policies for low volume roads - tests and development of proposals	Roadex II, Northern Periphery	No	
	Summary/Comment	Project investigating the road user needs and socio-economic impact of road conditions on low volume roads across the European Northern Periphery including Finland, Sweden, Scotland and Norway.				
	Useful extracts					

#	Author	Date	Title	Source	Relevant based on the 5 key questions?	Relevance matrix code
109	McDowall, E and Adams, C.	2008	Locally significant roads: An investment strategy	HITRANS	Yes	A11
	Summary/Comment	Study to develop a strategy for investment in the network over the period of 2008-11 in order to enhance the reliability and quality of the network, particularly for freight and public transport, and to enhance the accessibility of small rural communities				
	Useful extracts	Poor surface quality, poor geometry and alignment, poor visibility, inadequate numbers of passing places, narrow roads, high traffic volumes, weight and height restrictions and slow average speeds can have a serious impact on the sustainability of businesses and communities which rely on these routes. Poor conditions and long journey times along the routes can place a significant constraint on the ease and comfort with which residents can access employment and lifeline services such as health, education, retailing and banking. At the same time, the poor condition of the network also acts as a barrier to growth among local businesses by adding to journey times, increasing the cost of transport, increasing vehicle operating costs and restricting labour catchment areas (Executive Summary). With regard to social impacts, consultees noted the impact that road improvements would have on maintaining sustainable communities in rural areas. Key benefits for residents include: - Easier, less problematic access to lifeline services in regional centres - Easier access to the national strategic trunk network - Easier access to employment opportunities, opening up wider labour catchment areas across the region - Easier access to ferry and other transport services (p22).				
110	Halcrow.	2004	Investment in lifeline rural roads - Stage two final report	HITRANS	Yes	A11
	Summary/Comment	Study to assess the key problems, issues and constraint facing rural communities and the role of 'lifeline' roads.				
	Useful extracts	A number of these remote communities are only accessible by one single track road, or by a substitute route which entails a considerable degree of additional time or money expenditure. For the purposes of this study these roads which serve remote communities have been defined as 'lifeline roads'. The quality, reliability or the availability of these links is likely to have a significant impact on the social and economic fabric of the affected communities. Many of these 'lifeline roads' are currently of a poor standard and in need of repair or upgrade (p6) The quality, reliability or the availability of these links is likely to have a significant impact on the social and economic fabric of the affected communities (p129). Within the first two categories the main benefits are likely to accrue from sustaining and enhancing the local economies served directly by the routes. In most cases, in particular the islands routes, the road link will provide the sole means of access for a number of communities and thus the condition of the route is of high importance to the economic and social vitality of the area. It is therefore considered that the benefits should be examined within this context of the long-term				

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		prosperity of the area (p130). Again it has been demonstrated, to a greater or lesser degree, that the current conditions of these roads provide significant constraints to economic activity and thus the prosperity of the communities. The benefits should again therefore be examined within this context of the long-term vitality of the area (p139). The study included an economic analysis on a scheme-by-scheme basis of the impact of investment on nine key routes in terms of journey times and reliability, diversionary impacts, generated traffic, accident reductions impacts and total users benefit.				
111	Campbell, S.	2005	Deteriorating vision, falls and older people: the links	Visibility	No	
	Summary/Comment	This project aimed to establish if significant sight loss is occurring in older people who have fallen and if their visual problem has been identified.				
	Useful extracts					
112	Harding, E.	2007	Towards lifetime neighbourhoods: designing sustainable communities for all - a discussion paper	Communities and Local Government	Yes	C12, G12
	Summary/Comment	Lifetime neighbourhoods are those which offer everyone the best possible chance of health, wellbeing, and social, economic and civic engagement regardless of age. They provide the built environment, infrastructure, housing, services and shared social space that allow us to pursue our own ambitions for a high quality of life. They do not exclude us as we age, nor as we become frail or disabled.				
	Useful extracts	In particular, good street design and ongoing maintenance has been found to be crucial to older people's ability and confidence in going outside (p16). The NHS spends nearly £1bn a year on treating injures caused by falls, many of which involve older people tripping on damaged or uneven pavements (p17). Research found that 56% of people over 65 go out of their way to avoid routes that may have faulty or damaged pavements and that amounts to a restriction on movement of 5.5 m older people.				
113	Scottish Government.	2010	Scottish household survey - Annual report	Scottish Government	No	
	Summary/Comment	The Scottish Household Survey (SHS) is a continuous survey based on a sample of the general population in private residences in Scotland. The survey started in 1999 and, since then, has been carried out by a team from Ipsos MORI and TNS-BMRB (formerly TNS System Three).				
	Useful extracts	The SHS is designed to provide reliable and up-to-date information on the composition, characteristics, attitudes and behaviour of Scottish households and individuals, both nationally and at a sub-national level.				

#	Author	Date	Title	Source	Relevant based on the 5 key questions?	Relevance matrix code
114	Living Streets.	2010	Walkipedia	Living Streets	Yes	C7, C9, C11, C12, E9, G7, G9, G11, G12
	Summary/Comment	This document brings together various sources of information on walking, as a review of literature and practice. It includes case studies from various campaigns and studies in Scotland and the UK to improve conditions for pedestrians, as well as setting the scene for understanding the importance of walking for health, socio-economic sustainability and community vitality.				
	Useful extracts	This report describes factors which encourage people to walk more. 66% want better maintenance of paths, streets and public spaces. This figure increased to 81% in the most deprived areas The quality of environment in the vicinity of older people's homes has been assessed as a contributory factor in people not taking exercise. Quality of the walking environment as evidenced by Living Streets' community street audits confirms the that people's perceptions of safety are an important factor in decision-making about going out or participating in community life. Noise or air pollution, particularly in towns and cities, can make conditions for walkers unpleasant at best and a health issue for some people. It can be a disincentive to walk close to or along main roads or in areas of stationary vehicles Significant public health benefits can be realised through greater use of active transportation modes. 39% of respondents stated that the presence of the path networks contributes to a significant increase in the amount of physical activity in which they participated (p31). The frequency of stationary, street-based recreational activities is reduced as traffic flow increases, and that individuals' perceptions of safety of their neighbourhood may be disproportionately influenced by the amount of traffic on their street of residence. Air pollution also makes it unpleasant to spend time on the street and noise makes casual conversation much more difficult. The barrier effect of traffic creates impediments to freedom of movement. A 2005 study for the Scottish Executive found that the presence of environmental incivilities is likely to have an impact on health and attitudes to the local area in a Scottish context (p72). An 'environmental incivility' is any aspect of the environment that people are capable of discerning through hearing, sight, touch or smell and about which they may be inclined to feel negatively. Examples include 'street level' incivilities such as litter and graffiti... Incivilities most frequently mentioned all had an impact on the walking environment – cat and dog mess, lack of safe play spaces, litter, uneven pavements, traffic, vandalism, broken glass and lack of pleasant places to walk. The 'People and Places' programme is being used by Local Authorities across Scotland for education, prevention and enforcement on litter dropping, fly posting, graffiti, fly tipping and other environmental issues.				

#	Author	Date	Title	Source	Relevant based on the 5 key questions?	Relevance matrix code
		In West Lothian, environmental wardens identify and tackle local [incivility] problems. They respond to public demand for action against dog fouling, litter, fly tipping, abandoned vehicles and graffiti. In Scotland in 2007, the majority of people walking alone in the local neighbourhood after dark felt very safe or fairly safe (72%) but with 23% feeling a bit unsafe or not safe at all. In the 15% most deprived areas, this figure rose to 37% feeling a bit unsafe or not safe at all. Security indicators for introduction of new and proposed walking and cycling scheme have been identified by Transport Scotland and include CCTV...well lit areas and signposts, well located emergency call facilities. Those living in rural areas find services less convenient than those in small towns and urban areas (p76). There are clear links between access to a car and the level of deprivation of an area. 43% of households in the 15% most deprived areas of Scotland have at least one car available to them compared with 75% in the rest of Scotland. The absence of such facilities or barriers to facilities (e.g. steep hills, busy roads to cross) or the perception that such facilities are inadequate have negative associations with physical activity. See: http://www.gcph.co.uk/assets/0000/0447/Health_and_the_Physical_Characteristics_of_Urban_Neighbourhoods.pdf Perceptions of the neighbourhood are strongly associated with health and well-being. For example, the study by Curtice et al (Curtice, Ellaway, Robertson, G, Robertson, & Morris, 2005) which considered a number of environmental 'incivilities' (e.g. litter, dog fouling, poor street maintenance, absence of safe places for children to play, vandalism and graffiti) found that those who experienced higher levels of street incivilities reported higher levels of anxiety, depression, poor health, and smoking than people reporting lower levels of incivilities. They were also more likely to report more fear of crime, and be less trustful of others, and be more resigned to the difficulties in their area. A UK research study and interviews with 200 older people discovered that inaccessibility and difficulties presented by many outdoor environments is a major problem affecting older people. At least half of the interviewees faced problems in getting outdoors due to barriers in the environment and a lack of supportive facilities. Issues identified include bad or poorly maintained pavements, fear of crime and undesirable young people... See http://idgo.ac.uk/useful_resources/Publications/WISE_MTP_brochure_Final.pdf 36% of disabled/ long term ill adults considered their neighbourhood to be 'very unsafe' or 'a bit unsafe' for walking alone after dark. This compares with 21% of adults without a disability or long-term illness. The Joint Committee on Mobility of Blind and Partially Sighted People has issued a policy statement on walking, with actions to improve matters that include repair and maintenance of paths and pavements which must be given a higher priority and adequate budgets.				

#	Author	Date	Title	Source	Relevant based on the 5 key questions?	Relevance matrix code
115	Living Streets	(-)	Creating healthy environments - Practical tools for increasing walking in the built environment: Cleanliness Index Monitoring System	Living Streets	Yes	J4, J6
	Summary/Comment	This short document outlines the CIMS (Cleanliness Index Monitoring System), a tool developed by Keep Scotland Beautiful to assist Local Authorities to assess local environmental quality. It includes a brief case study of Glasgow City Council's use of CIMS to positive effect.				
	Useful extracts	What matters is maintaining the cleanliness of an area rather than how often it is cleaned The Clean Glasgow campaign recognises the link between anti-social behaviour and the environment. Within this context the cleanliness and safety of the city is a key issue for Glasgow citizens and businesses. One vision of the Clean Glasgow campaign was a Glasgow free from litter, graffiti and other "grime crime".				
116	Transport Scotland.	2009	Disability Discrimination Act - Good practice guide for roads	Transport Scotland	Yes	G6
	Summary/Comment	Guide that describes Transport Scotland's requirements for inclusive design in the construction, operation and maintenance of road infrastructure.				
	Useful extracts	Overhanging branches and foliage can reduce the effective width of footways and present a serious hazard to visually impaired pedestrians. Visually impaired people have difficulty detecting anything above waist height with a long cane and a guide dog can walk underneath this type of hazard. Branches overhanging a footway fall into this hazard category and can cause a serious injury to eyes and face (p45). Uneven and broken paving can present a trip hazard to pedestrians (p46)				
117	Transport Scotland.	2009	Forth replacement crossing: Managed crossing scheme: scheme definition report	Transport Scotland	No	
	Summary/Comment	Short statement of the wider economic impact of closure or restricted use of the Forth Road Bridge, without replacement crossing on the business community as a whole.				
	Useful extracts					
118	Scottish Executive.	2007	Controlling light pollution and reducing lighting energy consumption	Scottish Executive	Yes	E4, E9
	Summary/Comment	A guidance note on reducing light pollution and saving energy in Scotland. It recognises that well designed lighting installations can provide very positive benefits to communities through the reduction in perceived risk of crime, the enhancement of general public safety and adds to the feeling of wellbeing of a community.				
	Useful extracts	Obtrusive lighting is presently not classed as a statutory nuisance in Scotland, although in England and Wales it now can be. However, there are plans to add light pollution to the statutory nuisance regime in Scotland.				

<table>
<tr><th>#</th><th colspan="2">Author</th><th>Date</th><th>Title</th><th>Source</th><th>Relevant based on the 5 key questions?</th><th>Relevance matrix code</th></tr>
<tr><td rowspan="3">119</td><td colspan="2">Emery, M.</td><td>2008</td><td>Effect of street lighting on bats</td><td>Urbis Lighting Ltd</td><td>Yes</td><td>E3, E4</td></tr>
<tr><td>Summary/Comment</td><td colspan="6">This report highlights that Councils have a responsibility to avoid contravening the Wildlife and Countryside Act (DEFRA, 1981) which introduces a requirement not to disturb bats. This includes directly illuminating their roosts or the paths they follow to their feeding grounds.</td></tr>
<tr><td>Useful extracts</td><td colspan="6">Years of study reveal that all but 3 of the UK's 17 different bat species will not fly in directly illuminated areas. Bats leave their roosts at night and follow a regular commuting route to feeding areas. If this route is affected by artificial lighting, they can abandon it with potentially catastrophic consequences on their ability to feed.</td></tr>
<tr><td rowspan="3">120</td><td colspan="2">Institution of Lighting Professionals.</td><td>(-)</td><td>Lighting against crime - a guide for crime reduction professionals</td><td>Institution of Lighting Professionals</td><td>Yes</td><td>E4, E9</td></tr>
<tr><td>Summary/Comment</td><td colspan="6">The aesthetic value of a lighting installation is an important consideration as the daytime street scene suffers greatly if fittings, materials or paint finishes are of lesser quality. The shabby appearance of lighting street furniture can send the wrong signals to the community and contribute to a cycle of grime, crime and decline.</td></tr>
<tr><td>Useful extracts</td><td colspan="6"></td></tr>
<tr><td rowspan="3">121</td><td colspan="2">Scotland TranServ Environment Team.</td><td>2010</td><td>A82_Allt Chonoghlais bridge replacement: Environmental review report and proposed mitigation</td><td>Scotland TranServ Environment Team</td><td>Yes</td><td>B2, B3, B6, B11</td></tr>
<tr><td>Summary/Comment</td><td colspan="6">Environmental assessment of the proposed replacement of the Allt Chonoghlais Bridge which lies on the A82 Dalnotter-Inverness trunk road south of the Bridge of Orchy. The following predicted impacts of the bridge removal and construction are:
- Air Quality: Short term impacts as a result of dust generation and pollutants or fumes associated with the use of machinery and heavy goods vehicle movement, however there will be no increase in traffic volume as a result of the proposed scheme.
- Ecology and nature conservation: impact on the verge habitats during construction. There will also be potential for direct disturbance of the otter population, bats, fish and nesting birds.
- Landscape effects: new design would be a substantial change from the visual appearance of the current bridge and out of keeping with the character of the area.
- Community effects: There will be traffic disruption to all pedestrian, equestrian and cyclist traffic during the construction period while there is a controlled one way system over the temporary bridge. The new bridge will improve conditions for road users as it will provide a wider carriageway with improved surfacing and footpaths.</td></tr>
<tr><td>Useful extracts</td><td colspan="6"></td></tr>
</table>

#	Author		Date	Title	Source	Relevant based on the 5 key questions?	Relevance matrix code
122	Roads Liaison Group.		2004	Well-lit highways - Code of Practice for highway lighting management	Roads Liaison Group	No	
	Summary/Comment	Guidance document on public lighting maintenance. This Code of Practice aims to provide Local Authorities with guidance in an ever changing environment, creating a strong foundation for a positive and lasting road lighting maintenance policy.					
	Useful extracts						
123	Roads Liaison Group.		2010	Well-lit highways - Code of Practice for highway lighting management complementary guidance	Roads Liaison Group	No	
	Summary/Comment	Updated guidance to advise and direct users to where they may find more up to date information to assist them in implementing best practice and the recommendations of the code.					
	Useful extracts						
124	MTRU.		2006	Road maintenance costs to local authorities - Potential changes from transfers of goods between rail and road, and a methodology for assessing the impact of transfers from road to rail	MTRU	No	
	Summary/Comment	This report considers the potential cost increases which would fall on Local Authorities if heavy goods vehicle traffic rises through transfer of freight from rail.					
	Useful extracts						
125	Sustrans.		2001	Cycling in the city regions	Sustrans	Yes	H2, H7
	Summary/Comment	Report exploring the potential impact of a step change in the delivery of interventions to support and promote cycling in the English city regions outside London.					
	Useful extracts	Cycling can produce substantial economic benefits mainly by increasing physical activity through reduced congestion, lower carbon emissions, increasing physical activity and by improving access to employment, local facilities and public transport. Investment in cycling is highly cost-effective, delivering benefits at least three times higher than the costs. Area-wide cycling interventions similar to those implemented in the Cycling Demonstration Towns result in up to 307,000 new cyclists across the Passenger Transport Executive (PTE) areas, making 96 million additional cycling trips per year. This would generate substantial health, decongestion and carbon benefits, amounting to £716 million over a ten year period for new cyclists alone and representing benefit cost ratios of over 3:1. Delivery of large scale programmes similar to those implemented in the Sustainable Travel Towns (STT) would also have a substantial impact on both cycling and wider travel patterns within the PTE areas. STT-type interventions could generate 16 million additional cycling trips per year across the six PTE areas. Up to 71.6 million car trips per year could be replaced, with an associated decongestion and carbon savings valued at up to £181.4 million.					

#	Author	Date	Title	Source	Relevant based on the 5 key questions?	Relevance matrix code
126	Warren, J.	2008	Towards a healthier economy	Transform Scotland	No	
	Summary/Comment	Report seeking to increase the understanding of transport's known 'non-time savings' direct economic impacts, and also identify gaps in the collective knowledge.				
	Useful extracts					
127	Sustrans.	(-)	Creating your own DIY street	Sustrans	No	
	Summary/Comment	Guide to describe ways in which the physical layout and/or perception of how the street can be used can be altered and how as residents, it can be made to happen.				
	Useful extracts					
128	Cabinet Office.	2009	An analysis of urban transport	Cabinet Office	No	
	Summary/Comment	This report aims to provide an evidence base for ways of tackling congestion, poor air quality, ill-health, road safety, carbon emissions and unpleasant urban space.				
	Useful extracts	Analysis found that improved street lighting led to an overall reduction in recorded crime by 20% (p37).				
129	Transport Scotland.	2011	Trunk road network audit report	Transport Scotland	No	
	Summary/Comment	Findings of a desktop review of existing asset information including bus stops to identify the total extent of all types of barrier to travel for all users of the trunk road network.				
	Useful extracts					
130	National Transport Safety Board.	2007	Collapse of I-35W Highway Bridge Minneapolis, Minnesota	National Transport Safety Board	Yes	B8
	Summary/Comment	Accident report on the collapse of I-35W Highway Bridge Minneapolis, Minnesota.				
	Useful extracts	About 6:05pm central daylight time on Wednesday, August 1, 2007, the eight-lane, 1,907-foot-long I-35W highway bridge over the Mississippi River in Minneapolis, Minnesota, experienced a catastrophic failure in the main span of the deck truss. As a result, 1,000 feet of the deck truss collapsed, with about 456 feet of the main span falling 108 feet into the 15-foot-deep river. A total of 111 vehicles were on the portion of the bridge that collapsed. Of these, 17 were recovered from the water. As a result of the bridge collapse, 13 people died, and 145 people were injured. Major safety issues identified in this investigation include insufficient quality control procedures for designing bridges in the bridge design firm, and insufficient Federal and State procedures for reviewing and approving bridge design plans and calculations; lack of guidance for bridge owners with regard to the placement of construction loads on bridges during repair or maintenance activities; exclusion of gusset plates in bridge load rating guidance; lack of inspection guidance for conditions of gusset plate distortion; and inadequate use of technologies for accurately assessing the condition of gusset plates on deck truss bridges.				

#	Author	Date	Title	Source	Relevant based on the 5 key questions?	Relevance matrix code
131	Road Surface Dressing Association.	2008	Guidance note on quieter road dressings	Road Surface Dressing Association		
	Summary/Comment	Guidance note to advise highways engineers on the background and current state of knowledge to assist with a better understanding of tyre/road noise and the complex mechanisms involved.				
	Useful extracts	Based on the current state of knowledge, advice is given on selecting the type of surface dressing to minimise tyre / road noise. In most cases it will be possible to select a dressing, which will be comparable to SMA type thin surfacing (Executive Summary). Surface dressing is a cost effective and widely used highway maintenance tool. It extends the life of a pavement by sealing its surface to prevent the ingress of moisture whilst restoring texture and skid resistance. However, the introduction of thin surfacings that are relatively quiet and the increasing public awareness of traffic noise have exacerbated the perception that surface dressing generates unacceptable levels of noise. This need not be so. The aim of this Guidance Note is to show that surface dressings can provide an economic and acceptable surfacing option in an appropriate context. But for Local Authorities working with limited budgets, surface dressing remains the most cost-effective means of surface treatment in many locations. The aim of this Guidance Note is to show that surface dressings can provide a viable surfacing option that is more cost-effective than alternatives without generating an unacceptable level of noise.				

Appendix B Results of Literature Review

The literature was reviewed against each of the criteria within STAG. Five key questions were used to assess the relevance of each document:

- Does the document add any value or provide useful information for this study?
- Which impacts, activities and assets does the document cover?
- Where is the evidence from? How strong or significant is the evidence? (For example, higher relevance has been assigned to reports which focus on the UK and Europe).
- What are the key themes and messages?
- Of what value or relevance is this study to Scotland?

Table B.1 shows each of the STAG criteria and provides an overview of the relevant information identified in the literature review.

Table B.1 Summary of information provided by the literature review

Criterion	Sub-criterion	Users/Asset /Activities	Description of impact due to shortfall in maintenance
Environment	*Noise and Vibration*	Pavement (i.e. carriageway)	TRL's community severance report (James, Millington, & Tomlinson, no date) made reference to anecdotal evidence of traffic noise created by the arterial road through the community, but provided no evidence that this had increased as a direct result of reduced maintenance. From research carried out in the UK and in other European countries (Abbott, Morgan, & McKell, 2010), the acoustic performance of all surface types deteriorate with surface age, particularly as the surface reaches its end of life. Generally, it has been shown that there is a simple linear relationship between noise increase and age. Indicative results from an on-going research programme in the UK suggest that for dense surfacings such as 20 mm HRA the acoustic deterioration is about 0.2 dB(A) per year for high speed roads and for SMA type thin surfacings about 0.5 dB(A) per year. The study also showed that the acoustic performance of porous asphalt surfacings also deteriorated with age at a similar rate as thin surfacings for high-speed roads but for low speed roads the deterioration for light vehicles increased to about 0.9 dB(A) per year. A guidance note published by the Road Surface Dressing Association (Road Surface Dressing Association, 2008) showed that surfacing dressings can provide a viable surfacing option that is more cost-effective than alternatives (such as thin surfacing) without generating an unacceptable level of noise. This is particularly important at this time where Local Authorities are working with limited budgets. Therefore, this shows that reduction in road maintenance could lead to an increase in noise and vibration. However, the use alternative treatment options such as surface dressings over the more expensive thin surfacing have been shown to provide an economic and acceptable surfacing option without impacting on the level of noise.
		Pedestrians	According to Living Streets (Living Streets, 2010) noise pollution particularly in towns and cities, can make conditions for walkers unpleasant at best and a health issue for some people. It can be a disincentive to walk close to or along main roads or in areas of stationary vehicles. It also states that noise makes casual conversation much more difficult. Thus, an increase in noise and vibration through possibly a reduction of maintenance could have an impact on pedestrian's choices and way of life.
		Structures, Street Cleaning, Barriers, Footways and Drainage	No evidence found.

Criterion	Sub-criterion	Users/Asset /Activities	Description of impact due to shortfall in maintenance
	Global and Local Air Quality	Pavement (i.e. Carriageway) and Street Cleaning	TRL's community severance report (James, Millington, & Tomlinson, no date) made reference to anecdotal evidence of air quality being affected by the arterial road through the community, but provided no evidence that this had increased as a direct result of reduced maintenance. In a demonstration study of nonpoint pollution abatement through improved street cleaning practices (Pitt, 1979) street dirt loading was also found to increase more rapidly immediately after street cleaning, and then level off somewhat after several days. One week after street cleaning, approximately 4 to 6lb/curb mile [sic] per day of particulates were lost to the air. This rate increase for longer cleaning intervals. Furthermore, the median particle size of street dirt was also found to increase with time between cleaning and decrease with cleaning. Street cleaning equipment picks up larger particles more effectively than smaller particles. As a result, the study found that the small particles tend to increase in abundance with time. The report also found that different test area conditions affected performance more than differences in equipment type. Smoother (asphalt) streets were found to be easier to keep clean than streets with oil and screens surfaces or those in poor condition. The street surface loading values after cleaning were always lower on the asphalt streets in good condition as areas with better quality street surfaces had more of the smaller sized particles present. In conclusion, if carriageways are not cleaned, the accumulation of dirt/dust would contribute to air pollution.
		Structures	Zhang (Zhang, 2010) mentioned although bridge maintenance (including concrete repairs, painting of steel girders, replacement of moving joint and bearing, waterproofing and deck surfacing) needs to be carried out, these activities use materials, consume energy which contribute to carbon emission. Furthermore, bridge works disrupt traffic, causing queues and detours thus impacting on air quality through carbon emission. Therefore, by inference, it would appear that a reduction of maintenance would result in less carbon emission hence would have less impact on air quality.
		Pedestrians	According to Living Streets (Living Streets, 2010), air pollution particularly in towns and cities, can make conditions for walkers unpleasant at best and a health issue for some people. It can be a disincentive to walk close to or along main roads or in areas of stationary vehicles. It also states that air pollution also makes it unpleasant to spend time on the street. Thus, an increase in air pollution through possibly a reduction of maintenance could have an impact on pedestrian's choices and way of life.
		Footway, Drainage, Cycle-track, Cyclists	No evidence found

Criterion	Sub-criterion	Users/Asset /Activities	Description of impact due to shortfall in maintenance
	Biodiversity	Lighting	Little evidence was found to suggest that street lighting has an adverse effect on biodiversity. However, a key document reported on the potential harmful effects of light pollution on Britain's bat population. The report written by Emery (Emery, 2008) highlights that Local Authorities have a responsibility to avoid contravening the Wildlife and Countryside Act (DEFRA, 1981) which has a requirement not to disturb bats. This includes directly illuminating their roosts or the paths they follow to their feeding grounds. Years of study reveal that all but 3 of the UK's 17 different bat species will not fly in directly illuminated areas. Bats leave their roosts at night and follow a regular commuting route to feeding areas. If this route is affected by artificial lighting, they can abandon it with potentially catastrophic consequences on their ability to feed (Emery, 2008). This research identifies that reduced street lighting would have a beneficial impact on bats and their habitats.
		Vegetation Control	Glendinning et al (Glendinning, Loveridge, Starr-Keddle, Bransby, & Hughes, June 2009) made reference to the fact that vegetation is regarded as a benefit that can improve the aesthetic environment and provide visual and noise barriers. Vegetation provides important grassland habitats and migration routes for many native species. This study made reference to the fact that in order to reduce costs in 1975, the UK Department of Transport issued instructions to cease regular grass cuttings on trunk roads and motorways and only to cut in restricted circumstances. This caused a decline in species-rich grassland habitats and scrub encroachment across many roadside corridors. This shows that a lack of vegetation control could prevent the upkeep of grassland biodiversity.
		Pavement, Structures and Drainage	No evidence found
	Visual Amenity, Cultural and Landscape	Pavement (i.e. carriageway)	Even if Clegg (Clegg, June 2011) commented that poorly maintained surfacing and infrastructure discourages use of the street and dilapidated structures and that potholes, dark lamps and heavy patching can all detract from the perceived quality of the public realm in an area, there is little evidence to suggest that visual amenity is affected by a reduction in carriageway maintenance.
		Footway	The Social Exclusion Unit report (Social Exclusion Unit, 2003) suggests that poor walking environments and transport links can leave areas isolated and damage community cohesion. A 2005 study for the Scottish Executive (cited in (Living Streets, 2010) found that the presence of environmental incivilities are likely to have an impact on health and attitudes to the local area in a Scottish context. An 'environmental incivility' is any aspect of the environment that people are capable of discerning through hearing, sight, touch or smell and about which they may be inclined to feel negatively. Examples include 'street level' incivilities such as litter and graffiti. Incivilities most frequently mentioned all had an impact on the walking environment – cat and dog mess, lack of safe play spaces, litter, uneven carriageways, traffic, vandalism, broken glass and lack of pleasant places to walk. Thus, if these incivilities are not dealt with through maintenance, it would have an impact on the visual amenity and use of the footway.

Criterion	Sub-criterion	Users/Asset /Activities	Description of impact due to shortfall in maintenance
		Pedestrians	There is a significant amount of research on the 'broken window theory' which refers to the social effects of abandonment that can result in reduced walking, physical activity and recreation in public. Lopez and Hynes (Lopez & Hynes, 2006) have identified certain features of the built environment - such as the presence of sidewalks, streetlights, interconnectivity of streets, population density and use mix - that appear to encourage physical activity and thus reduce the risk of obesity and related health problems. Many factors of the environment in inner cities, including built, physical and social factors, may exert a net negative influence on the health of inner city residents. These factors and conditions include problem land use issues, such as waste sites, infrastructure maintenance and investment issues. Lopez and Hynes accuse a lack of pedestrian amenities for discouraging walking, and a fear of crime keeping people indoors; while unimproved sidewalks decay as utility crews dig up concrete, tree roots push up paved areas, and weather erodes surfaces. Urban neighbourhoods frequently have broken or impassable pedestrian sidewalks which reduces leisure walking. "Several features of the suburban built environment such as low densities, poor street connectivity and the lack of sidewalks are associated with decreased physical activity and an increased risk of being overweight. But compared to suburban residents, inner city populations (in America) have higher rates of obesity and inactivity despite living in neighbourhoods that are dense, have excellent street connectivity and who's streets are almost universally lined with sidewalks. In the inner city, densities may be lowered because of abandonment and disinvestment" (Lopez & Hynes, 2006). Indeed, the University of Groningen in the Netherlands conducted 'broken window theory' experiments to discover if signs of vandalism, litter and low-level law breaking could change the way people behave, and found that such conditions doubled the number of people prepared to litter and steal. The researchers' conclusion is that one example of disorder, like graffiti or littering, can indeed encourage another, like stealing - hence clearing up graffiti or littering promptly could help fight the spread of crime (Keizer, 2008). So, an increase in visual amenity (like graffiti, littering) through lack of maintenance, could encourage the spread of crime hence impacting on the use of public spaces by pedestrians.
		Street Cleaning	The Code of Practice of Litter and Refuse (DEFRA, 2006) states that management of an area should be focussed on keeping it clean, rather than how often it is cleaned. Graffiti and fly posting, even if partially removed, has an adverse effect on the quality of the environment. The Code suggests that this can lead to an increase in crime, or fear of crime. It suggests that cleaning litter and refuse alone is insufficient for an area to be considered clean; that "the public would still perceive the area to be defaced [if graffiti and / or fly posting were still present]". It also suggests that further degradation of an area can take place as the local environmental quality decreases. Therefore, a lack of street cleaning would impact on the visual amenity and consequently could lead to an increase in crime or fear of crime.

Criterion	Sub-criterion	Users/Asset /Activities	Description of impact due to shortfall in maintenance
		Structures, Cycle-track, Lighting, Drainage, Road Users and Vegetation Control	No evidence found
	Physical Fitness	Footway	Research conducted by the University of the West of England and partners (Sinnett D. W., 2011) states that the aesthetic quality of a place is the most consistently important factor in relationships between the public realm and recreational walking, health and well-being. Within the cited research, a study by Dempsey (Dempsey, 2008) found that the resident perceptions of a sense of community and attachment to a place were influenced by factors including level of maintenance. Living Streets (Living Streets, 2010) suggests the absence of facilities or barriers to facilities (e.g. steep hills, busy roads to cross) or the perception that such facilities are inadequate have negative associations with physical activity.
		Pedestrians	The Walkipedia publication (Living Streets, 2010) states that the quality of the environment in the vicinity of older people's homes has been assessed as a contributory factor in people not taking exercise. According to the same publication 39% of respondents stated that the presence of path networks contributes to a significant increase in the amount of physical activity in which they participated. Although this is not linked to levels of maintenance directly, it can be inferred that if negative changes to the levels of maintenance impacts on route choice and availability, there may be implications for levels of physical fitness and walking for health.
		Street Cleaning	A research study by Curtice et al (Curtice, Ellaway, Robertson, G, Robertson, & Morris, 2005), cited by Croucher et al (Croucher, Myers, Jones, Ellaway, & Beck, 2007) suggested that perceptions of the neighbourhood are strongly associated with health and well-being. The study considered the impact of a number of environmental 'incivilities' (including litter, dog fouling, poor street maintenance, absence of safe places for children to play, vandalism and graffiti) on public perception. They found that those who experienced higher levels of street incivilities were prone to higher levels of anxiety, depression, poor health, and smoking than people who are exposed to lower levels of incivilities. The former were also more likely to report increased fear of crime, and be less trustful of others, and be more resigned to the difficulties in their area. Therefore, a lack of street cleaning through possible a reduction in maintenance would impact the people's physical fitness.
		Cycle-track, and Road Users	No evidence found

Criterion	Sub-criterion	Users/Asset /Activities	Description of impact due to shortfall in maintenance
Safety	*Accidents*	Pavement (excluding skid resistance – addressed elsewhere in the study)	According to the ALARM survey (AIA, 2011), 90% of Authorities say they believe that the under-funding of the highway maintenance programme creates a threat to road users' safety with nearly a third of them thinking that the threat is major. Just over half (52%) of Authorities believe that the threat to road users' safety has increased over the past financial year (2010/11), whilst 41% feel it is unchanged. Another survey conducted by Audit Scotland (Audit Scotland, 2011) commented that road safety is also affected by poor road condition. The survey estimated that over 30,000 Scottish drivers had experienced a near miss with another vehicle or pedestrians due to either hitting a pothole or swerving to avoid one. In addition, in this study, it was estimated that Local Authorities would need to spend on average £167.6m on structural maintenance each year over the next ten years excluding inflation, to maintain the local road network in its current condition. This amounts to an annual shortfall of £45.1m compared to what was spent in 2009/10. The consequences of not spending at this level are forecast to result in a £1 billion decline in the value, and a 10% reduction in the condition of the local road network. In a study by (Ramdas, Thomas, Lehman, & Young, 2007), two wheeled vehicles were found to be most vulnerable to poor surface conditions, with the worst defects being those that are not visible but have the potential to disturb their balance. Additionally, both motorcyclists and cyclists were reported to often swerve and alter their "line" to avoid noticeable defects, with obvious implications for the safety of all road users. A project undertaken for the Scottish Executive (Granville, Rait, Barber, & Laid, 2001) to explore the attitudes of drivers and cyclists towards one another found that some conflict situations (between drivers and cyclists) were "created by the poor state of repair on the road". Road surfaces with loose stones were found to be a "serious concern" for motorcyclists, making them feel "particularly unsafe" because they "flew up and hit then as they drove over them". Therefore, a reduction or lack of maintenance leading to poor road condition would appear to affect road safety for various reasons noted above.
		Structures	An example of the safety impact of a failure in a structure can be demonstrated by the collapse of the I-35W highway bridge over the Mississippi River in Minneapolis, USA (National Transport Safety Board, 2007). Based on the accident report, the collapse of the bridge was inadequate load capacity due to a design error of the gusset places and inadequate attention to the gusset plates during inspections for conditions of distortion or corrosion. This bridge failure due to major safety issues resulted 13 fatalities and 145 people being injured. Thus, it can be shown that inadequate inspection regime results in a higher risk of catastrophic failure of structures which would consequently have an impact on safety.

Criterion	Sub-criterion	Users/Asset /Activities	Description of impact due to shortfall in maintenance
		Lighting	The Police Road Death Investigation Manual (National Policing Improvement Agency, 2007) identifies the responsibility of the Local Authority "when a collision has occurred and highway involvement is alleged, then the Highway Authority should be able to show that it took reasonable measures to ensure that the safety of the road user was not compromised" - highway lighting is an important component of that responsibility (Institution of Lighting Engineers, 2010). The literature search found a number of pertinent reports that explore the effect of reduced lighting on the health and safety of drivers and pedestrians. In recent years, schemes that switch off street lights all night, or where there is 'partial switch off' or 'part night lighting' have been adopted by some Authorities to make financial savings and meet carbon reduction targets (Institution of Lighting Engineers, 2010). A number of Local Authorities in England have reported on the results of trials to switch off street lights. (Buckinghamshire County Council, 2010) have reported on an energy saving trial that began in 2007 at seven sites where street lights were switched off (Phase 1), and at a further 39 sites in 2008 (Phase 2) with a total of 1,627 street lights switched off. Findings of the interim report provide significant evidence that switching off street lights does not increase the risks of road traffic accidents. To date, results of the trial include three year 'before' and 'after' data from Phase 1 sites and two year 'before' and 'after' data from Phase 2 sites. Where lights have been switched off, there is a general reduction in the overall number of collisions: • 31% reduction in all injury collisions • 32% reduction in all casualties • 9% reduction in injury collisions during darkness In support of this research, a spokeswoman for Buckinghamshire, Sheila MacDonald said "in seven sites monitored there were a total of seven collisions between August and December 2006 when lights were on, and only three in total between August and December 2007 when lights were off" (Tarry, 2008). A TRL report analysing STATS19 casualty data also found that in a five year study period 21% of accidents occurred in darkness where there was street lighting, with less than 6% of all accidents occurring where there is no street lighting, with lighting having a larger effect on reducing the number of fatal accidents than the number of serious and slight accidents (Crabb, Crinson, Beaumont, & Walter, 2009). In a comprehensive review of street lighting and road traffic injuries, (Beyer & Ker, 2010) report on the findings of Elvik (Elvik, An analysis of official economic valuations of traffic accident fatalities in 20 motorized countries., 1995) and (Elvik, Hoye, Truls, & Sorensen, 2004) who concluded that street lighting may reduce night time fatalities by as much as 65% and night-time injuries by 30%. He added that "increasing the level of lighting by up to double the previous level has a limited effect on the number of crashes, but is not so pronounced as for newly installed lighting on a previously unlit road". Hence, it can be deduced that if new lighting has a positive impact on the number of crashes, then removal of existing

Criterion	Sub-criterion	Users/Asset /Activities	Description of impact due to shortfall in maintenance
			lighting will have an equally negative effect, particularly as street lighting allows drivers to detect intersections sooner, decelerate earlier and reduce speed with improvements in driver visual certainty (Beyer & Ker, 2010). Certainly, another trial of 're-lighting' in Wakefield between 2004-08 helped reduce vehicle collision and damage by 50%, reduced night time accidents by 31% and night time fatalities fell from 9 to 0 during the same period (Institution of Lighting Engineers, 2010). In a research study for Transport for London (Transport for London, 2009), the main user priorities for footways and carriageways are maintenance and good lighting. About half of all respondents thought that in the dark, the risk and hazards associated with some or all condition defects (principally cracks and potholes for pedestrians) is higher than that in daylight. The literature provides mixed evidence as to the benefits and disbenefits of turning off street lights with respect to road safety, and there would appear to be some bias from the source of the evidence, with Buckinghamshire County Council finding a reduction in accidents after switching off the lights, and the Institution of Lighting Engineers finding a reduction in accidents after implementing new lighting. Nevertheless, there have been reported cases of fatalities directly linking the lack of lighting with road traffic accidents, including Buckinghamshire where a Coroner said "the driver had no chance to see the lady crossing the road without any street lights operating" (Institution of Lighting Engineers, 2010).
		Footway	A paper by (Borges, 2007) outlines the specific mobility difficulties faced by an aging population in Europe, and references the role of the built environment in terms of accessibility and perceptions of safety. It states that the largest barrier to older people's mobility are psychophysical related impairments associated with walking and accessing public transport such as uneven and narrow carriageways. It continues exploring the worry of older people in terms of their safety, for example fear of crime, falling over and becoming injured. This is reflected in earlier research into older people's transport needs by (Marsden, Jopson, Cattan, & Woodward, 2007). Their research found that older people's ability to get out and about was affected by environmental, social and psychological factors that include uneven surfaces and obstacles and a fear of being knocked or falling over. Research for Transport for London (Transport for London, 2009) aimed to gather user perceptions and preferences related to condition defects of various types, extents and severities and to seek to understand tolerances to nuisance and disruption to maintenance works required for remedy. About 75% of the respondents thought that condition defects could have an impact on safety. About half of all respondents thought that some or all condition defects would have a worse impact in the dark, principally cracks and potholes for pedestrians. Therefore, based on these studies, it can be concluded that deterioration in the footway surface through lack of maintenance would have an impact on safety especially for users with mobility difficulties.

Criterion	Sub-criterion	Users/Asset /Activities	Description of impact due to shortfall in maintenance
		Pedestrians	TRL's community severance report (James, Millington, & Tomlinson, no date) made reference to anecdotal evidence of increased risk of road traffic accidents created by the arterial road through the community, particularly where pedestrians were deterred from using the footbridge and subways, leading to dangerous crossing activity across the dual carriageway. However, it provided no evidence that this activity had increased as a direct result of reduced maintenance. TRL research for the Department of Transport (Ramdas, Thomas, Lehman, & Young, 2007) found that elderly and/ or disabled road users are "most critical" of surface conditions. Unlike many other groups, they are "highly aware" of surface problems. This is mainly because of "fears for personal safety and discomfort". On footways, "tripping or falling on raised or lowered paving slabs and potholes is a particular concern". As a result of this, there is a greater tendency to take an alternative route to avoid poor surfaces. This can take the form of a deviated path (e.g. onto the carriageway) or a different route altogether, with clear implications for the accessibility of destinations for particular pedestrian types who are unable to walk far.
		Cyclists	"Department for Transport guidance on the appraisal of walking and cycling schemes (Department for Transport, 2010)refers to "perceived safety or the fear of potential accidents" being mentioned by cyclists as being a "major barrier" to cycling and cycling more often. However, the Department for Transport report does not link this fear to levels of maintenance. A TRL report undertaken for the Department for Transport (Ramdas, Thomas, Lehman, & Young, 2007) found that cyclists are mainly concerned about step changes (>2mm) in their line of travel caused by potholes, sunken or raised ironworks, failed potholes and debris in the carriageway. Given that cyclists generally travel to the left of the travel lane, they are particularly susceptible to edge deterioration and raised ironworks. Cyclist perceptions uncovered in the study suggest that cycle lanes are often covered in "debris". The study found that this can force cyclists to change their route, to avoid poor surface conditions. For some this may mean swerving into other parts of the road. Any deviation of the cyclists' 'line' is seen as very dangerous. Poor surfaces, especially at the edge of the road, may cause a sudden deviation that would then put the cyclist and other road users in danger." Therefore, poor surfaces potentially through lack of maintenance may compromise the safety of cyclists.
		Cycle-track, Signs, Barriers and Road users	No evidence found
	Security	Structures	Although there is a perception that there are safety issues associated with subways (West Midlands Council, 2006) as they suffer from vandalism due to their secluded nature, poor lighting and lack of maintenance, there is little evidence on the impact of security as a result of reduced structure maintenance.

Criterion	Sub-criterion	Users/Asset /Activities	Description of impact due to shortfall in maintenance
		Footway	London Borough of Greenwich Local Implementation Plan (London Borough of Greenwich, 2004) included aspects of maintenance for trees and foliage to reduce hiding areas, dark areas and to limit escape routes. The Social Exclusion Unit (Social Exclusion Unit, 2003) report states that "crime and the fear of crime can deter walking, cycling and the use of public transport". Social interaction in the street environment has been linked with lower crime rates (Sinnett, Williams, Chatterjee, & Cavill, 2011). The study states that the perception of safety (distinct from reported crime levels), fear and mistrust have all been linked to levels of maintenance or presence of incivilities (e.g. graffiti and vandalism) in a neighbourhood. The overall level of safety in a neighbourhood is affected by its appearance, crime rate and level of incivilities, suggesting that factors which affect the perceptions of safety are critical in contributing to overall levels of safety.
		Lighting	A number of literature reports point to evidence that street lighting has a positive impact on crime reduction and fear of crime, as well as assisting the emergency services after dark and promoting the evening economy offering safe and secure access to public transport, evening work, education and leisure activities (Institution of Lighting Engineers, 2010). One such report by children's charity PLAN highlighted that 91% of 13-18 year olds said better street lighting would make a big difference to whether they felt safe on the streets (Institution of Lighting Engineers, 2010). Furthermore, a Home Office study from 1991 found that lighting was more likely to have a positive impact on the public's fear of crime, than on the incidence of crime itself, stating that "better lighting by itself has very little impact on crime" (Tarry, 2008). Certainly, evaluation studies undertaken in Bristol, Dudley, Stoke-on-Trent, Dover and Birmingham showed that improved lighting led to a 29% decrease in crime, although night time crimes did not decrease more than daytime crimes, suggesting a 'community pride' theory where improved lighting signals community investment leading to community cohesion and informal social control, rather than a 'deterrence/surveillance' theory whereby improved lighting leads to increased surveillance of potential offenders by improving visibility and increasing the number of people on the street thus creating a deterrent to criminals: "As a highly visible sign of positive investment, improved street lighting might reduce crime if it physically improved the environment and signalled to residents that efforts were being made to invest in and improve their neighbourhood. In turn, this might lead them to have a more positive image of the area and to have increased community pride, optimism and cohesion" (Swedish National Council for Crime Prevention, 2007). In the 2004 Local Implementation Plan, London Borough of Greenwich included the pledge to improve street lighting to "reduce the risk of accidents and violent attack" (London Borough of Greenwich, 2004). In a Guide for Crime Reduction Professionals, the Institution of Lighting Professionals (Institution of Lighting Professionals, no date) highlights that the aesthetic value of a lighting installation is important as the daytime street scene suffers greatly if fittings, materials or paint finishes are of lesser quality. The shabby appearance of lighting street furniture can send the wrong signals to the community and contribute to a cycle of grime, crime and decline.

Criterion	Sub-criterion	Users/Asset /Activities	Description of impact due to shortfall in maintenance
		Pedestrians	The TRL report on community severance (James, Millington, & Tomlinson, no date) made reference to anecdotal evidence that poor design and a lack of maintenance of mitigation measures (subways and footways) across the arterial road created an environment of fear among vulnerable pedestrians. The West Midlands Local Transport Plan on Bridge Maintenance (West Midlands Council, 2006) identified safety and security issues in connection with subways: "Many subways suffer from vandalism and are used for anti-social behaviour. They are often perceived by the public as being unsafe generally due to their secluded nature, poor lighting and lack of maintenance. Many subways are being infilled and replaced by alternative facilities as part of other programmes. However, it is recognised that subways often provide the safest routes for pedestrians crossing roads and a number of Authorities have a programme of works to improve them so as to encourage their use and reduce the amount of vandalism". According to a study by Sinnett et al (Sinnett, Williams, Chatterjee, & Cavill, 2011), people walk more when they feel their environment is safe, well maintained and lively, and the report links the level of investments in the walking environment with places which are perceived to be more attractive and safe. A study in Glasgow referenced in the research found that those who felt their neighbourhoods were safe to walk in after dark were 70% more likely to walk at least five times per week than those who did not feel their neighbourhoods were safe, with clear implications for health and fitness.
		Street Cleaning	The Code of Practice of Litter and Refuse (DEFRA, 2006) states that management of an area should be focussed on keeping it clean, rather than how often it is cleaned. Graffiti and fly posting, even if partially removed, has an adverse effect on the quality of the environment. The Code suggests that this can lead to an increase in crime, or fear of crime. This is echoed by a Living Streets publication (Living Streets, No date) which also suggests that maintaining the cleanliness of an area is more important than the frequency of its cleaning regime. The Clean Glasgow campaign, cited in the document, "recognises the link between anti-social behaviour and the environment". Furthermore, the "cleanliness and safety of the city is a key issue for Glasgow citizens and businesses". One of the visions from the campaign is "A Glasgow free from litter, graffiti and other grime crime", which suggests that they have found a relationship between street cleanliness (this is assumed to include incivilities like graffiti) and perceptions of crime.
		Pavement, Cycle-track and Cyclists	No evidence found

Criterion	Sub-criterion	Users/Asset /Activities	Description of impact due to shortfall in maintenance
Economy (Transport Economic Efficiency)	*Vehicle Operating Cost*	Pavement (in addition to quantitative effects analysed elsewhere in the study)	Crick (Crick, 2005) mentions that reduced funding is taking its toll on the condition of the roads with a more than doubling of the number of visual defects, including potholes and cracks over the past 10 years. Potholes, defects and cracks result in an increase in the level of compensation claims Local Authorities receive from road users for damage to vehicles. According to highways departments in Wales the knock-on effect of lack of maintenance lead to a 50% increase in the amount of money paid out (£790,000) by Local Authorities in Wales in 2004. In addition, based on a public survey, The Asphalt Industry Alliance (Asphalt Industry Alliance, 2011) estimated that on average those affected by damage to vehicles because of poorly maintained roads spent £340 on repairing them (£500 spent in the West Midlands area and £200 spent in the South West). This figure is further confirmed by two other studies: • TRIP (TRIP, April 2011) estimated that Oklahoma motorists spent an additional vehicle operating cost of \$425-\$662 (about £260-£414) per motorist per year as a result of driving on roads in poor condition. • A survey undertaken as part of the Maintaining Scotland's Roads study (Auditor General for Scotland and Accounts Commission 2011) estimated that over a third of Scottish motorists have suffered car damage because of potholes. The average cost of repairing damage to their vehicles is thought to be between £133 and £220 per motorist per year. This cost related to pothole-related car repairs such as suspension problems, burst tyres, chipped windscreens and paintwork damage. All these studies have shown that a lack of maintenance resulting in the increased levels of potholes, defects and cracks in the road pavement (i.e. carriageway) would result in increased vehicle operating cost ranging from £133 to £500 per motorist per year.
		Structures	No evidence found

Criterion	Sub-criterion	Users/Asset /Activities	Description of impact due to shortfall in maintenance
Accessibility and Social Inclusion	*Community Accessibility*	Pavement	Research carried out by HITRANS (McDowall & Adams, 2008) and (Halcrow, September 2004) explored the current conditions and constraints of locally significant roads (specifically Lifeline Rural Roads) in Scotland and the economic and social impacts of investment in the network. These studies concluded that many of these 'lifeline roads' are currently in a poor standard and in need of repair and consequently there is a significant constraint on the ease and comfort with which residents can access employment and lifeline services such as health, education, retailing and banking. Therefore, these studies included an economic analysis on a scheme-by scheme basis of the impact of investment on nine key routes in terms of journey times and reliability, diversionary impacts, generated traffic, accident reductions impacts, total user benefits. For example, a proposed road improvement scheme (widening, re-surfacing, small scale works on structures and drainage) over 17.1 km costing £0.5m would result in an estimated journey time saving of 1 minute, vehicle operating cost savings of 1 pence per trip and a total user benefits of £41k per year. The Social Exclusion Unit Report (Social Exclusion Unit, 2003), Making the Connections, stated that "busy roads can divide and damage local communities and restrict walking, especially among children and elderly people". In the same report, "the building of the M32 in Bristol severed one traditional neighbourhood (Easton) into two parts". While these case study examples do not provide firm evidence that a reduction in road maintenance would impact on the community accessibility, they do illustrate that a lack of road improvements through investment will impact on the social and economic fabric of remote communities. It can be inferred that community accessibility especially in rural areas are reliant on the quality, reliability or availability of the road network and this can have an impact on the long-term sustainability of communities.
		Structures	In recent years there have been incidences involving the collapse of bridge structures in both Britain and the United States caused by flooding and structural design failure respectively. These cases, while not directly caused by reduced maintenance, demonstrate the wide reaching and adverse impacts of severing access across a river that services local communities. In November 2009, severe flooding across Cumbria led to the closure of 16 bridges and 25 roads causing widespread travel chaos. Six bridges collapsed and Calva bridge which serviced the town of Workington was condemned resulting people on the North side of the town having to make a 40 mile detour to reach the town centre. According to the BBC, a teacher in Wigton said his usual journey to work is 15 miles and takes 20 minutes, but as the two main bridges out of Cockermouth are closed, he now has to take an alternative route which is 40 miles. Workington MP Tony Cunningham said "the lack of bridges meant people were being forced to travel 90 miles for a journey that would usually take a minute and a half, and temporary structures may be needed". A Minnesota newspaper also reported on the economic effects that the bridge collapse on Interstate Highway I-35W had in August 2007 (Cormany, 2008). Small retail establishments including the Johnson Avenue Northeast businesses especially have reported revenue declines of up to 50%. The article reports that the roads immediately surrounding the retail district on the 2800 block of Johnson Street Northeast are open as usual, although drivers who once passed through the area to or from I-35W South seem to be

Criterion	Sub-criterion	Users/Asset /Activities	Description of impact due to shortfall in maintenance
			finding other routes, and as a result local merchants say traffic flow has reduced significantly. Another retailer located at the final exit before southbound I-35W crosses the Mississippi River reported an 80% drop in sales immediately after the bridge accident (Cormany, 2008). These case study examples illustrate how the removal of key infrastructure assets (in this case through the catastrophic failure of the bridge structures) can have devastating socio-economic impacts on the local communities and the wider commuting populations. Both these bridge collapses resulted in fatalities, and have been responsible for the complete severing of road links across the rivers that separate the settlements. One can therefore infer from these examples, that where such vital links are severed, either through the removal of an asset or possibly a shortfall in maintenance resulting from austerity measures, the community severance impacts are likely to be extremely serious.
		Footway	Living Streets (Living Streets, 2010) suggest that the quality of the walking environment as evidenced by their community street audits confirms the view that people's perceptions of safety are an important factor in decision-making about going out or participating in community life. According to Living Streets (Living Streets, 2010), a 2007 study undertaken in Scotland reported that the majority of people walking along in the local neighbourhood after dark felt very safe or fairly safe (72%) but with 23% feeling a bit unsafe or not safe at all. In the 15% most deprived areas, this figure rose to 37% feeling a bit unsafe or not safe at all. There is no evidence on whether people felt that their community was safe because the footway is well maintained.
		Cycle-track	Guidance from the Department for Transport in relation to the appraisal of walking and cycling schemes (Department for Transport, 2010) suggests that cycling and walking schemes may "positively affect severance by reducing barriers to opportunities and destinations". The guidance suggests that this can be achieved by addressing indirect routes, a lack of provision, safety concerns and levels of information for cyclists. However, there is no research cited which specifically links a lack of maintenance of cycle-track facilities to levels of community severance.

Criterion	Sub-criterion	Users/Asset /Activities	Description of impact due to shortfall in maintenance
		Pedestrians	Research conducted by TRL on community severance (James, Harper, Reid, McColl-Grubb, & Tomlinson, 2004); (James, Millington, & Tomlinson, no date); and (Tomlinson & James, 2005) explored how a community in the South West of England experiences community severance effects. The qualitative empirical study found that mitigation measures used to reduce severance impacts, for example subways and footbridges cause 'secondary severance' effects whereby the mitigation measure itself creates a barrier to access because of poor maintenance. The presence of graffiti, rubbish and vomit were cited as particular problems, and vandalised lighting and mirrors, as well as flooding were reported as contributing to anti-social behaviour and criminal activity. A TRL study in 2008 (Bradbury, Tomlinson, & Branning, 2008) suggested that "there is no evidence to support the claim in the DMRB Volume 11 that residents adjust to severance over a period of years". The Social Exclusion Unit (Social Exclusion Unit, 2003) report states that "poor transport as a barrier to work may contribute to higher benefit payments, reduced tax contributions, missed health appointments, delays in patient discharge from hospital, course drop-outs in education. The impact of transport through pollution and pedestrian deaths has significant immediate and long-term costs", however this is not linked to levels of maintenance. Definitions of community severance refer to physical barriers, psychological or perceived barriers (including traffic noise and personal security fears) and the social impacts of reduced community interaction. However, existing definitions of community severance do not include changes to existing infrastructure, for instance caused by reductions in maintenance. The research showed that the lack of maintenance of subways and footbridges put in place to mitigate against severance effects had in itself caused severance impacts, principally to deter people from using them. However, the study did not determine the nature of maintenance withdrawal or how it contributed to the severance effects over time.
		Road Users	An investigation into the socio-economic impacts of road condition on low volume roads (Johansson 2004) explored the concept of 'lifeline rural roads' in the Scottish highlands. It showed that where a transport link which has no substitute, or where the substitute entails a considerable increase in time or money expenditures, where any diminution in the quality, reliability or availability of the former is likely to have a significant impact on the social or economic viability of an affected community.
		Drainage and Cyclists	No evidence found
	Comparative Accessibility	Structures	Marsden et al (Marsden, Jopson, Cattan, & Woodward, 2007) research into the barriers faced by older people found that steps were a particular challenge for many older people. However, there was no evidence to suggest that this problem is particularly linked to maintenance.

Criterion	Sub-criterion	Users/Asset /Activities	Description of impact due to shortfall in maintenance
		Footway	In Marsden et al (Marsden, Jopson, Cattan, & Woodward, 2007) research, inadequate footways were found to be a problem cited by many older people when exploring barriers in the walking environment. Participants talked about changing their route to avoid areas with bad paving. This included them being badly maintained or even not being where they wanted to walk. Ramdas et al (Ramdas, Thomas, Lehman, & Young, 2007) cited a study by DPTAC (Disabled Persons Transport Advisory Committe (DPTAC), 2002) which found that visually impaired people were more likely to be dissatisfied with road and footways than other disabled users and about half (48%) of the disabled people said that they would go out more if the conditions for walking were better. This was also found in Burnett's report (Burnett, 2005) which reported that poor quality carriageways, hilly terrain, inadequate street lighting, noise and pollution, threats to safety and inconsiderate behaviour towards older, vulnerable people are cited as 'tipping points' - key elements in deciding whether to go out or not, when and where. Therefore, it could be interfered that accessibility especially for visually impaired people would improve if the footway condition is better and vice versa.
		Pedestrians	Ramdas et al (Ramdas, Thomas, Lehman, & Young, 2007) cited a study by DPTAC (Disabled Persons Transport Advisory Committe (DPTAC), 2002) which found that "visually impaired people were more likely to be dissatisfied with road and footways than other disabled users and about half (48%) of the disabled people said that they would go out more if the conditions for walking were better". A study by Lavery and Davey (Lavery & Davey, 1996) explored whether the increased use of low floor buses will have a positive effect on the travelling population, particularly older people and those who suffer from mobility impairments. In doing so, the study addressed travel behaviours and barriers for these two groups which are more fundamental than boarding and alighting public transport vehicles; namely those related to the built environment which can prevent people from accessing public transport stops. The National Travel Survey 1991-93 (Department of Transport, 1994) cited within the research states that "one of the three greatest barriers to bus travel by those with mobility impairments is getting to the bus stop". The paper suggests that a high proportion of the most prevalent barriers to walking presented by the built environment relate to surfacing quality, some of which can be linked to surface decay and broken paving stones. Tranter et al (Tranter, Slater, & Vaughan, 1991) indicates that "four out of the six most prevalent built environment barriers" are related to surfacing: • Uneven carriageways • Kerbs that don't drop smoothly • Awkward kerbs • Broken paving stones The research project included in the study included focus groups, interviews and travel diaries amongst

Criterion	Sub-criterion	Users/Asset /Activities	Description of impact due to shortfall in maintenance
			older people in Northern Ireland. The results of the research supported previous research in the area, with stated barriers to walking uncovered by the research include both trip hazards and the poor maintenance of footways. A paper by Borges (Borges, 2007) outlines the specific mobility difficulties faced by an aging population in Europe, and references the role of the built environment in terms of accessibility and perceptions of safety. It states ""the largest barrier to older people's mobility are psychophysical related impairments associated with walking and accessing public transport such as uneven and narrow carriageways"". It continues exploring the worry of older people in terms of their safety, for example fear of crime, falling over and becoming injured. Research undertaken for Transport for London (Transport for London, 2011) gathered minimum and preferred levels of service from pedestrians in London, with regard to specific footway condition defects such as cracking, subsidence, flooding, depressions and raised or sunken ironworks. More than a third of the sample had a long-term physical or mental disability (including those related to old age) which limited their daily activities or work that they could do. Pedestrians with a mobility impairment were slightly more likely to say the condition of the Red Route Network was poor or very poor, as well as slightly more likely to say the condition was good than those with a visual impairment or without an impairment. This suggests that there are pedestrian types with much greater sensitivity to surface conditions."
		Pavement, Cycle-track, and Road users	No evidence found

Appendix C Summary of Key Data and Assumptions

Key economic information including the cost of carbon, value of time and improvements in vehicle efficiency were taken from data published in STAG (Transport Scotland, 2011a) and the Department for Transport Analysis Guidance (webTAG) website (Department for Transport, 2011a).

Note that the analysis of Vehicle Operating Costs used the HDM-4 model produced by HDM-4 Global not the Vehicle Operating Cost relationships from webTAG.

C.1 Economic cost of accidents and casualties

The figures from webTAG relate to 2007 values and have been increased by the growth in GDP per capita (estimated as 2.5% per year), as recommended by the specification, to bring to 2010 figures. The costs are shown in Table C.1.

Table C.1 Costs of road accidents

Type of Accident	Casualty Cost (£)	Accident Cost (£)
Fatal	1,764,367	2,021,141
Serious injury	199,462	231,715
Slight injury	15,378	23,939
Average all accidents	56,914	81,424

C.2 Discount rate

The discount rate assumed in all analyses is the Treasury Test Discount Rate taken from the Department for Transport website and is 3.5% per year.

C.3 Traffic

The 2009 traffic flow data used in the analysis for this study is shown in Table C.2.

C.4 Traffic growth rate factors (NRTF)

Traffic growth rates used in the analysis were consistent with the Department for Transport National Road Transport Forecast (NRTF) (Department for Transport, 2011a) and are reproduced for the modelled years in Table C.3.

C.5 Value of Time

The values of time used in this study, shown in Table C.4, were taken from Department for Transport guidance (Department for Transport, 2011).

C.6 GDP deflator

Where cost data was not available in 2002 prices the costs were deflated to 2002 using the GDP deflator indices in Table C.5.

Table C.2 Traffic on Scottish local roads by vehicle type (2009)

Road Type	Traffic (Million vehicle kilometres)					
	Cars	2 wheel motor vehicles	Buses	Light Goods Vehicles (LGV)	Heavy Goods Vehicles (HGV)	All motor vehicles
Major local roads						
Non-trunk A roads – urban[1]	3,747	21	86	503	153	4,510
Non-trunk A roads – rural[1]	6,184	74	99	1,068	443	7,868
All major local roads	**9,931**	**95**	**185**	**1,571**	**596**	**12,378**
Minor roads (B, C and Unclassified)						
Urban roads[1]	6,662	66	216	1,024	132	8,100
Rural roads[1]	5,233	59	90	1,319	215	6,916
All minor local roads	**11,895**	**125**	**306**	**2,343**	**347**	**15,016**
All local roads						
Urban roads[1]	10,409	87	302	1,527	285	12,610
Rural roads[1]	11,417	133	189	2,387	658	14,784
All local roads	**21,826**	**220**	**491**	**3,914**	**943**	**27,394**

Note: 1. Scottish Transport Statistics uses the Department for Transport classification of urban and rural roads which is based on population. The classification used here is based on built up/non-built up areas.

Table C.3 Traffic growth rate factors from NRTF*

Year	Car	LGV	PSV	HGV
2009	1	1	1	1
2010	1.014600	1.021700	1.006900	1.024400
2013	1.057812	1.092228	1.029521	1.102951
2017	1.113016	1.194830	1.062652	1.216857
2020	1.147082	1.275811	1.090629	1.306208
2025	1.190979	1.414822	1.143427	1.463062
2030	1.231660	1.556266	1.204254	1.627888

** National Road Traffic Forecast*

Table C.4 Value of time for each vehicle type

Year	Car	Van	PSV	3 axle Truck	Artic
2011	8.71	9.66	59.43	8.47	8.47
2012	8.78	9.75	59.89	8.55	8.55
2013	8.91	9.92	60.75	8.70	8.70
2014	9.07	10.13	61.82	8.89	8.89
2015	9.23	10.35	62.91	9.09	9.09
2016	9.39	10.56	63.98	9.28	9.28
2017	9.55	10.77	65.03	9.47	9.47
2018	9.69	10.95	65.91	9.62	9.62
2019	9.82	11.13	66.80	9.79	9.79
2020	9.96	11.31	67.70	9.95	9.95
2021	10.09	11.49	68.62	10.12	10.12
2022	10.23	11.68	69.54	10.28	10.28
2023	10.37	11.87	70.48	10.46	10.46
2024	10.52	12.07	71.43	10.63	10.63
2025	10.66	12.26	72.40	10.81	10.81
2026	10.81	12.46	73.37	10.99	10.99
2027	10.96	12.67	74.36	11.17	11.17
2028	11.11	12.87	75.37	11.36	11.36
2029	11.27	13.08	76.38	11.55	11.55
2030	11.42	13.30	77.41	11.74	11.74

C.7 Longitudinal Profile Variance (3m)

A conversion of IRI to 3m LPV has been adopted based on a preliminary analysis of the FILTER experiment correlating various profile measurements (Alonso, 2001). This is shown in Equation A1.

$$LPV = 0.2117\ IRI^{1.8507} \qquad (A1)$$

Where LPV is the 3m longitudinal profile variance (mm^2)

IRI is the International Roughness Index (m/km)

C.8 Carbon costs

In calculating the costs of vehicle emissions from the emissions results from the HDM-4 analyses the central non-traded price of carbon was used from webTAG (Department for Transport, 2011a) as shown in Table C.6**Error! Reference source not found.**.

Table C.5 GDP deflator indices

Year	GDP deflator at market prices		GDP (£m)
	2010 = 100	Per cent change on previous year	
2002	81.274	3.10	1,075,564
2003	83.771	3.07	1,139,744
2004	85.883	2.52	1,202,956
2005	87.627	2.03	1,254,058
2006	90.301	3.05	1,328,363
2007	93.004	2.99	1,404,845
2008	95.763	2.97	1,445,580
2009	97.147	1.45	1,394,989
2010	100.000	2.94	1,455,397
2011	103.000	3.0	1,526,000
2012	105.472	2.4	1,603,000
2013	108.320	2.7	1,694,000
2014	111.244	2.7	1,789,000
2015	114.248	2.7	1,889,000

C.9 Analyses driven by surface condition

The analysis assumes that the traffic flow in veh. km is distributed evenly over the road network.

The analysis did not include any consideration of the quality of the carriageway condition data provided by WDM (based on SCANNER network surveys). For this reason a maximum IRI value of 10 was set and any lengths with an IRI >=10 were deemed to have an IRI of 10.

C.10 Analyses of delays and emissions through roadwork sites

When developing the input data for the QUADRO analyses for road classes with both dual and single carriageway roads, the carriageway traffic flows for both single and dual carriageways were set to the same average flow for that road type.

Notional works lengths of 250m for single carriageways and 1000m for dual carriageways were chosen for the QUADRO analyses.

In determining the length of maintenance carried out the total length of maintenance over each 3, 4 or 5 year time interval was divided by the number of years in the time interval to obtain a treatment length per year. In the analysis, time intervals between 2020 to 2025 and 2025 to 2030 budgets for Scenarios 2 and 3 increase linearly. Therefore, in practice, the amount of maintenance would also have increased linearly over these intervals. However this simplification to a fixed average length maintained per year was considered sufficient for these analyses and required no further assumptions to be made on the amount of maintenance being carried out over the intervals of increasing budget.

Table C.6 Central non-traded price of carbon (2002 prices)

Carbon Costs Central Non-Traded Price	
Year	(£/Tonne)
2011	158.87
2012	161.25
2013	163.67
2014	166.13
2015	168.62
2016	171.15
2017	173.71
2018	176.32
2019	178.97
2020	181.65
2021	184.68
2022	187.70
2023	190.73
2024	193.76
2025	196.79
2026	199.81
2027	202.84
2028	205.87
2029	208.90
2030	211.92

C.11 Local Authority network lengths

Network carriageway length data for each Local Authority (based on data from the SRMCS 2008/10 report) is shown in Table C.7.

C.12 Local Authority budgets

The annual carriageway maintenance budgets, supplied by SCOTS, used by WDM for the 8 sample Authorities in the condition projection modelling and those used in the scaling up for the non-sample Authorities are shown in Table C.8 in 2010 prices.

Table C.7 Network length for Scottish local roads

Area	Network Length (Carriageway km)							
	Urban				Rural			
	A	B	C	U	A	B	C	U
Aberdeenshire	62	65	50	616	625	736	1,486	1,780
Dumfries and Galloway	68	55	85	402	427	679	1,091	1,334
Edinburgh, City of	127	43	101	1,019	39	11	18	20
Fife	87	79	74	1,137	261	259	218	271
Glasgow City	174	72	243	1,275	0	0	0	0
Highland	74	91	97	756	1,314	888	1,341	2,178
North Lanarkshire	66	68	113	965	64	65	117	70
South Ayrshire	32	23	25	333	83	183	207	271
Rural	40	25	33	291	154	230	451	548
Rural	71	37	33	254	479	582	398	456
Rural	38	31	24	254	430	560	744	869
Rural	23	20	28	261	135	271	338	432
Rural	55	33	24	380	379	333	614	608
Urban	17	11	16	138	35	23	13	17
Urban	25	20	18	327	29	29	18	36
Urban	26	19	50	257	7	31	33	33
Urban	57	46	19	526	55	45	96	61
Urban	11	6	32	230	13	16	22	32
Urban	38	26	55	483	36	19	60	74
Urban	33	10	12	237	23	0	15	14
Semi Urban	25	46	21	327	97	150	190	263
Semi Urban	33	35	16	230	63	134	207	199
Semi Urban	19	20	20	251	69	76	81	98
Semi Urban	37	46	25	446	64	109	182	116
Semi Urban	75	61	77	872	202	182	359	369
Semi Urban	46	25	23	256	170	136	148	187
Semi Urban	33	45	16	492	128	73	100	88
City	65	29	40	642	12	17	53	53
City	44	12	94	346	4	3	26	15
Islands	20	7	6	82	141	198	154	370
Islands	13	5	23	81	212	157	176	379
Islands	47	16	31	41	285	166	143	461
TOTAL	**1,578**	**1,126**	**1,522**	**14,206**	**6,033**	**6,359**	**9,097**	**11,702**

Table C.8 Maintenance budgets used in condition modelling and scaling

Authority	2010 Budgets		
	Current (£)	20% Cut (£)	40% Cut (£)
Aberdeenshire	9,737,910	7,790,328	5,842,746
Dumfries and Galloway	6,293,000	5,034,400	3,775,800
Edinburgh, City of	7,105,000	5,684,000	4,263,000
Fife	9,887,115	7,909,692	5,932,269
Glasgow City	2,908,990	2,327,192	1,745,394
Highland	7,493,745	5,994,996	4,496,247
North Lanarkshire	3,045,000	2,436,000	1,827,000
South Ayrshire	1,292,095	1,033,676	775,257
Rural	3,451,000	2,760,800	2,070,600
Rural	6,617,800	5,294,240	3,970,680
Rural	1,624,000	1,299,200	974,400
Rural	2,588,250	2,070,600	1,552,950
Rural	4,669,000	3,735,200	2,801,400
Urban	908,425	726,740	545,055
Urban	2,427,880	1,942,304	1,456,728
Urban	1,538,740	1,230,992	923,244
Urban	1,511,132	1,208,906	906,679
Urban	954,100	763,280	572,460
Urban	2,436,000	1,948,800	1,461,600
Urban	1,725,500	1,380,400	1,035,300
Semi Urban	2,126,425	1,701,140	1,275,855
Semi Urban	3,024,700	2,419,760	1,814,820
Semi Urban	1,618,925	1,295,140	971,355
Semi Urban	2,624,421	2,099,536	1,574,652
Semi Urban	21,755,510	17,404,408	13,053,306
Semi Urban	3,940,230	3,152,184	2,364,138
Semi Urban	2,664,375	2,131,500	1,598,625
City	406,000	324,800	243,600
City	1,294,548	1,035,639	776,729
Islands	1,492,050	1,193,640	895,230
Islands	1,799,464	1,439,571	1,079,678
Islands	3,316,850	2,653,480	1,990,110
TOTAL	**124,278,180**	**99,422,544**	**74,566,908**

Source: SCOTS

Appendix D Details of Scotland's Local Road Network

D.1 Classification of Scottish Local Authorities

The 32 Local Authorities in Scotland were classified into the types shown in Table D.1**Error! Reference source not found.** in accordance with earlier work by SCOTS. These types were used to characterise the Local Authorities when scaling the results from the 8 sample Authorities to the entire network. For the analyses in this study, the Authorities have been assumed to be rural, urban, semi-urban or cities. The Authorities in Table D.1 classed as 'islands' have been assumed to be rural for this study. Note that Glasgow City does not classify any of its roads as rural. There was therefore no analysis of rural roads for Glasgow.

Table D.1 Classification of Local Authority types

Authority	Classification	Authority	Classification
Aberdeen City	City	Inverclyde	Urban
Aberdeenshire	Rural	Midlothian	Semi-Urban
Angus	Rural	North Ayrshire	Semi-Urban
Argyll & Bute	Rural	North Lanarkshire	Urban
City of Edinburgh	City	Orkney Islands	Islands
Clackmannanshire	Urban	Perth & Kinross	Rural
Comhairle nan Eilean Siar	Islands	Renfrewshire	Urban
Dumfries and Galloway	Rural	Scottish Borders	Rural
Dundee City	City	Shetland Islands	Islands
East Ayrshire	Semi-Urban	South Ayrshire	Semi-Urban
East Dunbartonshire	Urban	South Lanarkshire	Semi-Urban
East Lothian	Semi-Urban	Stirling	Semi-Urban
East Renfrewshire	Urban	The Highland	Rural
Falkirk	Urban	The Moray	Rural
Fife	Semi-Urban	West Dunbartonshire	Urban
Glasgow City	City	West Lothian	Semi-Urban

Table D.2 shows the breakdown of the 2009/10 budgets for all the Local Road network and for each of the sample Authorities.

Table D.2 Summary of budgets – outturn costs for 2009/10

Budget Head	All Network	Aberdeenshire	Dumfries and Galloway	City of Edinburgh	Fife	Glasgow City	Highland	North Lanarkshire	South Ayrshire
Capital (£m)									
Traffic Calming	2,987	609	0	0	1,094	442	51	0	204
Road Safety	8,521	497	290	1,110	109	1,478	0	0	43
New Road Schemes	11,757	0	0	2,779	0	0	1,857	0	686
Lighting	20,629	1,032	445	1,433	4,151	586	705	2,054	827
Structural Maintenance	109,906	0	4,187	17,099	5,066	0	5,585	4,567	136
Other	34,477	11,525	2,055	3,200	0	0	2,997	0	684
Total Capital	**188,277**	**13,663**	**6,977**	**25,621**	**10,420**	**2,506**	**11,195**	**6,621**	**2,580**
Revenue (£m)									
Road Construction	1,370	0	0	0	0	0	0	0	609
Structural Maintenance	65,432	0	4,440	6,375	9,005	3,317	1,290	1,629	167
Environmental Maintenance	13,950	980	425	0	538	2,102	1,151	542	227
Winter Maintenance	92,261	8,263	1,795	3,309	4,441	3,973	7,283	5,209	836
Lighting	53,449	2,976	1,033	5,166	1,508	5,495	1,429	5,856	1,318
Safety Maintenance and Emergency Patching	33,880	3,331	485	2,973	2,363	1,253	5,737	881	134
Routine Repairs	42,895	5,104	1,166	743	1,991	4,929	1,286	9,614	2,043
Total Revenue	**303,236**	**20,654**	**9,344**	**18,566**	**19,846**	**21,069**	**18,176**	**23,731**	**5,334**
TOTAL (£m)	**491,513**	**34,317**	**16,321**	**44,187**	**30,266**	**23,575**	**29,371**	**30,352**	**7,914**

Source: (Audit Scotland, 2011)

Appendix E Refinement of Funding Scenarios

Figure E.1 shows the results of the analysis of budget reductions based on refinement to the funding Scenarios described in Section 5. The following points should be noted:

- The quantified economic analysis of carriageway conditions is based on 2007/08 structural maintenance budgets indexed to +/10 prices. However, the overall budgets provided for the Audit Scotland assessment have been used for the scenario refinement and these are based on Local Authority outturn costs in 2009/10. It is likely that the structural maintenance outturn costs in 2009/10 for each Authority is not the same as their 2007/08 budgets prices indexed to 2009/10. However, it was considered that the results of the refinement analysis of the entire Local Authority network would still be broadly applicable to identify the range of expected expenditure cuts on structural maintenance.

- Structural maintenance might include expenditure on carriageways, footways and cycle-tracks or structures. Returns from 8 Authorities (not the 8 included in the study sample) show that the average ratio of carriageway to non-carriageway was around 95% to 5%. There is variation across Authorities with regard to itemising expenditure and it is likely that structural maintenance of non-carriageways is often captured in other budget heads. The results adopted for use in the analysis are based on the sample returns from 8 Authorities (i.e. assuming 95% is carriageway maintenance).

- Assessment of the contribution of New Road Schemes to the different outcomes is difficult. An asset management perspective of maintaining existing assets before constructing new assets might be that all new road expenditure should be ceased should funding be constrained to the extent of the given scenarios. However, such a perspective needs to be balanced against the realities of political drivers for capital projects, their contribution to key outcomes and existing commitments. A balance of these different issues has been adopted.

- The review is not addressing winter maintenance. However, assumptions have had to be made in order to assess the likely impact of budget reductions. The analysis shows that winter maintenance remains fairly well protected but will still suffer some reductions which are considered reasonable.

09/10 Allocation		20% Scenario		40% Scenario	
Safety	32%	32%	0%	32%	0%
Access	7%	7%	0%	7%	0%
Reliability	10%	10%	0%	10%	0%
Condition	28%	16%	-12%	4%	-24%
Sustainability	9%	6%	-3%	4%	-5%
Customer Care	15%	9%	-6%	4%	-11%
TOTAL	100%	80%	-20%	60%	-40%

Allocation by Activity for 2009/10				Outcome contribution							Allocation by Outcome by Activity (£m)						20% Scenario		40% Scenario	
Item	2009/10 Outturn (£m)			Safety	Access	Reliability	Condition	Sustainability	Customer Care	Check	Safety	Access	Reliability	Condition	Sustainability	Customer Care	Total (£m)	% of Original	Total (£m)	% of Original
Capital																				
Traffic Calming	2,987			90	0	0	0	0	10	100	2,688	-	-	-	-	299	2,874	96%	2,761	92%
Road Safety	8,521			90	0	0	0	0	10	100	7,669	-	-	-	-	852	8,198	96%	7,875	92%
New Road Schemes	11,757			20	10	40	0	0	30	100	2,351	1,176	4,703	-	-	3,527	10,420	89%	9,083	77%
Lighting	20,629			60	0	20	0	0	20	100	12,377	-	4,126	-	-	4,126	19,065	92%	17,501	85%
Structural Maintenance - Cway	109,906	104,411	95	15	0	0	65	10	10	100	15,662	-	-	67,867	10,441	10,441	68,354	65%	32,297	31%
Structural Maintenance - Other		5,495	5	30	10	0	20	10	30	100	1,649	550	-	1,099	550	1,649	4,241	77%	2,988	54%
Other (sum of 5 categories)	34,477			30	10	10	30	20		100	10,343	3,448	3,448	10,343	6,895	-	28,065	81%	21,653	63%
Total capital	**188,277**										**52,739**	**5,173**	**12,276**	**79,309**	**17,886**	**20,893**	**141,217**	**75%**	**94,157**	**50%**
Revenue																				
Road Construction	1,370			20	10	40	0	0	30	100	274	137	548	-	-	411	1,214	89%	1,058	77%
Structural Maintenance - Cway	65,432	62,160	95	15	0	0	65	10	10	100	9,324	-	-	40,404	6,216	6,216	40,694	65%	19,228	31%
Structural Maintenance - Other		3,272	5	30	10	0	20	10	30	100	981	327	-	654	327	981	2,525	77%	1,779	54%
Environmental Maintenance	13,950			20	0	0	0	40	40	100	2,790	-	-	-	5,580	5,580	10,235	73%	6,521	47%
Winter Maintenance	92,261			30	30	30	0	0	10	100	27,678	27,678	27,678	-	-	9,226	88,763	96%	85,265	92%
Lighting	53,449			50	0	20	0	0	30	100	26,725	-	10,690	-	-	16,035	47,370	89%	41,292	77%
Safety Maintenance and Emergency Patching	33,880			90	0	0	0	0	10	100	30,492	-	-	-	-	3,388	32,596	96%	31,311	92%
Routine Repairs	42,895			10	0	0	40	30	20	100	4,289	-	-	17,158	12,868	8,579	28,596	67%	14,297	33%
Total revenue	**303,236**										**102,554**	**28,142**	**38,916**	**58,217**	**24,992**	**50,416**	**251,994**	**83%**	**200,751**	**66%**
TOTAL	**491,513**										**155,293**	**33,315**	**51,192**	**137,526**	**42,878**	**71,309**	**393,210**	**80%**	**294,908**	**60%**
											32%	7%	10%	28%	9%	15%				

Note: All coloured numerical cells are generated values

Figure E.1 Subjective analysis of local road spending cuts by activity

Appendix F Network Pavement Model and Vehicle Operating Cost Analyses

F.1 Background and pre-analysis steps

WDM Ltd was contracted by Transport Scotland to run the pavement model to predict the condition of the road networks in 8 sample Authorities (Aberdeenshire, Dumfries and Galloway, City of Edinburgh, Fife, Glasgow City, Highland, North Lanarkshire and South Ayrshire) under the 3 different budget Scenarios. WDM provided outputs for the years 2010, 2013, 2017, 2020, 2025 and 2030 and included:

- Predicted carriageway condition parameters including longitudinal profile variance and rutting for each 10m carriageway length in the asset database for the 8 Authorities
- An accumulated depreciation for each of the 8 Local Authorities
- Treatment types, lengths and areas for each of the time intervals used in the model (i.e. 2010 to 2012, 2013 to 2016, 2017 to 2019, 2020 to 2024 and 2025 to 2029).

The economic analysis based on the condition of the carriageway was driven by the longitudinal profile variance of the network and the traffic flow over the network. The following methodology was used to process the projected network condition data, provided by WDM, and the network traffic data.

1. Using the projected 3m Longitudinal Profile Variance (LPV) data the International Roughness Index (IRI) was calculated for each 10m surveyed length using the same relationship that was used for the trunk road analysis (Alonso, 2001).
2. The calculated IRI values were then rounded into 0.5 IRI increments (maximum of IRI 10, minimum of 1). Sections with an IRI > 10 were set to 10 and those with an IRI < 1 were set to 1.
3. The proportion of the surveyed network by road type, road environment and Local Authority by the rounded IRI condition established in step 2 was calculated.
4. The traffic flows for each Local Authority was taken from the traffic count vehicle kilometre travelled data in 2009. The proportion of traffic by road class, road environment and vehicle type was then used to determine a traffic flow for each of the sample Authorities by road class (i.e. A, B, C or Unclassified), road environment (i.e. rural or urban) and vehicle type (car, van, bus and HGV).
5. For each Local Authority, vehicle type, road class and road environment the base traffic data calculated in step 5 was grown using traffic growth forecasts found in the National Road Traffic Forecast, to calculate the traffic in each of the analysis time-steps (2010, 2013, 2017, 2020, 2025 and 2030).
6. Using the network proportions by condition calculated in step 3 together with the appropriate traffic flow for each time-step, Authority, road type and road environment, calculated in step 5, the number of vehicle kilometres travelled

over different network condition in each time step for each vehicle type, road type and road environment was calculated.

The resulting vehicle proportions were used as the basis of the calculation of vehicle operating cost; travel time delay; and CO_2 emissions from vehicles under normal running conditions.

F.2 Predicted maintenance and condition

The results of the analyses of wider economic impacts are dependent on the predicted outcomes from the condition prediction modelling. The details of the rules and algorithms are not known but some observed characteristics of the modelling may impact on the results of the analyses.

After treatment the treated lengths are placed in a pavement category with very long life. These lengths have, typically, 50 years life so do not get considered again in the analysis period but the long life may affect the depreciation calculation.

There is no consideration of unexpected performance of urban roads due to utility works so this is likely to over-estimate the lives of maintenance treatments in urban areas.

Similarly winter maintenance is not included and sudden cold winters can also reduce the carriageway lives.

Plots of the projected pavement condition from the WDM condition projection outputs of all 8 sample authorities are shown in Figure F.1 to Figure F.3 for 3mLPV and Figure F.4 to Figure F.6 for rutting. The projected 3mLPV condition is a key parameter in the economic analysis carried out in this study.

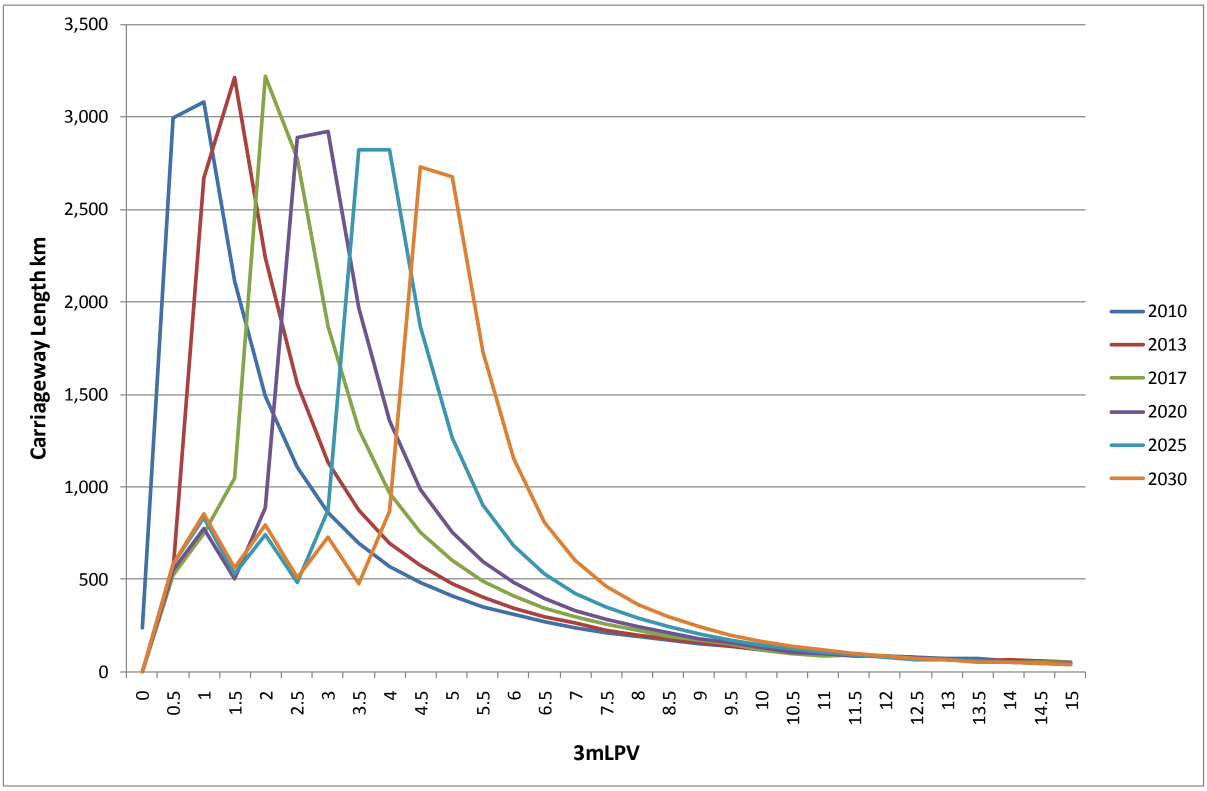


Figure F.1 Distribution of 3mLPV for the 8 Sample Authorities and Scenario 1

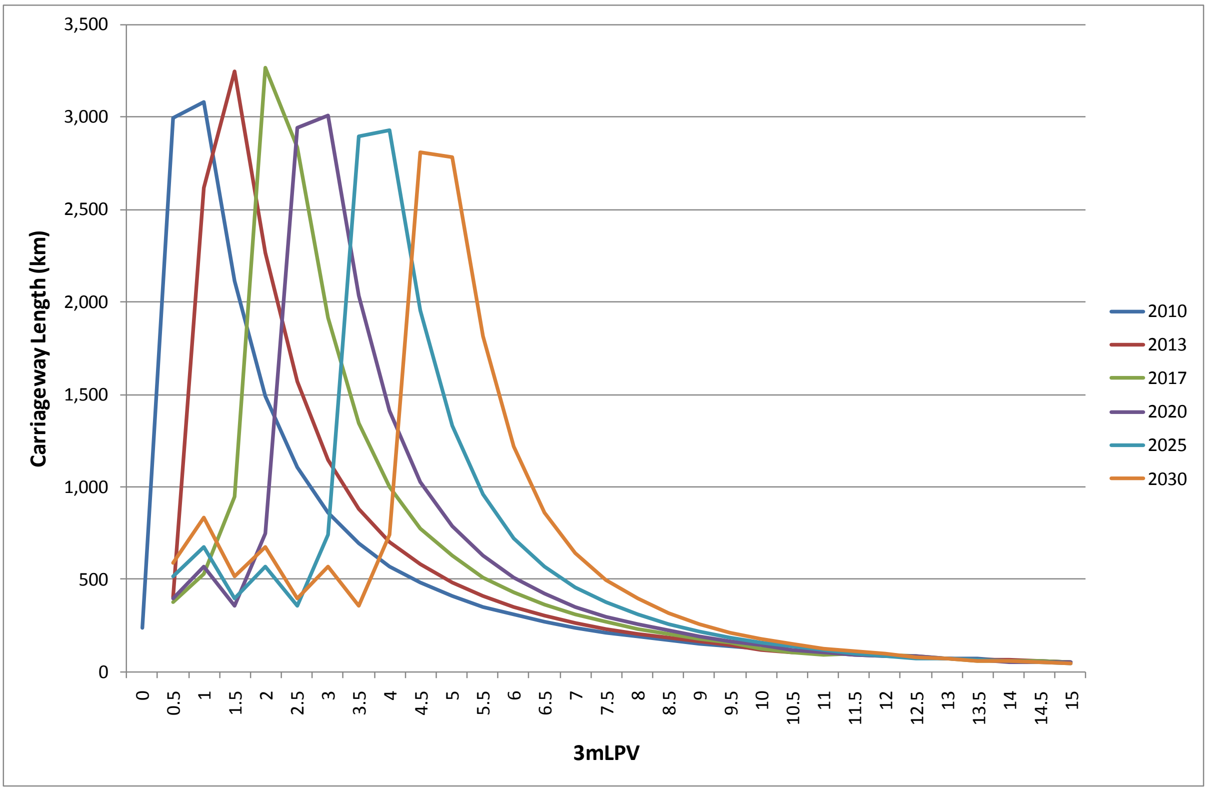


Figure F.2 Distribution of 3mLPV for the 8 Sample Authorities and Scenario 2

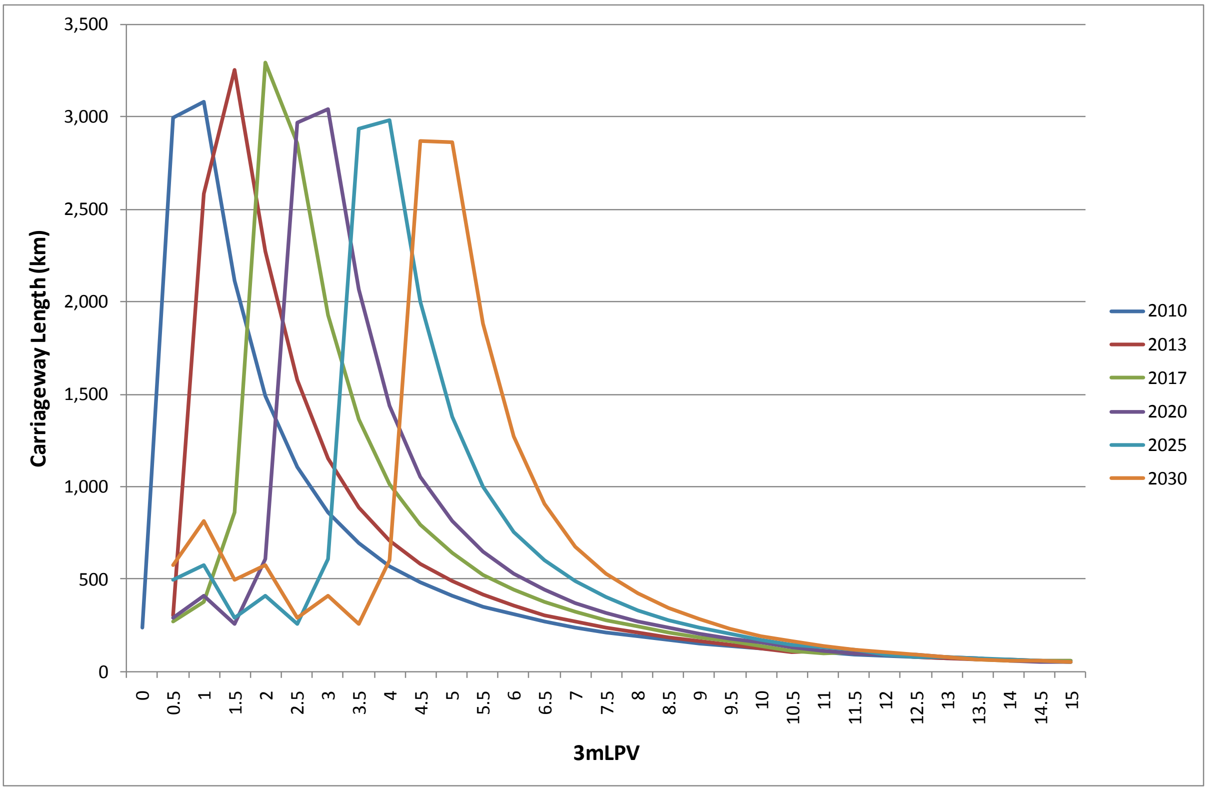


Figure F.3 Distribution of 3mLPV for the 8 Sample Authorities and Scenario 3

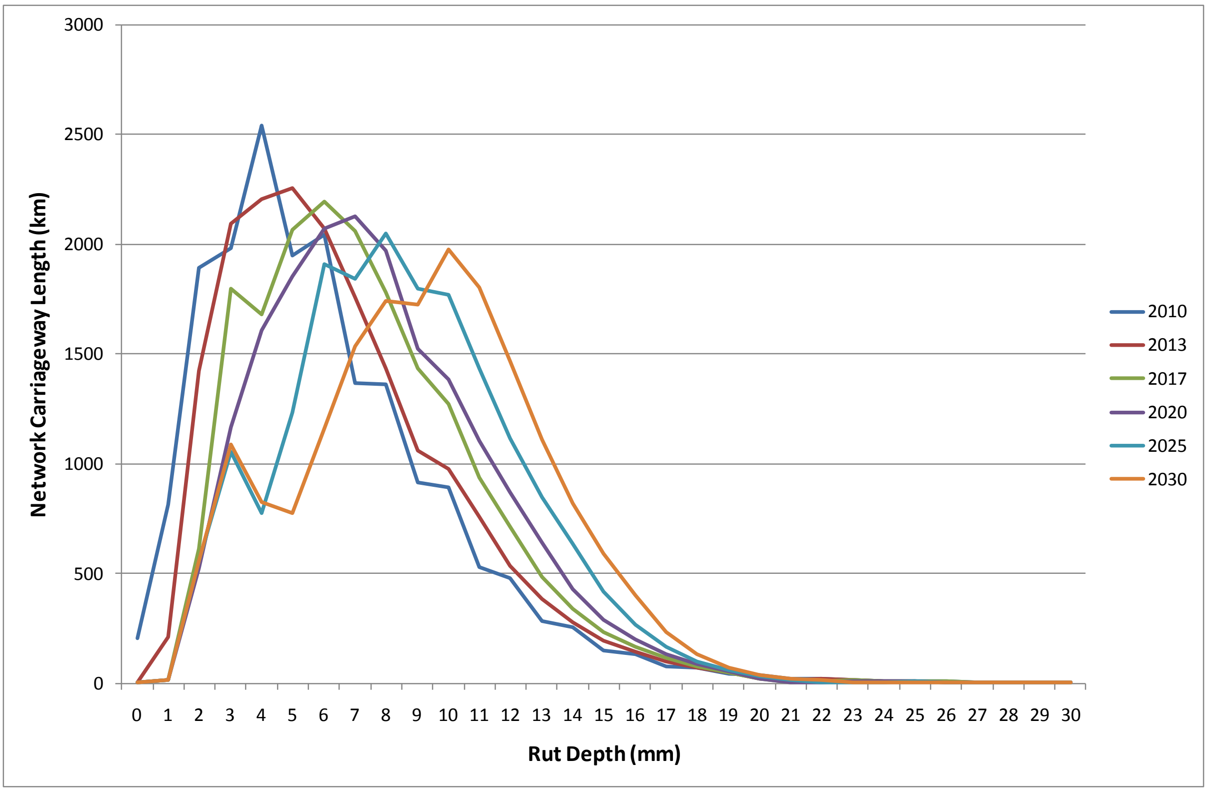


Figure F.4 Distribution of rut depth for the 8 Sample Authorities and Scenario 1

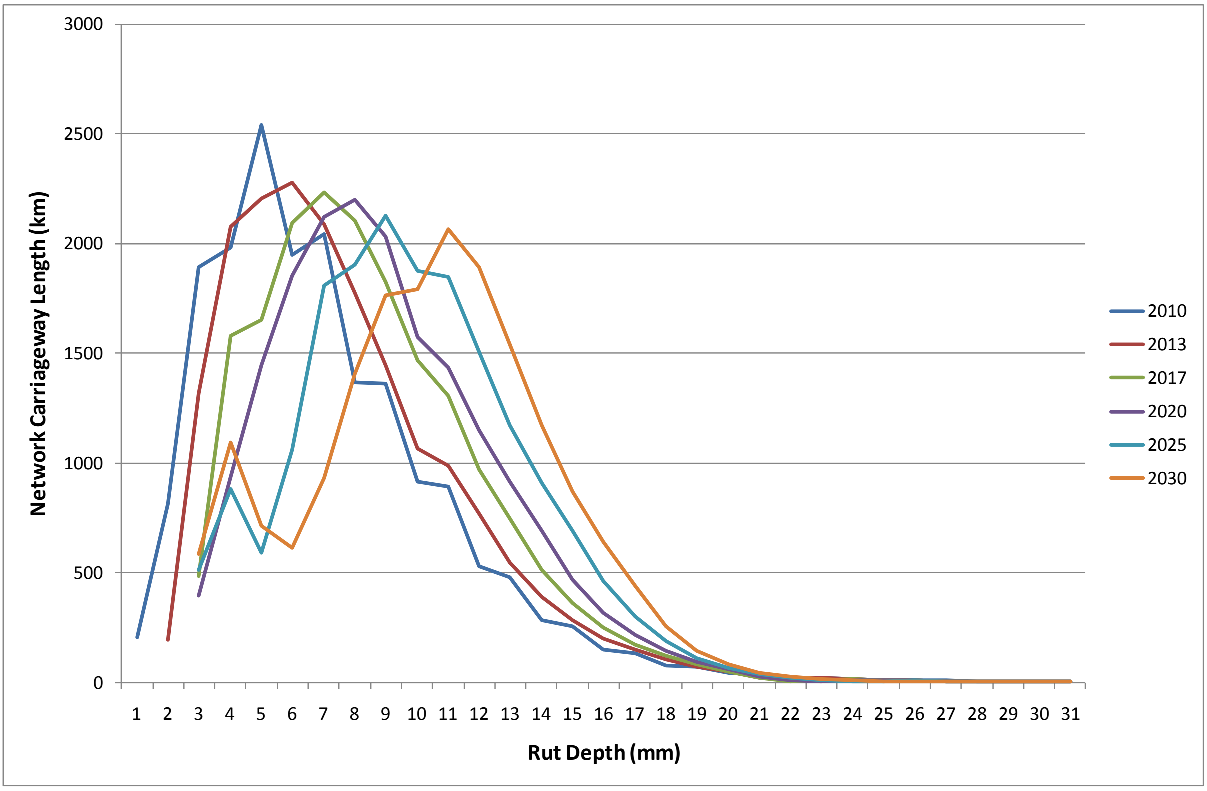


Figure F.5 Distribution of rut depth for the 8 Sample Authorities and Scenario 2

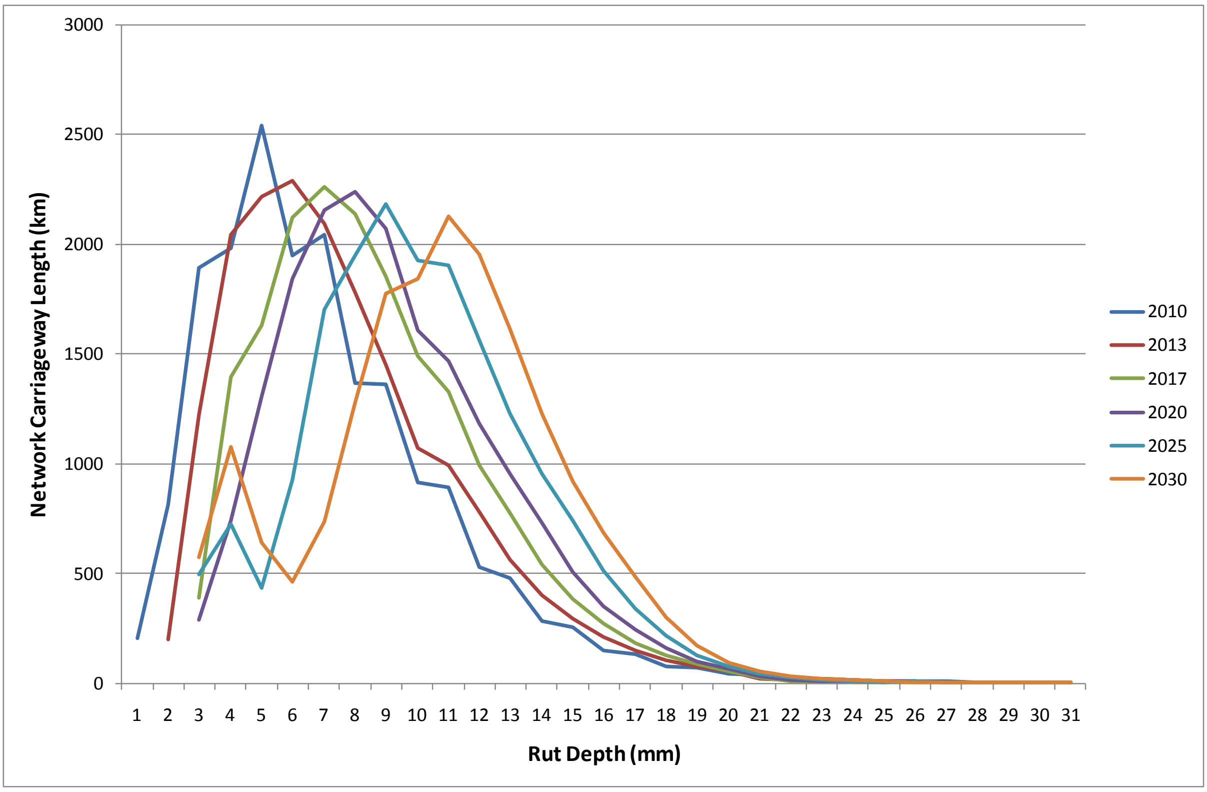


Figure F.6 Distribution of rut depth for the 8 Sample Authorities and Scenario 3

F.3 Vehicle operating costs

The HDM-4[9] model includes modules to calculate vehicle operating costs (VOCs) and vehicle emissions and was considered to be an appropriate tool for this analysis. Typically HDM-4 is not used in the UK as the road network is, by international standards, relatively smooth and VOCs are not sensitive to roughness until the pavement has an IRI of around 4 or 5. Based on this threshold it is only the worst parts, in terms of longitudinal profile variance, of the Scottish road network that will have any impact on VOCs.

Using the HDM-4 model 19 notional 1km road lengths were defined with different levels of roughness ranging from IRI 1 to 10 in 0.5 IRI increments. Four vehicle types (car, van, bus and truck) with appropriate economic values were defined in the HDM-4 model to represent the different types of vehicle on the Local Authority network based on published data and consultation with TRL experts and the outputs from the literature review. The parameters used for each vehicle type are shown in Table F.1.

Speeds appropriate for the vehicles travelling on Local Authority roads, shown in Table G.1, were also set in the HDM-4 model. The crew cost parameter was set to zero for the purposes of this analysis to avoid double counting with the travel time delay analysis, which was carried out separately.

[9] The analysis used HDM-4 version 2.

All the modelled road sections were of asphalt construction, had a width of 7.5m, a Rise and Fall of 10m/km and a curvature of 15 degrees/km. A further set of 3 lengths were modelled with a surface dressing wearing course to investigate the sensitivity of the model outputs to the different material type. No significant changes in the results of the economic analysis were found due to the change in surfacing type and as a result one surfacing type has been used in this analysis.

Table F.1 HDM-4 vehicle parameters

Parameter	Car	Light Goods Vehicle (LGV)	HGV	Public Service Vehicle (PSV)
Passenger car equivalent	1	1	1.8	1.5
No. of wheels	4	4	12	6
No. of axles	2	2	5	2
Tyre type	Radial ply	Radial ply	Radial ply	Radial ply
Tyre Retread cost (%)	20	30	50	50
Annual kilometres	10000	20500	60000	45000
Working hours	700	2250	3500	4000
Average life (yrs)	14	9	10	10
Private use (%)	100	0	0	0
Passengers (persons)	1	0	0	50
Work related passenger trips (%)	75	0	0	75
Operating weight (t)	1	2.5	44	7.5
New vehicle cost (£)	13600	18000	56000	36000
Replacement tyre cost (£)	36	64	336	200
Fuel cost (£ per litre)	0.46	0.48	0.48	0.48
Lubricating oil cost (£ per litre)	4	12	4	4

Note: Costs are economic costs

HDM-4 was run for each of the vehicles travelling over each of the 1km lengths to evaluate the economic costs associated with each vehicle type.

To take account of vehicle engine efficiency improvements and predicted growth in the resource cost of fuel, the fuel costs in the HDM-4 outputs were replaced with values calculated from:

- The amount of fuel used given in the outputs from the HDM-4 modelling, modified for each year of the analysis based on the assumed vehicle fuel efficiency improvements given in webTAG unit 3.5.6 (Department for Transport, 2011a).
- The resource cost of fuel based on the vehicle type, taking into account the proportion of the vehicle type using petrol or diesel and the growth forecast for the resource costs of petrol and diesel given in webTAG unit 3.5.6. (Department for Transport, 2011a)

Using the calculated vehicle operating costs per vehicle kilometre together with the vehicle kilometre proportions calculated using the methodology in Section F.1 the total vehicle operating costs for each of the 8 sample Local Authority road networks was calculated for 2010, 2013, 2017, 2020, 2025 and 2030 under the 3 budget scenarios.

The vehicle operating costs for each of the modelled years under the 20% and 40% budget cut Scenarios were then linearly interpolated and extrapolated to represent a 35% and 69% budget cut to account for the fact that the WDM model runs were carried out using a 20% and 40% budget cut, but the subjective budget analysis identified that these would be equivalent to a 35% and 69% budget cut in carriageway maintenance respectively.

To calculate VOCs for the intermediate years between the modelled years the results of the analysis were linearly interpolated.

F.4 Results of vehicle operating cost analysis

The results from the VOC analysis are shown in Figure F.7 to Figure F.14. They show the vehicle operating costs increasing with time, which is consistent with the growth in traffic. There is little difference between the VOCs for the different budget scenarios, but in every case the vehicle operating costs for Scenario 1 (no budget cut) are less than those for budget Scenario 2, which are less than those for budget Scenario 3.

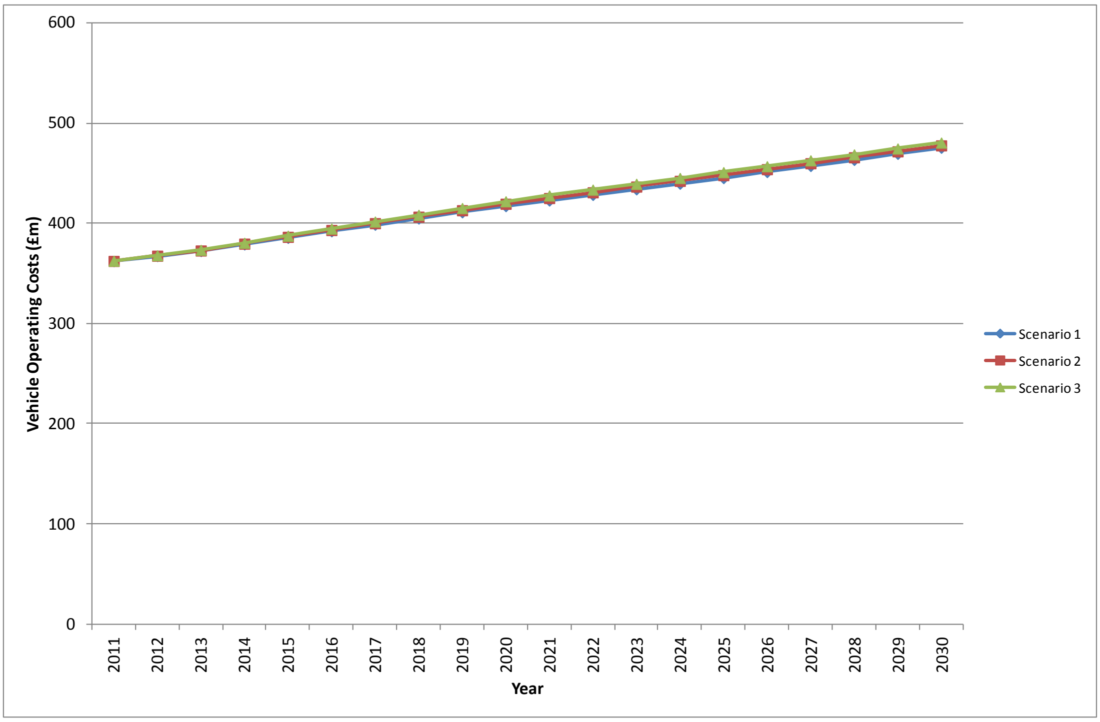


Figure F.7 Aberdeenshire vehicle operating costs
(2002 prices undiscounted)

Figure F.8 Dumfries and Galloway vehicle operating costs

(2002 prices undiscounted)

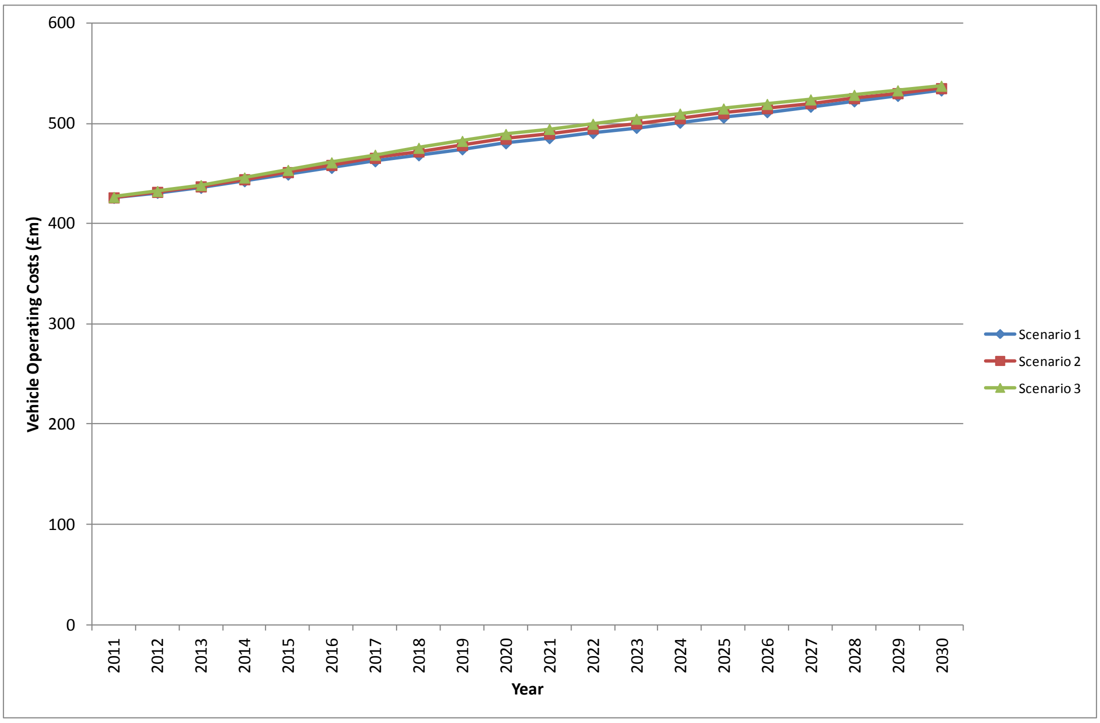


Figure F.9 City of Edinburgh vehicle operating costs

(2002 prices undiscounted)

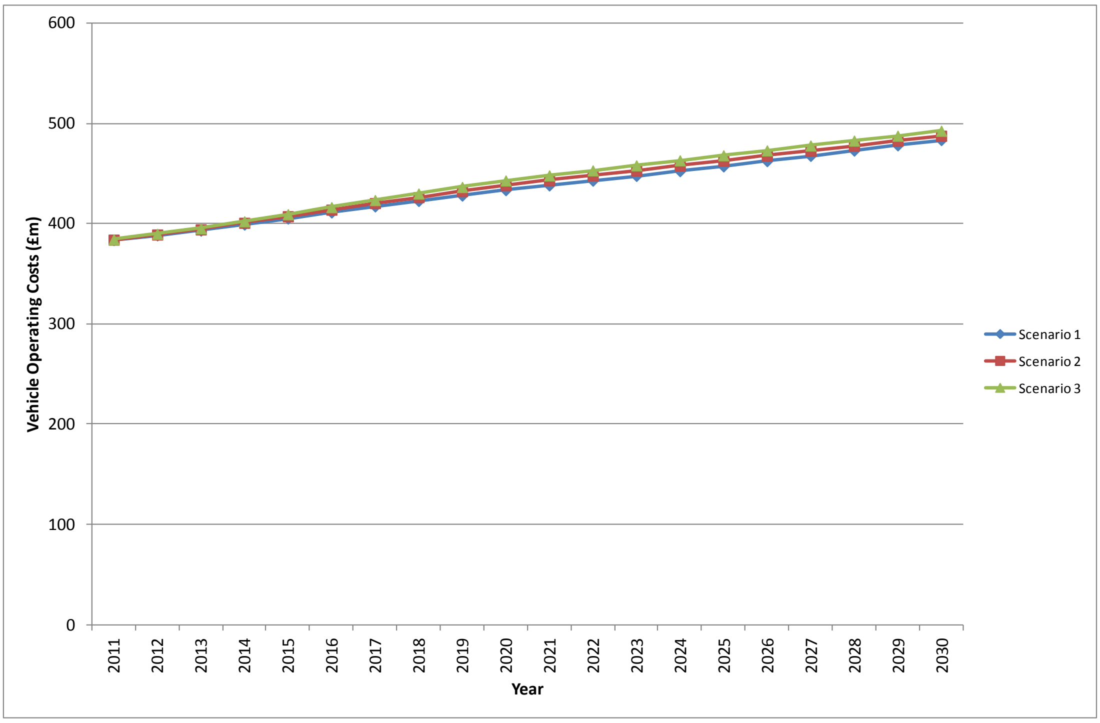


Figure F.10 Fife vehicle operating costs
(2002 prices undiscounted)

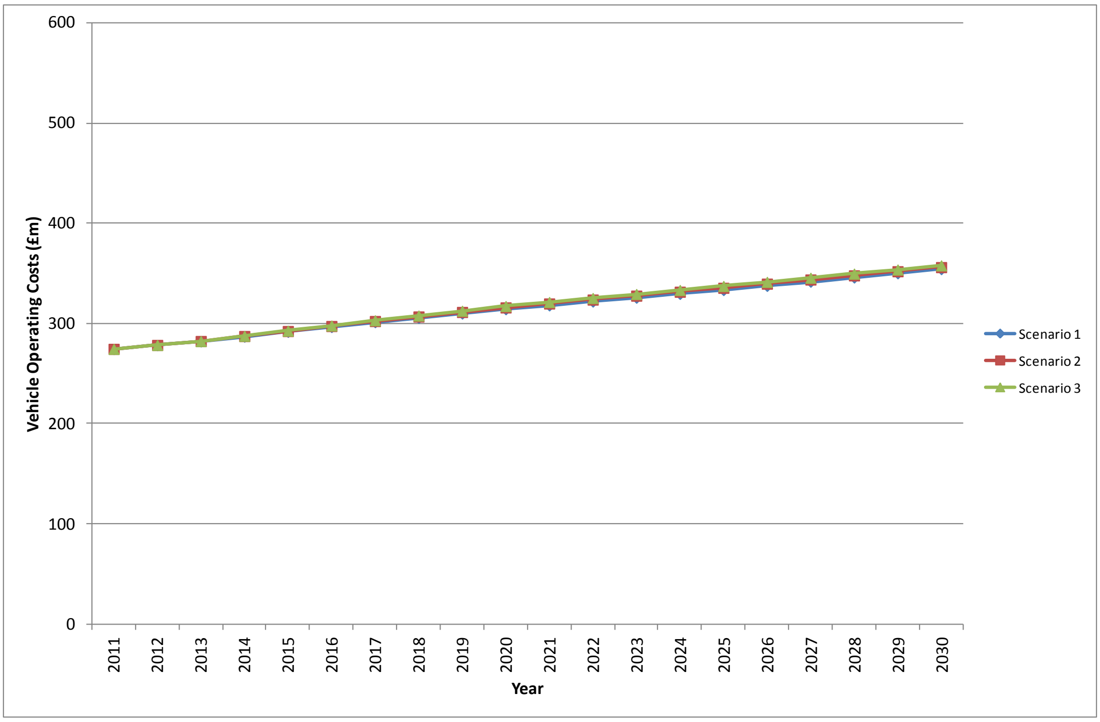


Figure F.11 Glasgow City vehicle operating costs
(2002 prices undiscounted)

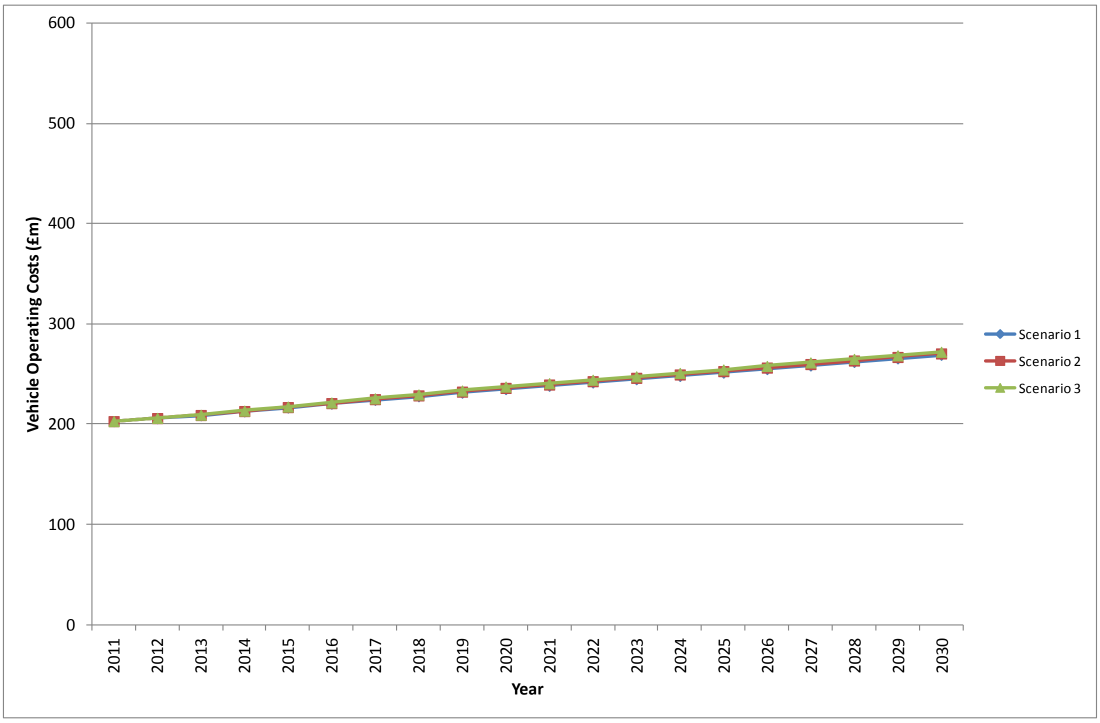


Figure F.12 Highland vehicle operating costs
(2002 prices undiscounted)

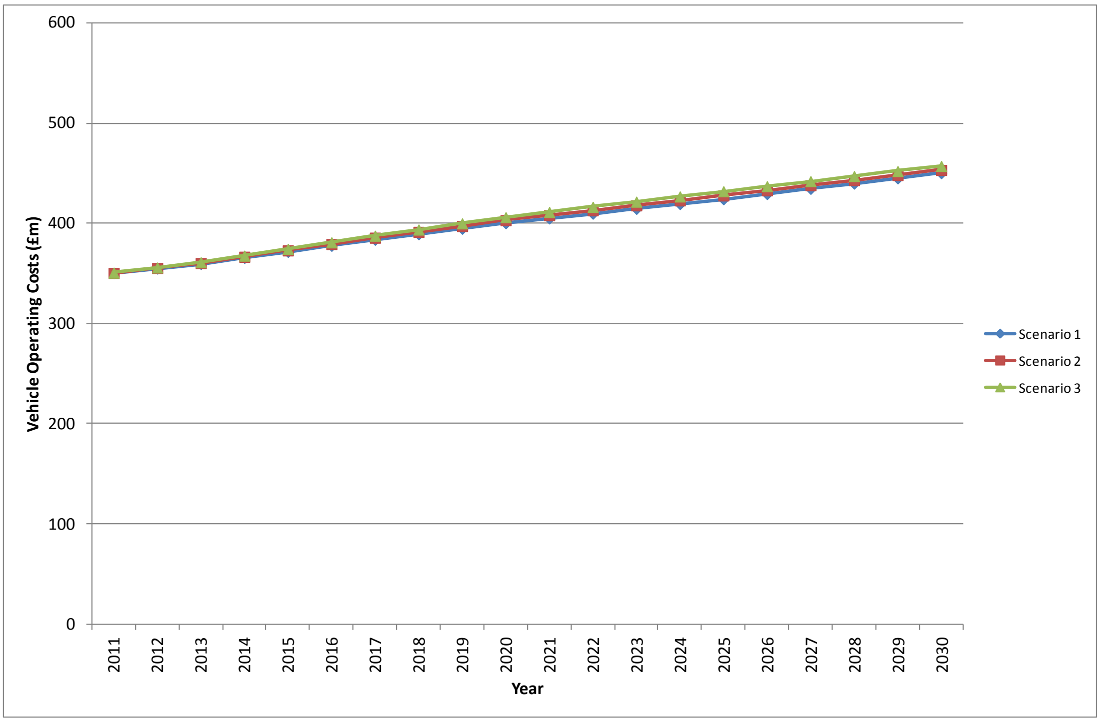


Figure F.13 North Lanarkshire vehicle operating costs
(2002 prices undiscounted)

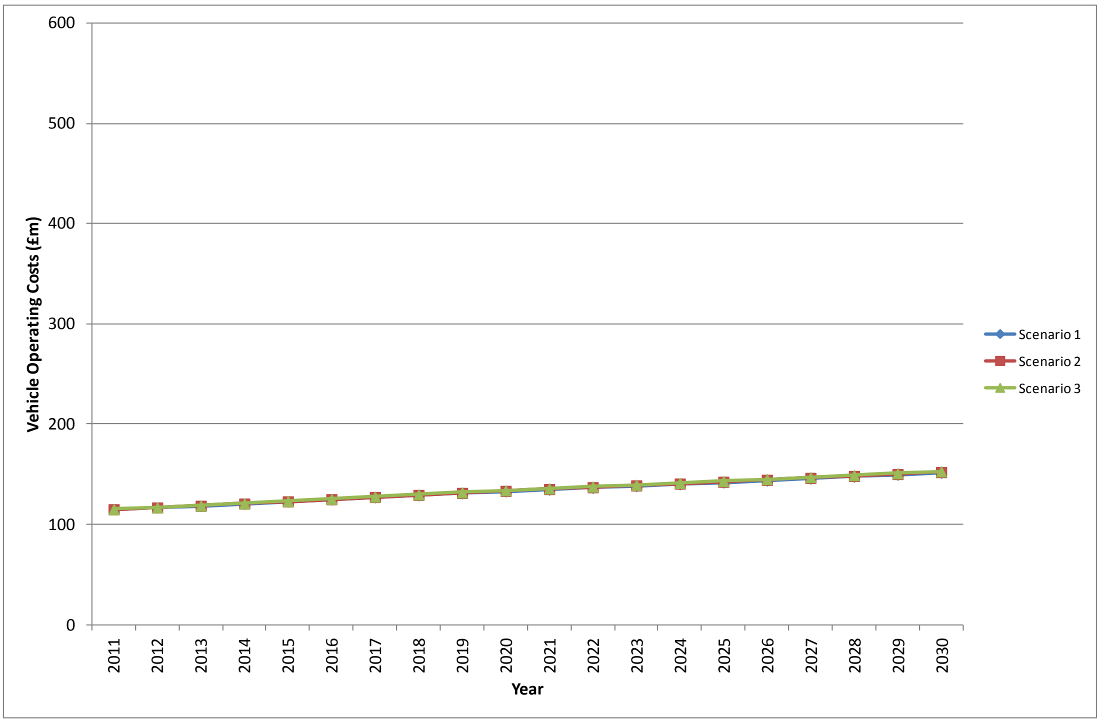


Figure F.14 South Ayrshire vehicle operating costs
(2002 prices undiscounted)

F.5 Effect of discounting

The effect of discounting the vehicle operating costs can be seen in Figure F.15 for Fife. The discounted values show the Net Present Value of the vehicle operating costs decreasing with time. This behaviour was common to all 8 sample Authorities.

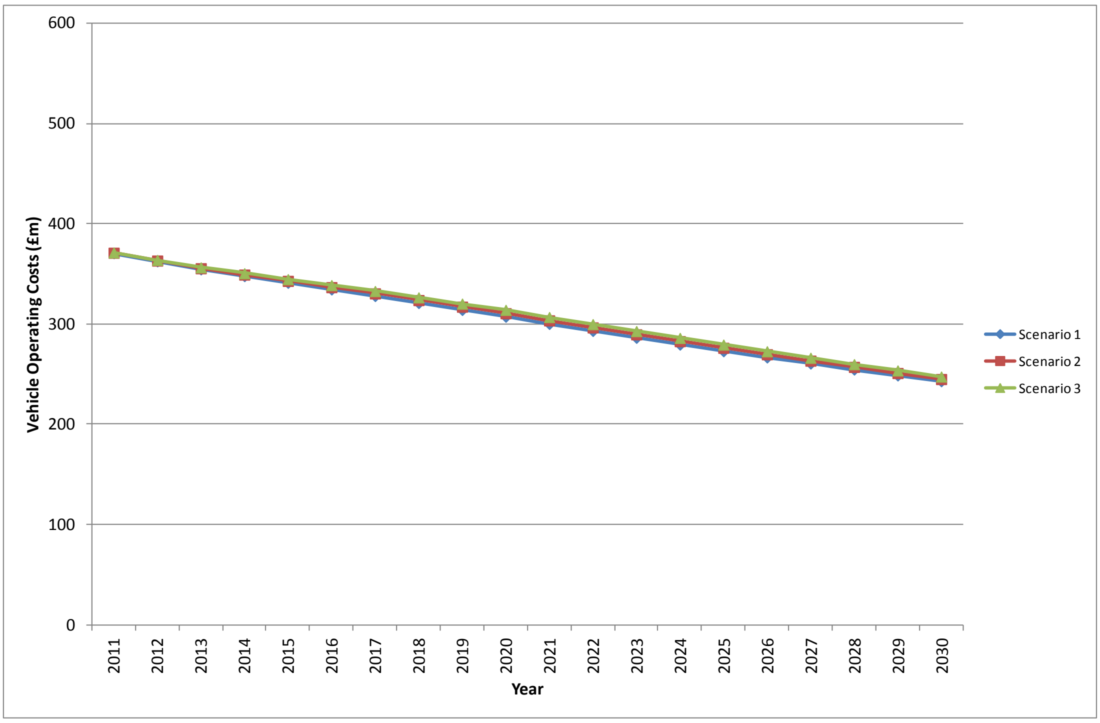


Figure F.15 Fife vehicle operating costs
(2002 prices discounted)

Appendix G Increase in Travel Time Costs

G.1 Methodology

This analysis is based on the observation that vehicles travel faster on pavements in good (recently maintained) condition. The analysis assumes therefore that as pavement surface condition deteriorates vehicle speeds reduce. The analysis is based on the findings by (Cooper, Jordan, & Young, 1980) who observed the increases in vehicle speeds shown in Table G.1 on a newly maintained trunk road compared with the observed speeds prior to maintenance.

Table G.1 Change in vehicle speed

Vehicle Type	Speed increase (km/h)	Base Speed (km/h)
Car	2	72
LGV	2.3	72
HGV	2.6	65
PSV	2	65

Since the conclusions in (Cooper, Jordan, & Young, 1980) are based on observations on trunk roads the travel time analysis for the Local Authority network was based on vehicles travelling over A class roads only.

The methodology for proportioning vehicles by carriageway surface condition detailed in Section F.1 was used, but instead of proportioning the network by IRI, 3mLPV was used ranging from 3mLPV 0.5 to 5 mm^2 in 0.5 mm^2 increments.

To calculate the change in speed it is assumed that vehicles travelling over lengths of the network with a 3mLPV of 0.5 mm^2 travel at the base speed shown in Table G.1. Vehicles travelling on lengths with and IRI of 5 or greater have a reduced vehicle speed as per the Speed Change values shown in Table G.1 and the change in speed is assumed to vary linearly between these two condition extremes.

Using this methodology the total increase in travel time for each vehicle type was calculated for each of the sample Authorities, in each model year and under each of the 3 budget scenarios. The increase in travel time was then monetised using the appropriate values for the value of time taken from TAG unit 3.5.6 (Department for Transport, 2011b). Since the condition of the network in 2011 is not in perfect condtion (all roads having a 3mLPV of 0.5mm^2 or less) there is an initial starting value for the increase in travel time in 2011.

The Travel time costs for each of the modelled years under the 20% and 40% budget cut scenarios were then linearly interpolated and extrapolated to represent a 35% and 69% budget cut to account for the fact that the WDM model runs were carried out using a 20% and 40% budget cut, but the subjective budget analysis identified that these would be equivalent to a 35% and 69% budget cut in carriageway maintenance respectively.

To calculate the travel time costs for the intermediate years, between the modelled years, the results of the analysis were linearly interpolated.

G.2 Results

The results of the journey time analysis are shown in Figure G.1 to Figure G.8. Fife and Edinburgh demonstrate a larger difference in travel time costs for the different scenarios compared to the other sample Authorities. The data for Edinburgh and Fife also show changes in the gradient of the Scenario 3 line at 2020 and 2025, commensurate with the increase in budget over these periods and the corresponding improvement in carriageway deterioration.

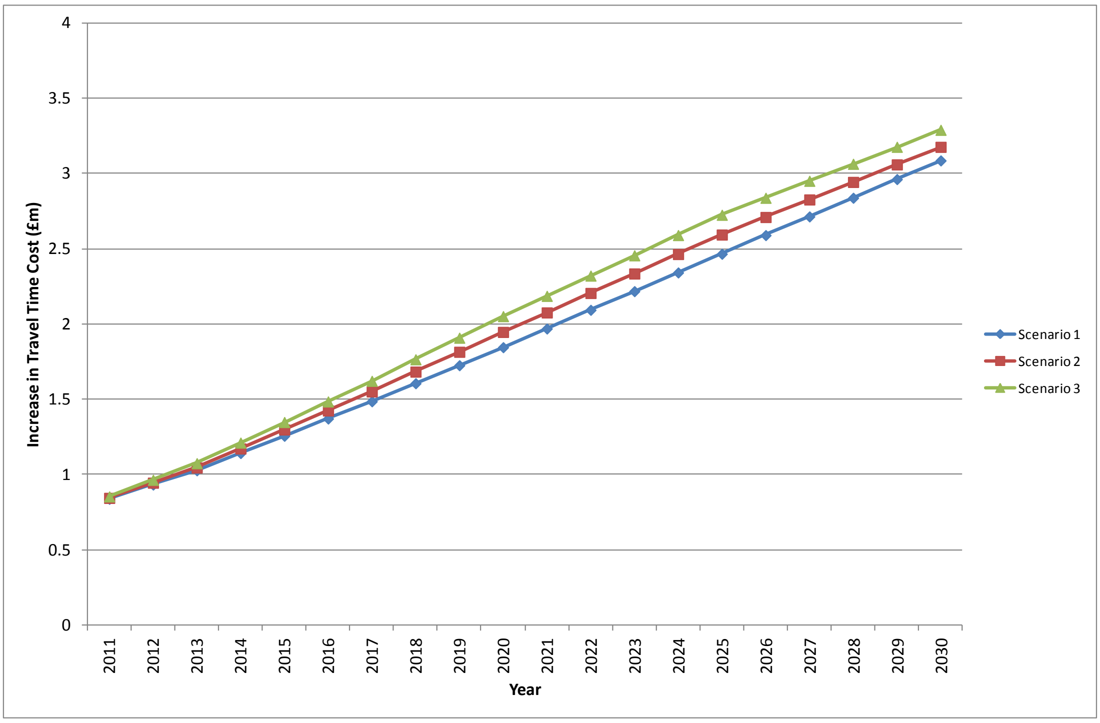


Figure G.1 Aberdeenshire increase in travel time costs

(2002 prices undiscounted)

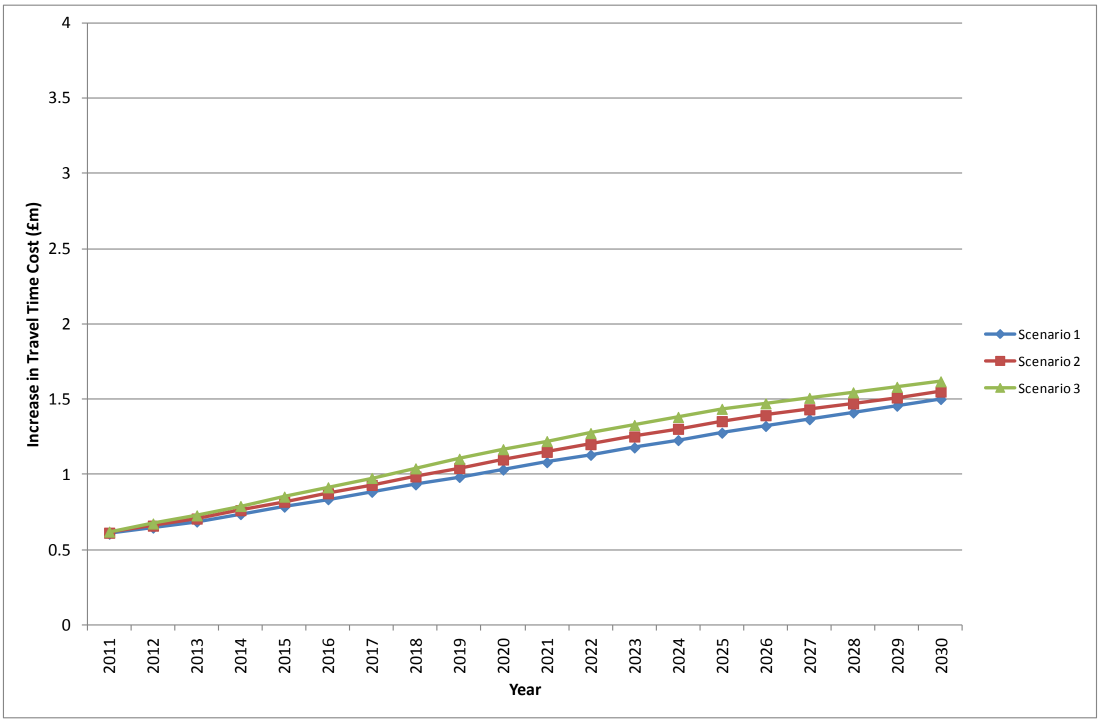


Figure G.2 Dumfries and Galloway increase in travel time costs
(2002 prices undiscounted)

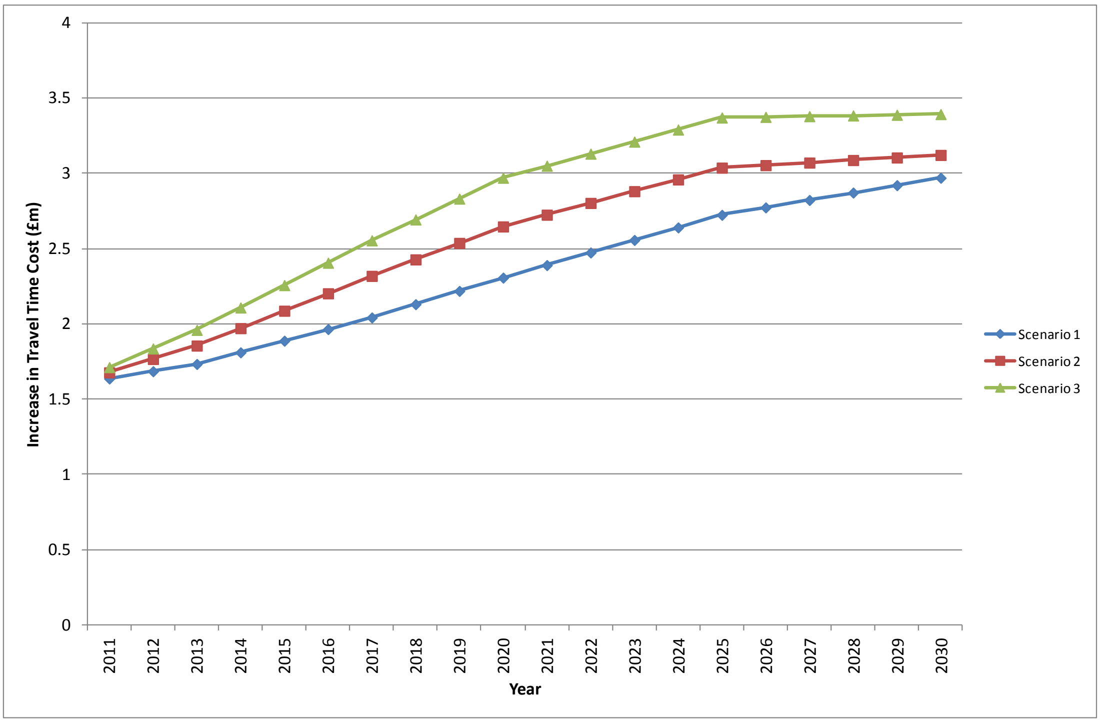


Figure G.3 City of Edinburgh increase in travel time costs
(2002 prices undiscounted)

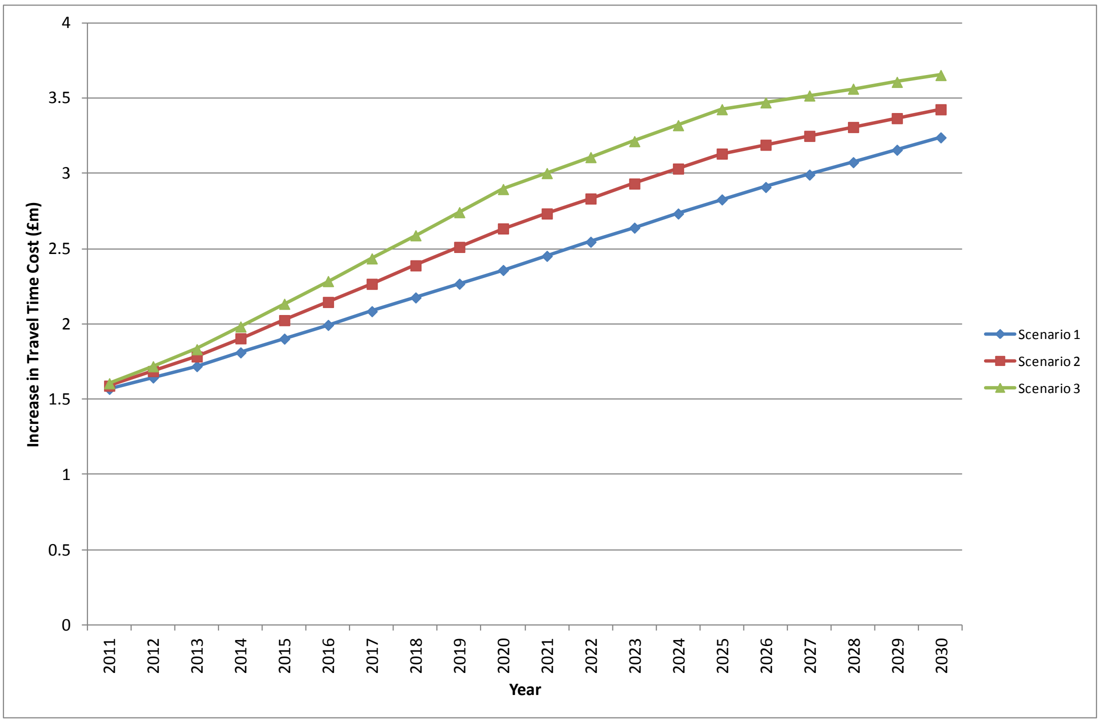


Figure G.4 Fife increase in travel time costs

(2002 prices undiscounted)

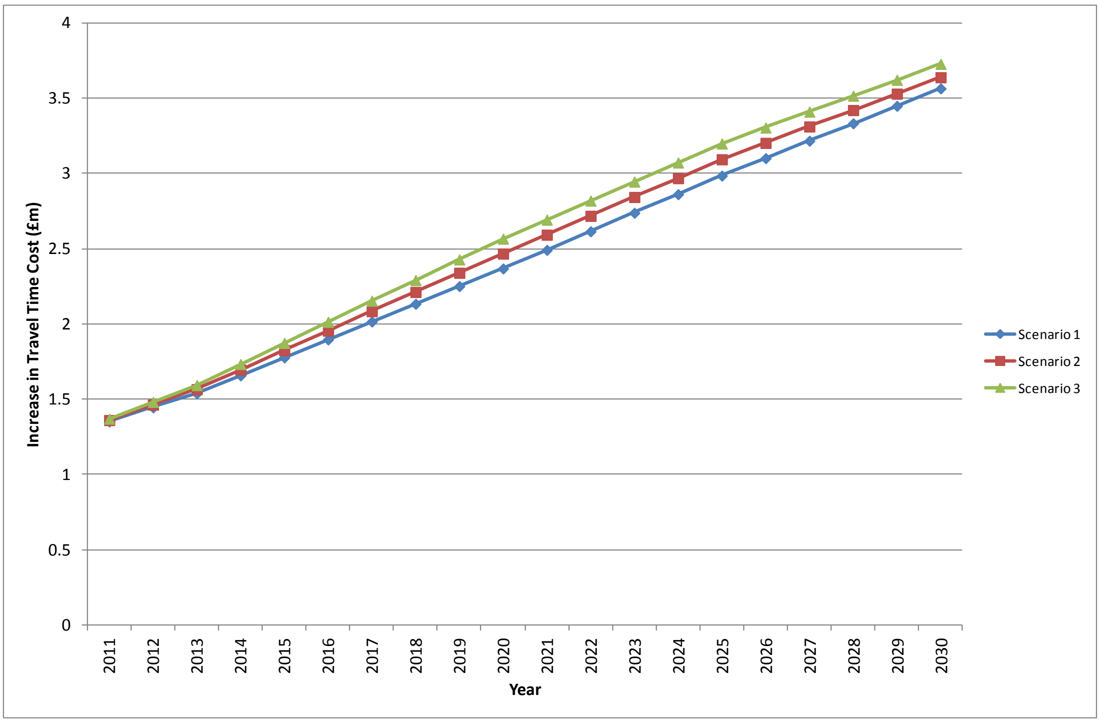


Figure G.5 Glasgow City increase in travel time costs

(2002 prices undiscounted)

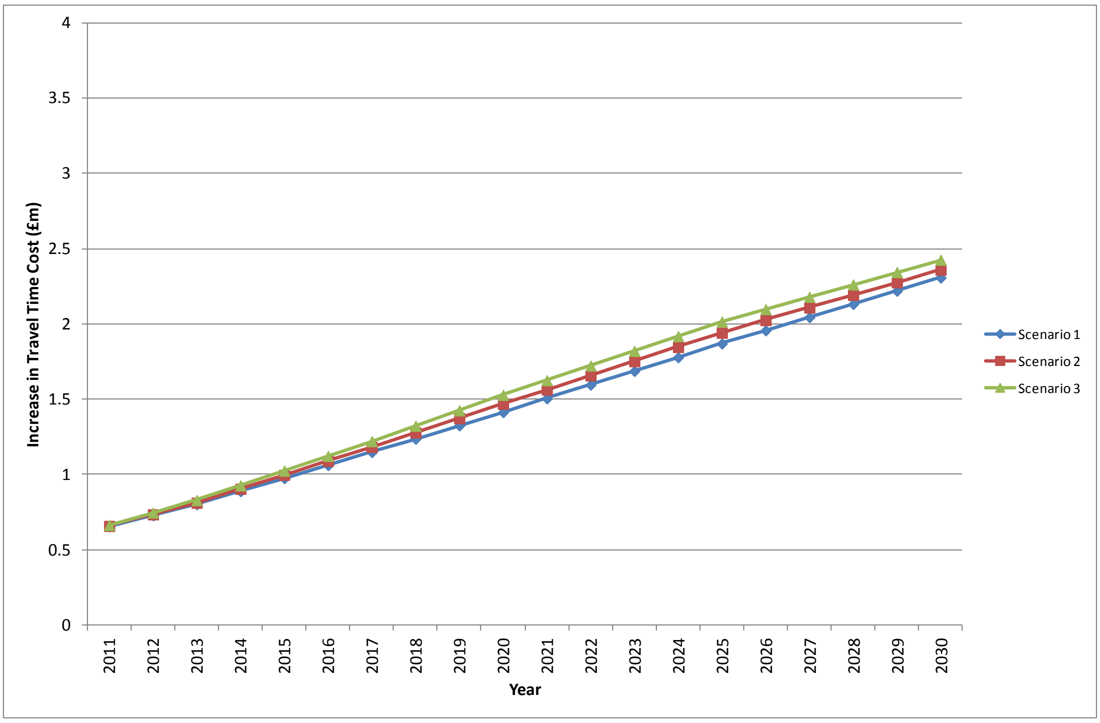


Figure G.6 Highland increase in travel time costs

(2002 prices undiscounted)

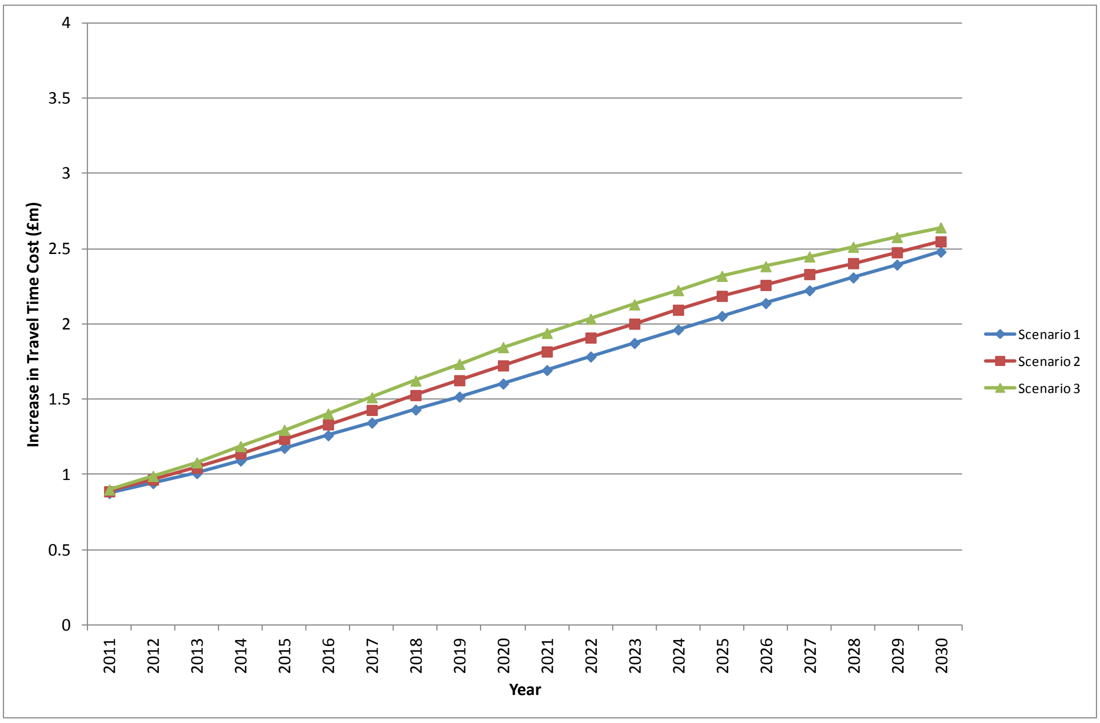


Figure G.7 North Lanarkshire increase in travel time costs

(2002 prices undiscounted)

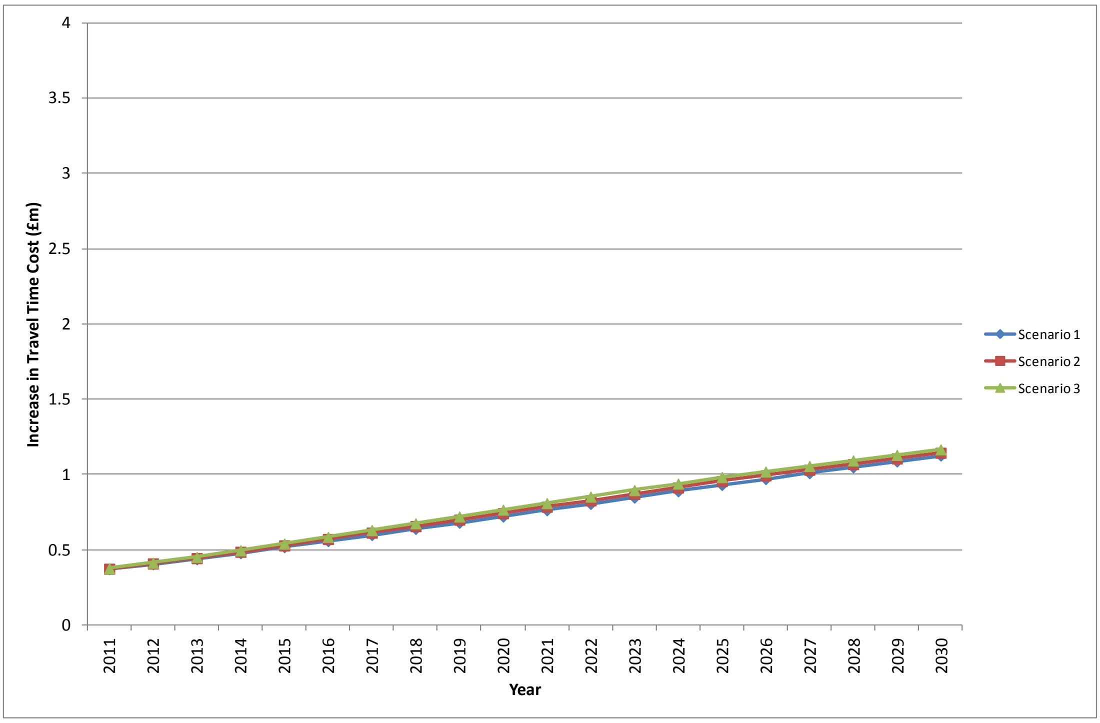


Figure G.8 South Ayrshire increase in travel time costs
(2002 prices undiscounted)

G.3 Effect of discounting

The Travel Time Costs were discounted by 3.5% per year the effect of this discounting can be seen in Figure G.9 for Fife. The discounted values show the Net Present Value of the VOCs decreasing with time. This behaviour was common to all 8 sample Authorities.

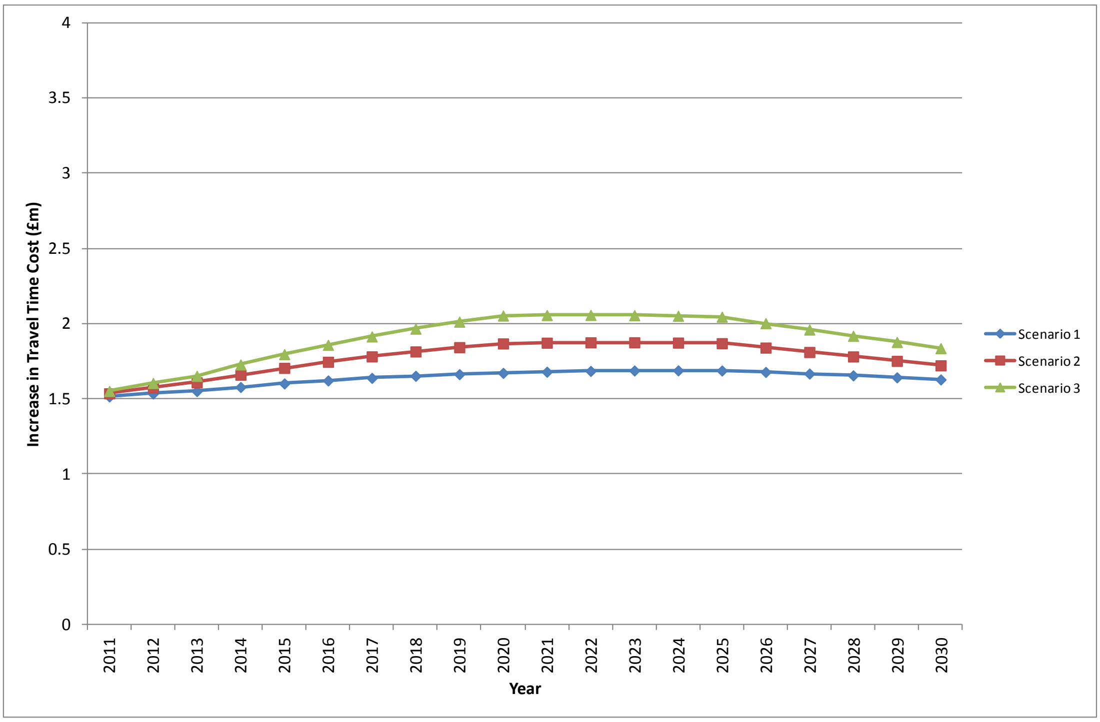


Figure G.9 Fife increase in travel time costs
(2002 prices discounted)

Appendix H Analysis of Roadworks and Delay Costs

H.1 Methodology

The user delay costs at roadworks were calculated using the treatment length data provided by the WDM model runs and outputs from the DfT Queues and Delays at Roadworks (QUADRO) user delay cost model (Highways Agency, 2009b).

Treatment length data from WDM was by road type, road environment, treatment type and time period. The lengths provided were aggregated over 5 time intervals:

- 2010 to 2012 (3 years)
- 2013 to 2016 (4 years)
- 2017 to 2019 (3 years)
- 2020 to 2024 (5 years)
- 2025 to 2029 (5 years)

To determine the treatment length data within each year the treatment lengths and areas were divided by the number of years in the corresponding time interval. The resulting annual treatment lengths and areas were then used in the subsequent analysis. The proportioning of the treatment lengths and areas evenly across the time intervals in this manner meant that the treatment lengths between 2020 to 2024 and 2025 to 2029 were not commensurate with the linearly increasing budgets for scenarios 2 and 3 during these time intervals. The effect of this can be seen by the sudden changes in delay costs results for 2020 and 2025.

From the treatment lengths a number of notional schemes were calculated for each year in the analysis period, assuming a 250m scheme length for single carriageway and a 1000m scheme length for dual carriageways.

Using the traffic data for each of the Local Authorities by road type and the network length of each road type a traffic flow was calculated for each type of road in each Authority. The proportion of HGVs in the traffic flow was also calculated. Using these flows and the notional closure lengths of 250m and 1000m a series of QUADRO runs were carried out to calculate the user delays of a single scheme for each Local Authority, road type, carriageway type, road environment, and year of the analysis period (taking into account the growth in traffic). The resulting delay costs were then multiplied by the number of schemes calculated from the treatment length data to obtain an overall delay cost for each year of the analysis period for each sample Authority.

The user delay costs for each of the modelled years under the 20% and 40% budget cut scenarios were then linearly interpolated and extrapolated to represent a 35% and 69% budget cut to account for the fact that the WDM model runs were carried out using a 20% and 40% budget cut, but the subjective budget analysis identified that these would be equivalent to a 35% and 69% budget cut in carriageway maintenance respectively.

H.2 Results

The results of the analysis are shown in Figure H.1 to Figure H.8. The analysis shows that Edinburgh will experience the largest delay costs of all the sample Authorities, which is rational since delay costs are sensitive to traffic and Edinburgh has high traffic flows. Surprisingly this behaviour is not observed in the Glasgow results. Further analysis shows that Glasgow and Edinburgh have similar network condition, with Glasgow having a longer network length compared to Edinburgh. The difference is that Glasgow has a significantly smaller budget compared to Edinburgh and consequently less carriageway maintenance schemes. This demonstrates that the analysis is highly sensitive to the amount of maintenance and by association the maintenance budgets set.

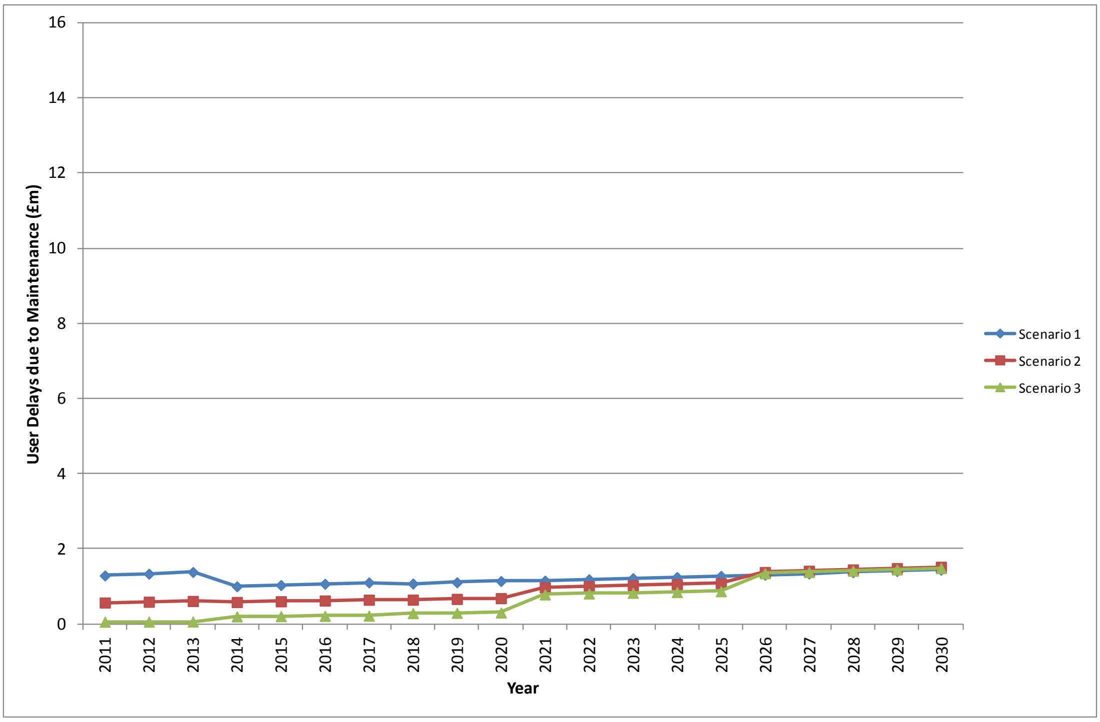


Figure H.1 Aberdeenshire delay costs at roadworks

(2002 prices undiscounted)

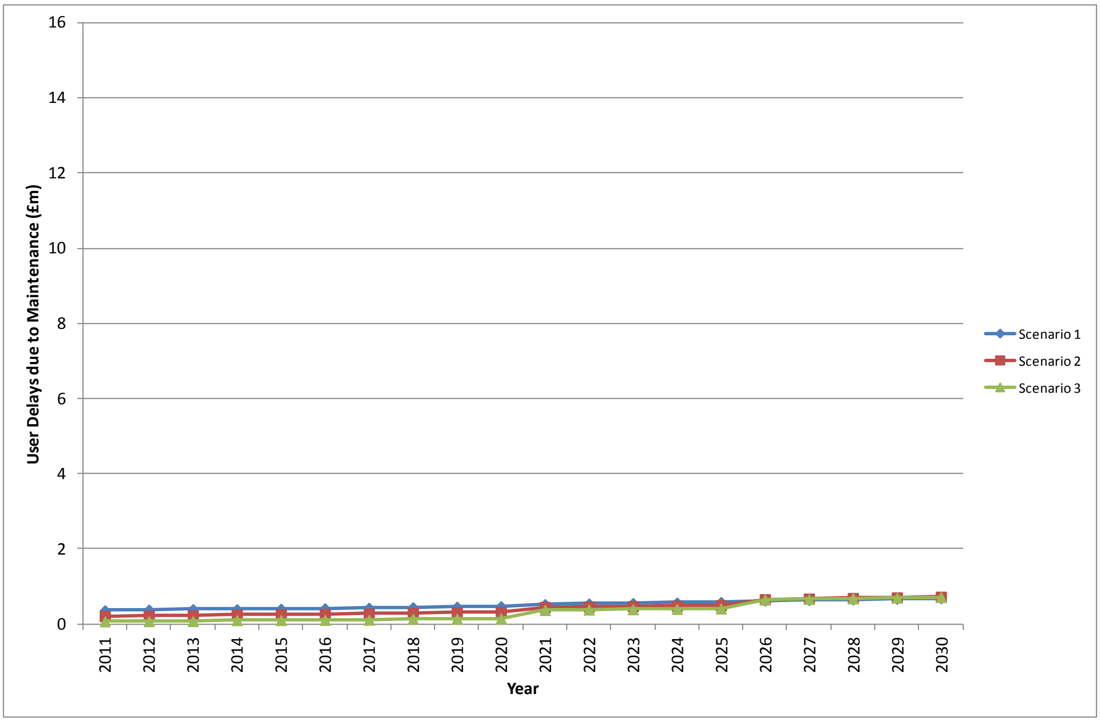


Figure H.2 Dumfries and Galloway delay costs at roadworks

(2002 prices undiscounted)

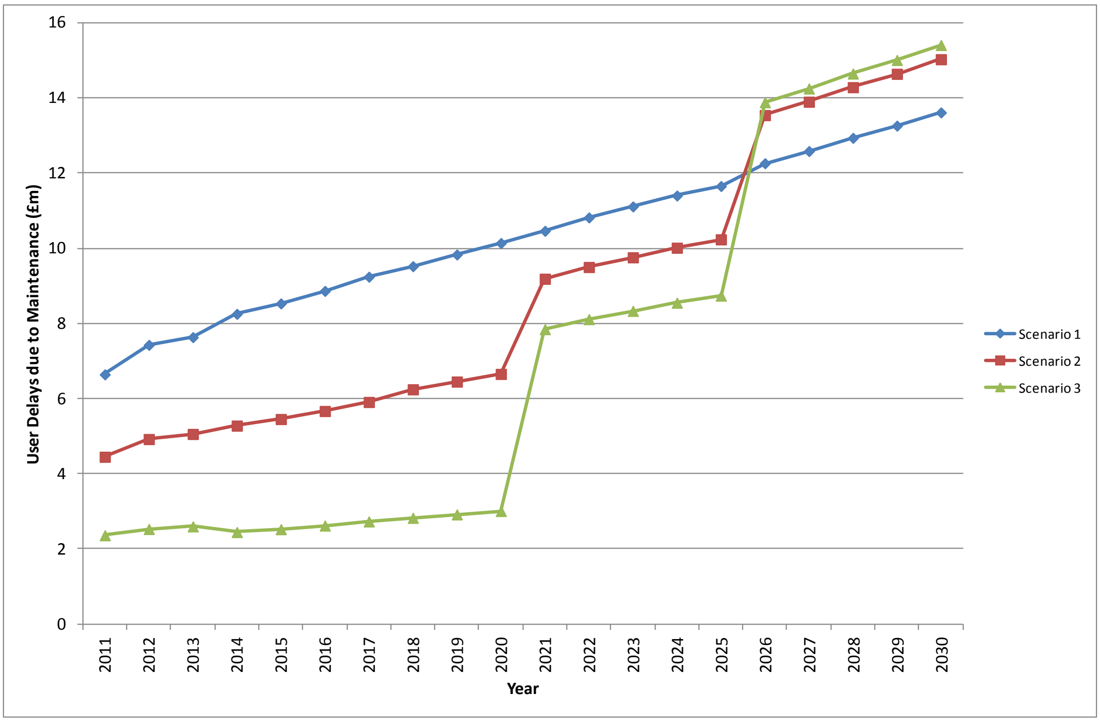


Figure H.3 City of Edinburgh delay costs at roadworks

(2002 prices undiscounted)

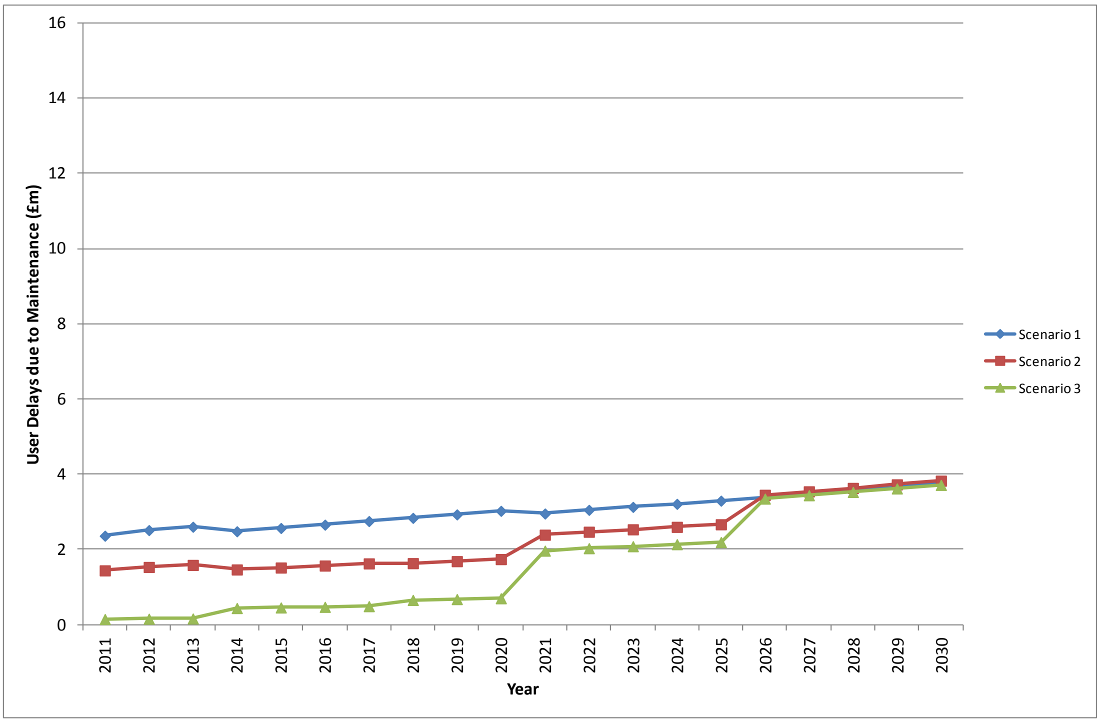


Figure H.4 Fife delay costs at roadworks

(2002 prices undiscounted)

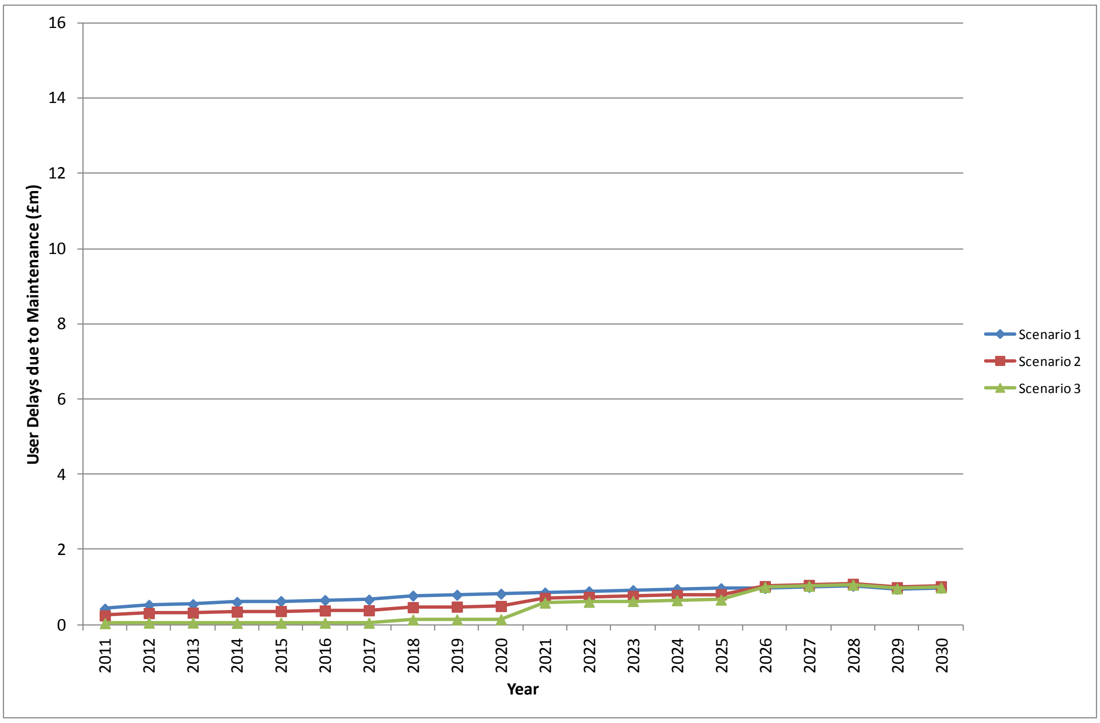


Figure H.5 Glasgow City delay costs at roadworks
(2002 prices undiscounted)

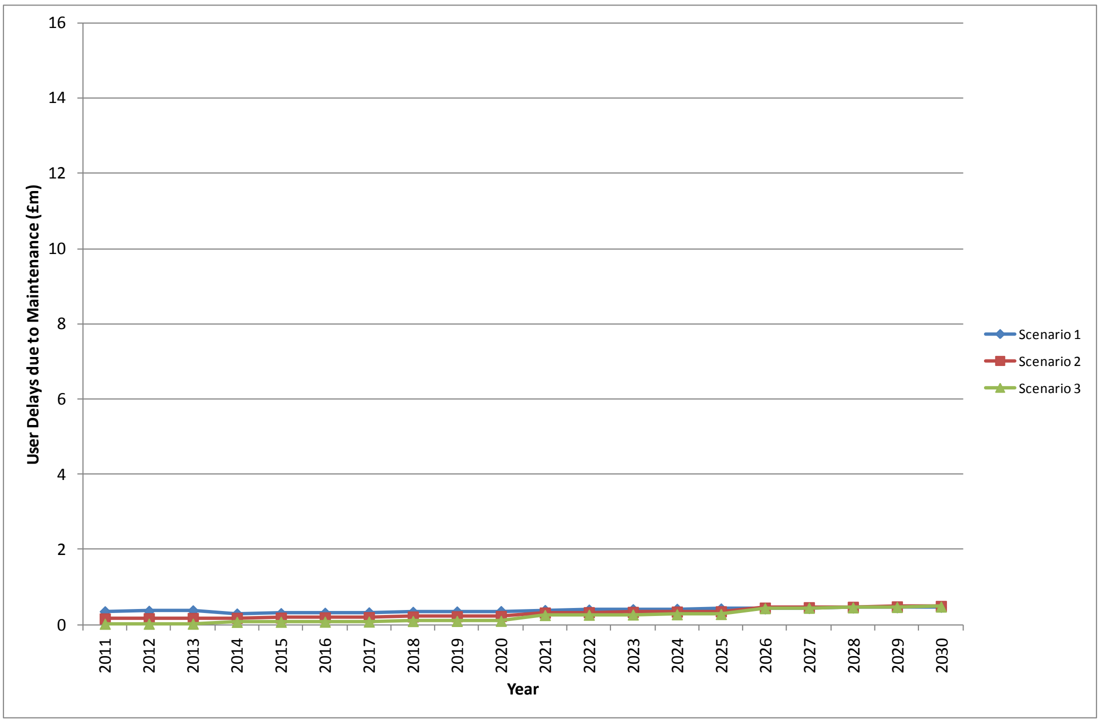


Figure H.6 Highland delay costs at roadworks
(2002 prices undiscounted)

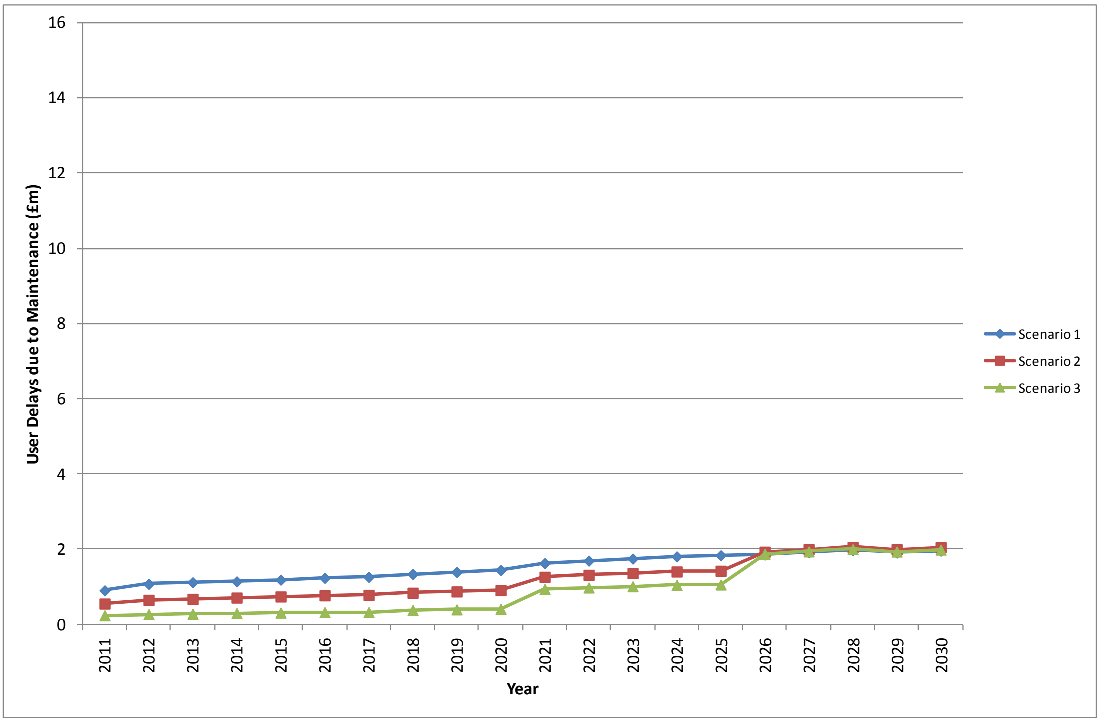


Figure H.7 North Lanarkshire delay costs at roadworks

(2002 prices undiscounted)

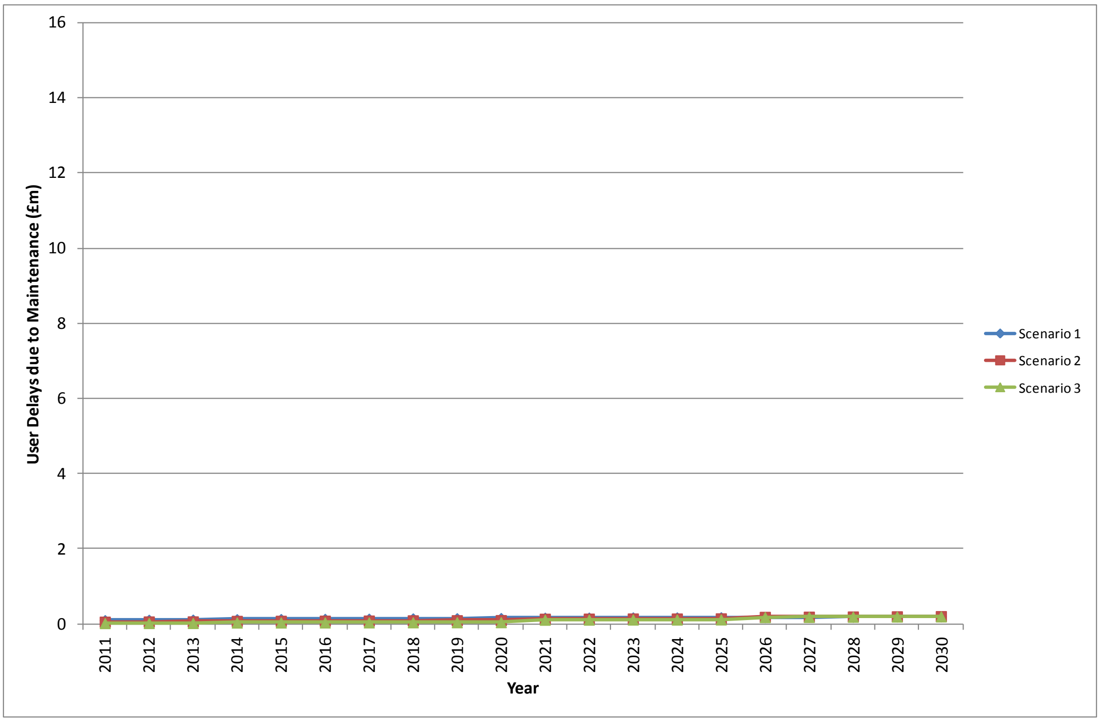


Figure H.8 South Ayrshire delay costs at roadworks

(2002 prices undiscounted)

H.3 Effect of discounting

The User Delay Costs were discounted by 3.5% per year. The effect of this discounting can be seen in Figure H.9 for Fife.

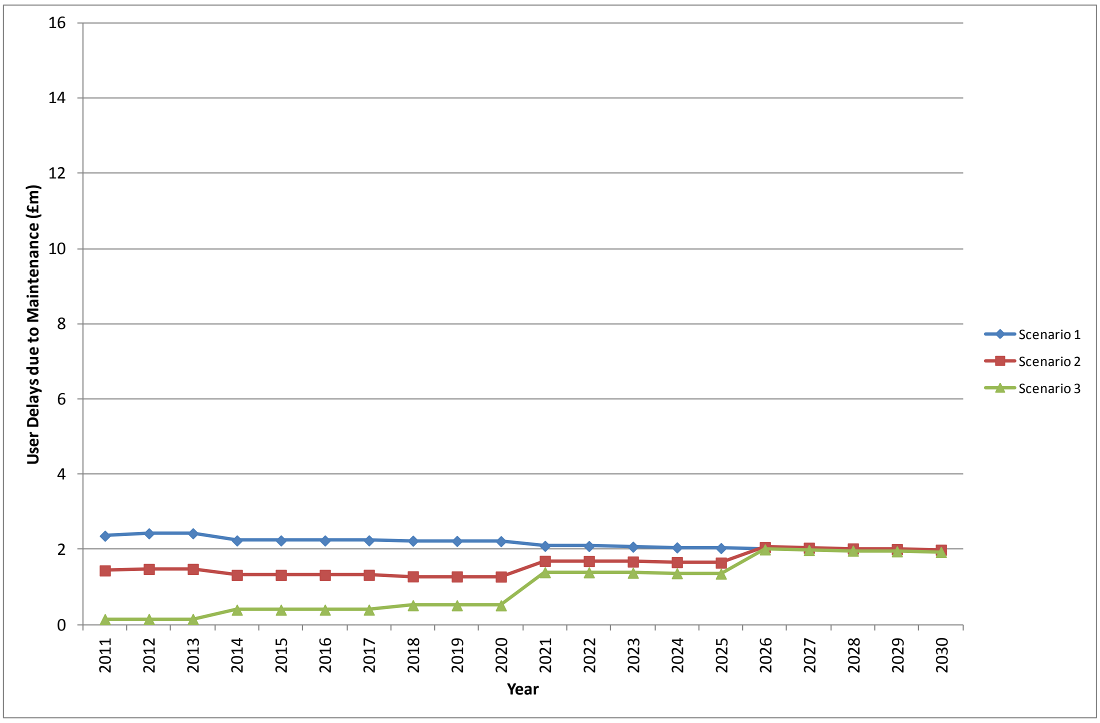


Figure H.9 Fife delay costs at roadworks
(2002 prices discounted)

Appendix I Analysis of Emissions and Air Quality

I.1 Methodology

The emissions analysis includes 3 separate components as follows:

- The carbon costs of emissions from vehicles travelling over the road network under normal running conditions, where changes in the carriageway roughness have an impact on vehicle emissions: modelled using the HDM-4 emissions model.
- The carbon costs of emissions from vehicles delayed through roadwork sites either due to a reduction in speed or due to idling at traffic lights: modelled using the emissions model in the DfT Queues and Delays at Roadworks (QUADRO) model.
- The costs of embodied CO_2e (carbon dioxide equivalents) in carriageway maintenance materials and the activities carried out during carriageway maintenance (e.g. fuel consumed by plant): modelled using the treatment extent information and default values of CO_2e from the asPECT tool (Wayman, Schiavi-mellor, & Cordell, 2011).

I.1.1 Methodology for the calculation of carbon emissions vehicles under normal running conditions

The methodology adopted was identical to the methodology described in Appendix F for the calculation of VOCs with the following differences:

- Instead of the VOC outputs from HDM-4 the emissions outputs were used, specifically the kg of $C0_2$ figures reported for each of the model runs.
- The projected increase in fuel efficiency for each vehicle type was used with the mass of CO_2 from the HDM-4 runs to determine the time variation in emissions for each vehicle type.
- The increase in the cost of carbon was included in the analysis using the central non-traded carbon costs from webTAG. Note that the mass of CO_2 was converted to a mass of Carbon using the ratio of the atomic mass of carbon and $C0_2$ (12/44).

I.1.2 Methodology for the calculation of carbon costs from vehicles delayed through roadworks.

The methodology adopted was identical to the methodology used to calculate the user delay costs due to roadworks described in Appendix H but the CO_2 cost outputs from the QUADRO model were used in place of the delay cost outputs.

I.1.3 Methodology for the calculation of carbon costs from embodied carbon in road maintenance materials and works activities

Using the treatment lengths and areas from the WDM model runs the area of treatment for each road type over each interval was divided using the same methodology as described in Section H.1. This provided a treatment area for each treatment type in each of the analysis years for each Scenario and sample Authority. To determine the volume of materials, asphalt thicknesses were assumed for the 3 different treatment types as shown in Table I.1

Table I.1 Treatment thicknesses for each treatment type

Treatment	Assumed Depth (mm)
Reconstruction	200
Strengthening	40
Resurfacing	15

Using default carbon footprint data from the asPECT carbon footprinting tool and the density of asphalt the corresponding mass and embodied carbon dioxide equivalents were calculated for each sample Authority and analysis year under the 3 scenarios. The data used for this calculation is shown in Table I.2.

Table I.2 Density and embodied CO_2 data for maintenance treatments

Treatment	Embodied CO_2e by volume of asphalt ($kgCO_2e/m^3$)
Reconstruction	104
Strengthening	104
Resurfacing	104

Finally the equivalent mass of carbon was calculated using the ratio of the atomic mass between carbon and CO_2 (12/44) and the resulting mass of carbon was costed using the central non-traded price of carbon from webTAG (Department for Transport, 2011a).

I.1.4 Methodology for calculating other pollutants.

Using the calculated carbon costs a mass of CO_2 was back calculated using the central non-traded cost of carbon from webTAG and the ratio of the atomic mass of carbon dioxide to carbon (44/12). From this it was possible to calculate the mass of the other combustion products using proportions derived from the Emission Factors Toolkit for Vehicle Emissions, version 4.2.2 (DEFRA, 2009).

I.2 Results

I.2.1 Carbon costs from vehicles using the network under normal running conditions

Figure I.1 to Figure I.8 show the carbon emissions from vehicles using the network under normal running conditions for the 8 sample Authorities. Whilst the magnitude of these numbers is much larger than the emissions due to roadworks the difference between Scenarios 2 and 3 and the base scenario (Scenario 1) is relatively small at approximately £4m at the point of greatest difference (Scenario 3 compared with Scenario 1 in 2030). The general upwards trend of the graphs is due to increasing traffic with time.

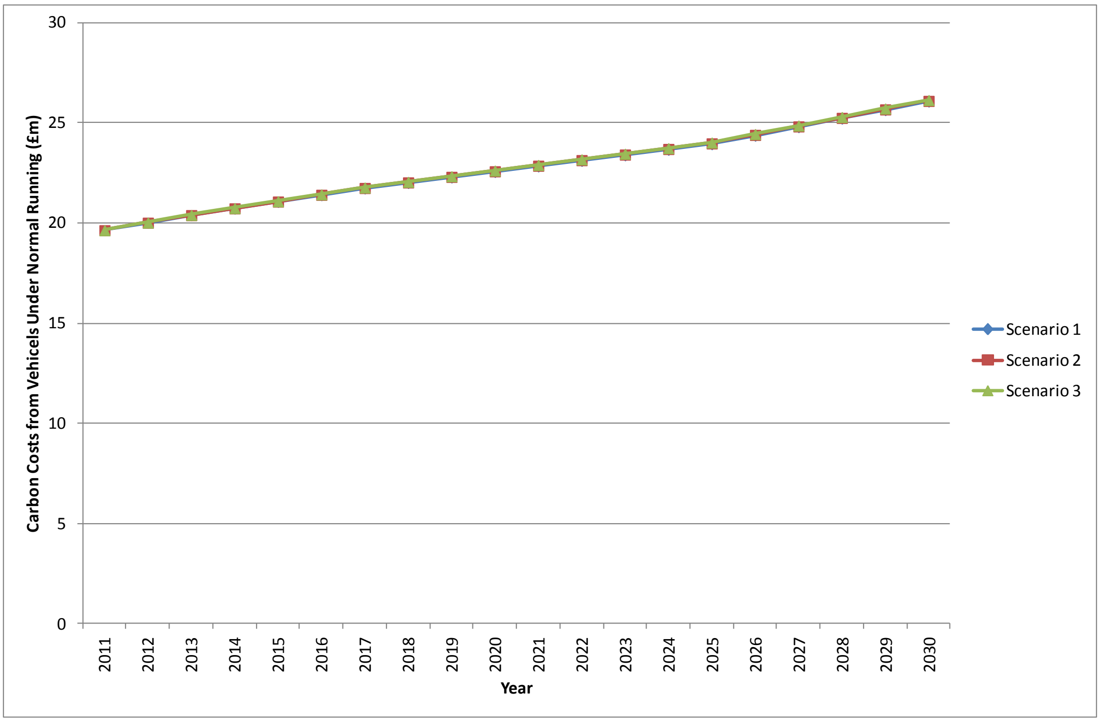


Figure I.1 Aberdeenshire carbon costs for vehicle normal running
(2002 prices undiscounted)

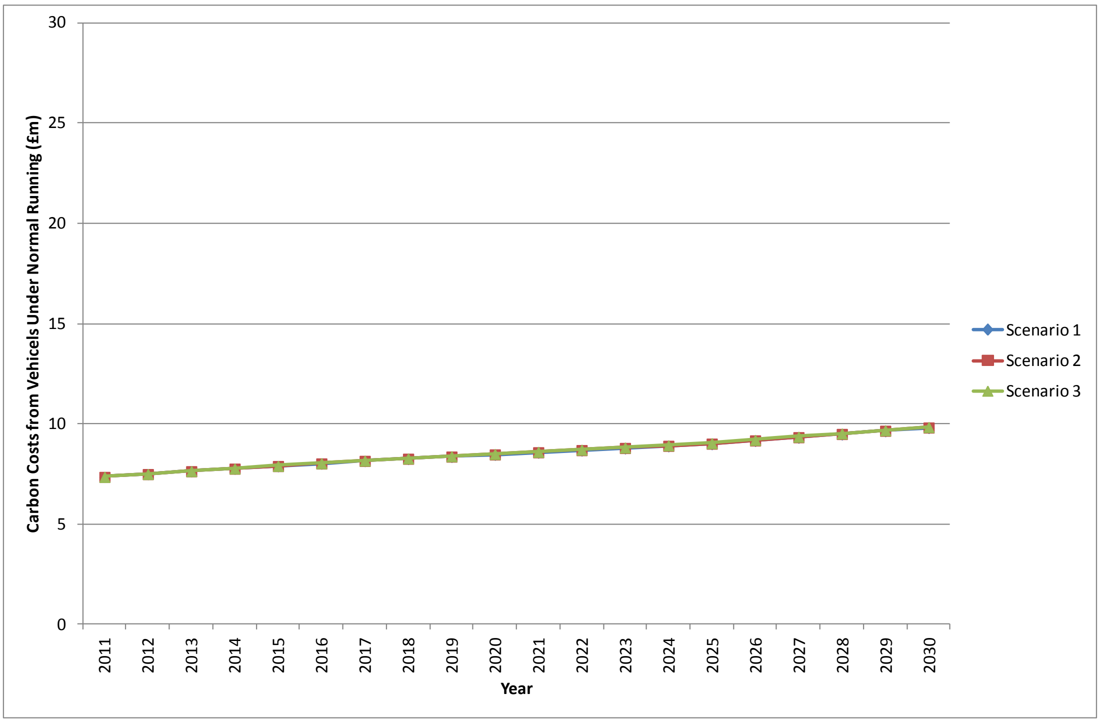


Figure I.2 Dumfries and Galloway carbon costs for vehicle normal running
(2002 prices undiscounted)

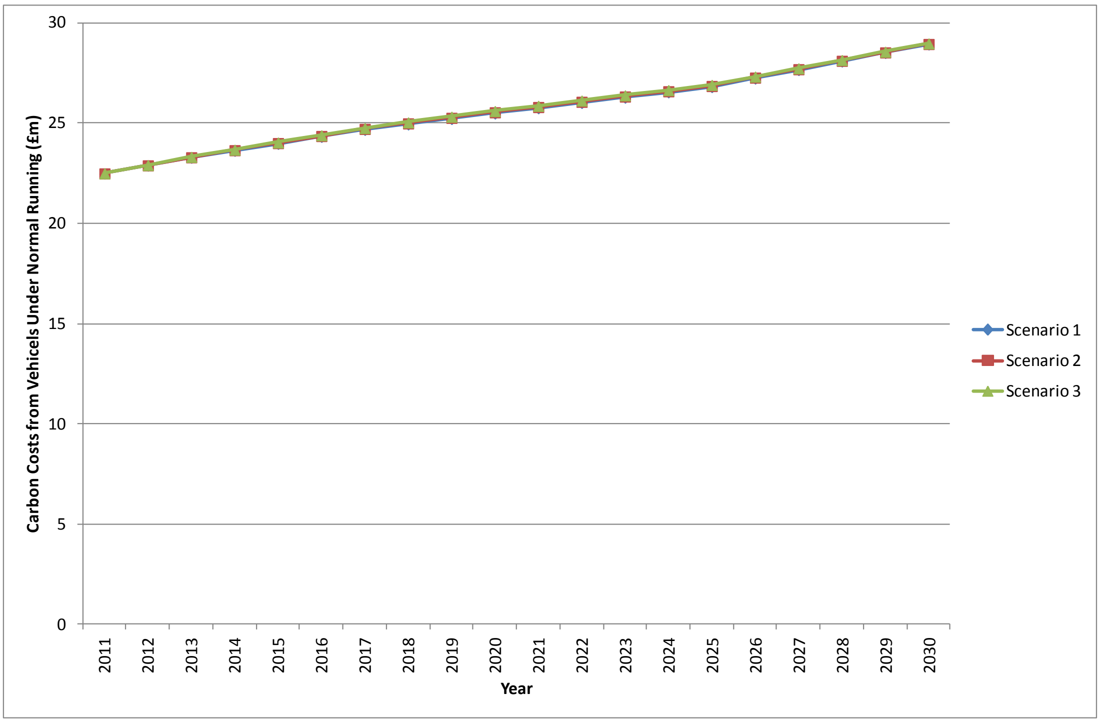


Figure I.3 City of Edinburgh carbon costs for vehicle normal running
(2002 prices undiscounted)

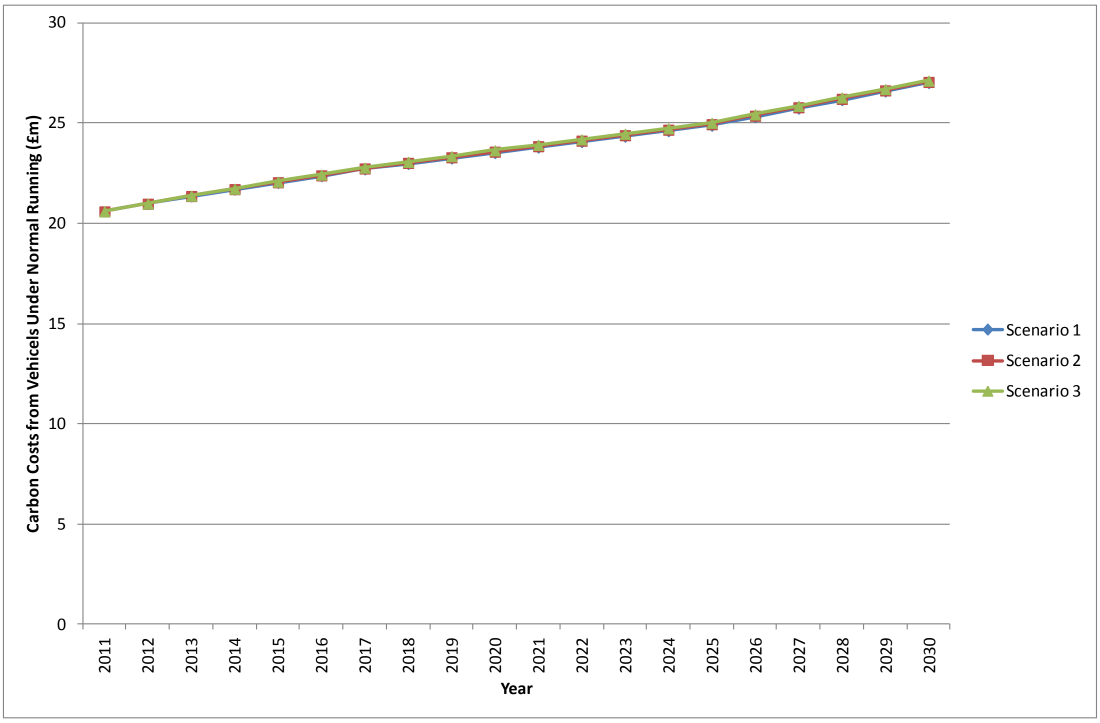


Figure I.4 Fife carbon costs for vehicle normal running
(2002 prices undiscounted)

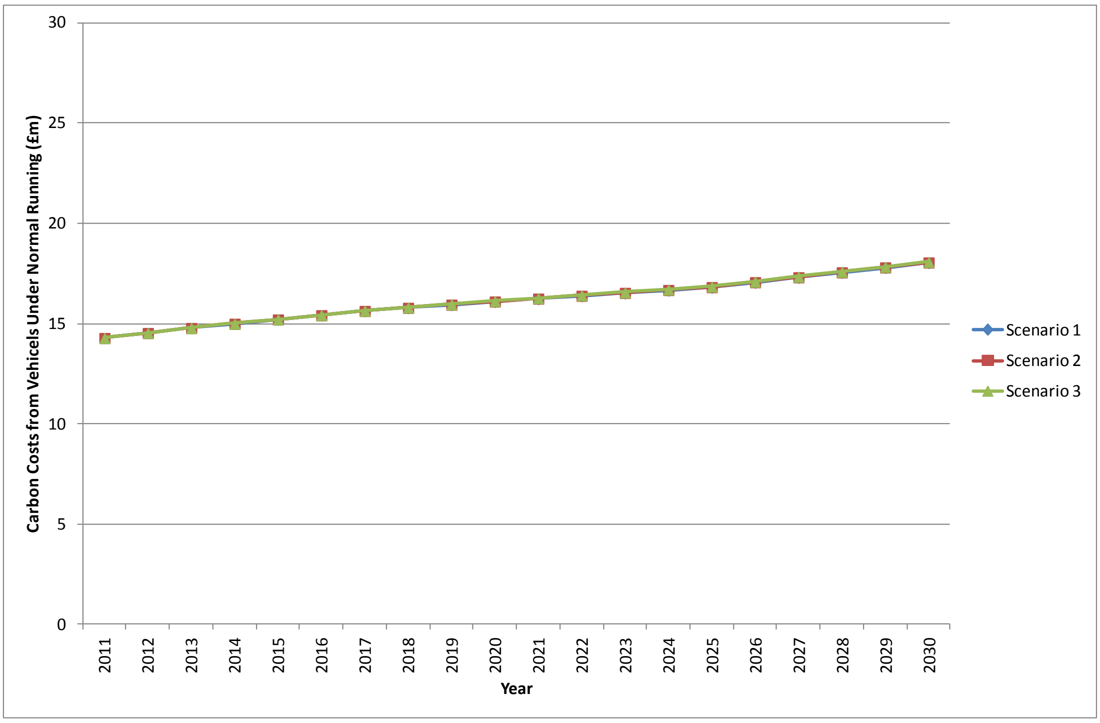


Figure I.5 Glasgow City carbon costs for vehicle normal running
(2002 prices undiscounted)

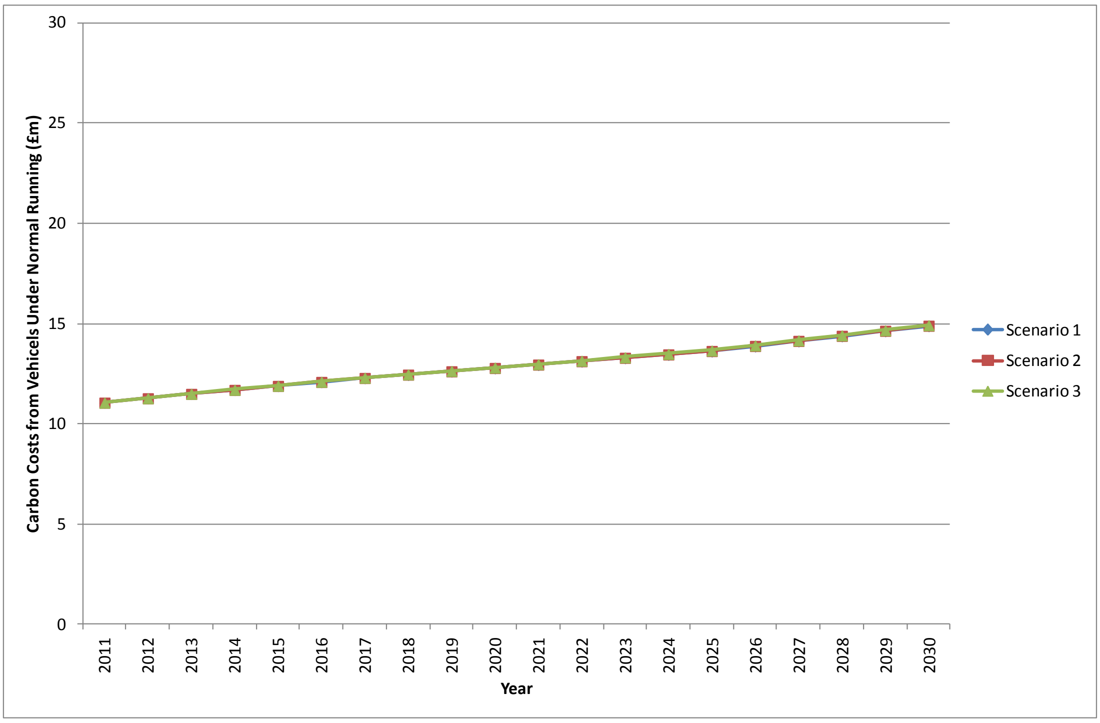


Figure I.6 Highland carbon costs for vehicle normal running
(2002 prices undiscounted)

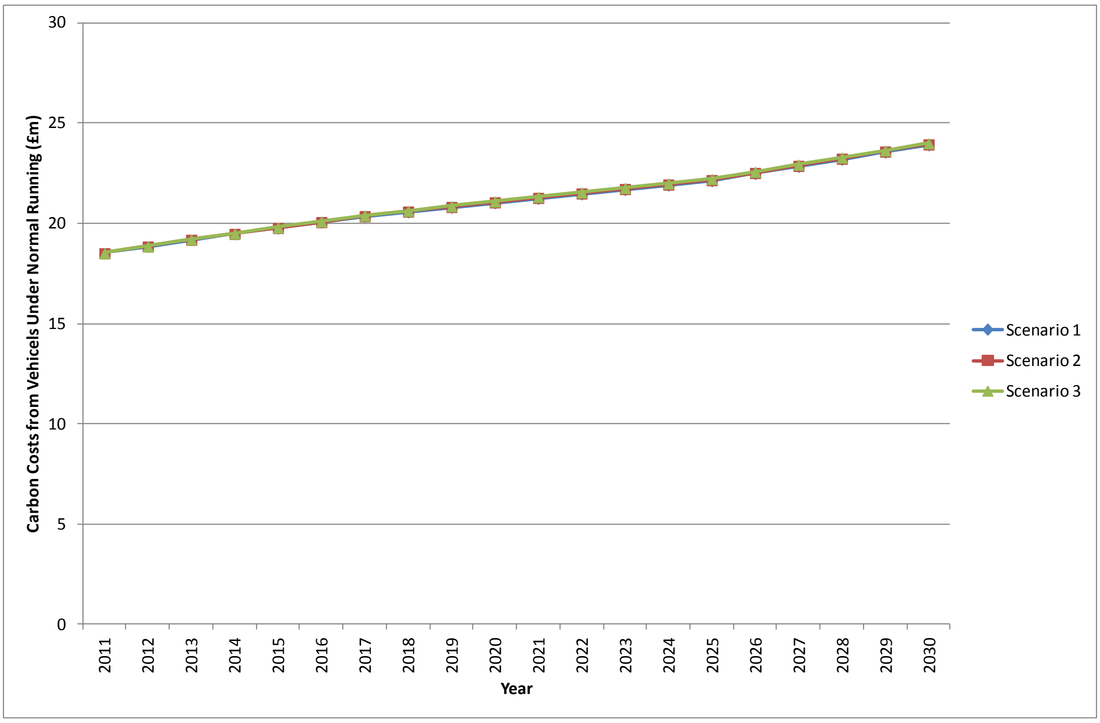


Figure I.7 North Lanarkshire carbon costs for vehicle normal running
(2002 prices undiscounted)

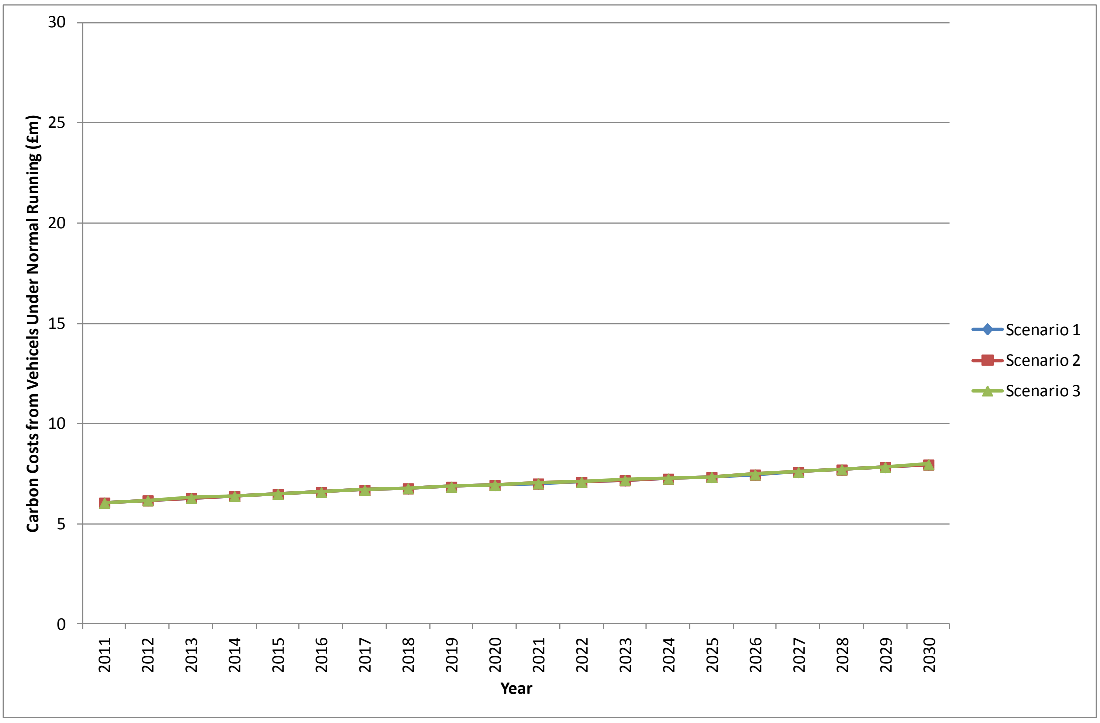


Figure I.8 South Ayrshire carbon costs for vehicle normal running
(2002 prices undiscounted)

I.2.2 Carbon costs from delayed vehicles through roadworks

The increase in carbon emissions, and costs, from vehicles delayed through roadwork sites is shown for the 8 sample Authorities in Figure I.9 to Figure I.16. These results show that with decreasing maintenance spend there is correspondingly less maintenance works on the network and consequently a reduction in vehicle delays. This analysis does not include consideration of delays caused by unplanned maintenance, which may increase as planned maintenance activities are reduced.

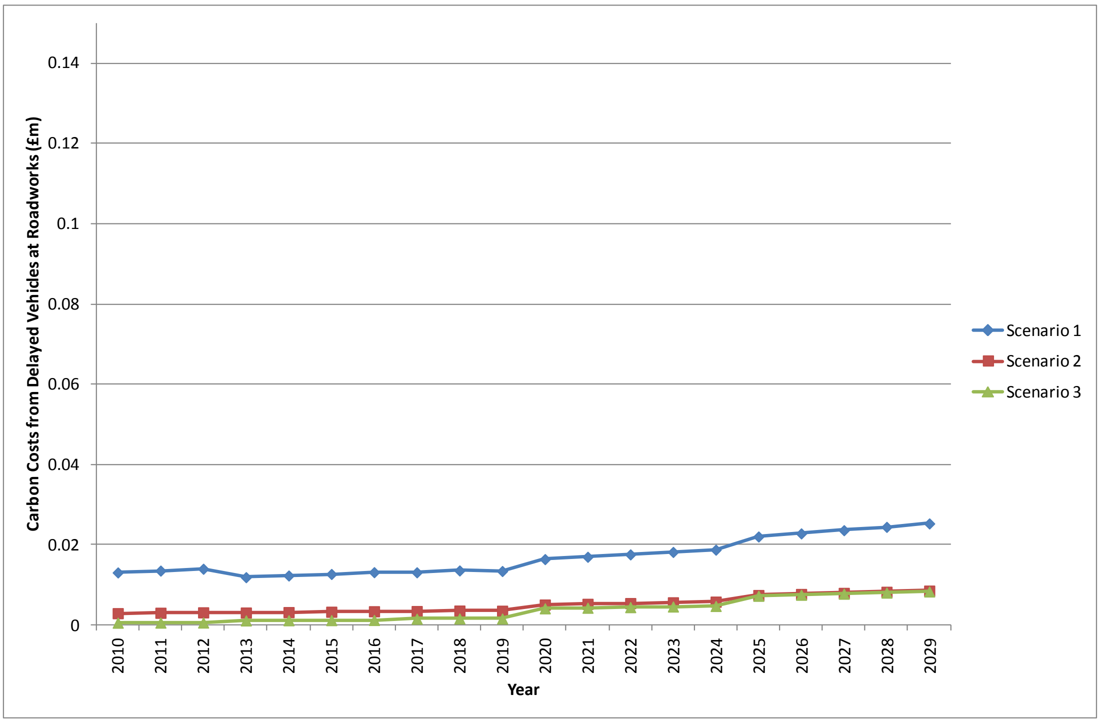


Figure I.9 Aberdeenshire carbon costs from vehicles delayed at roadworks

(2002 prices undiscounted)

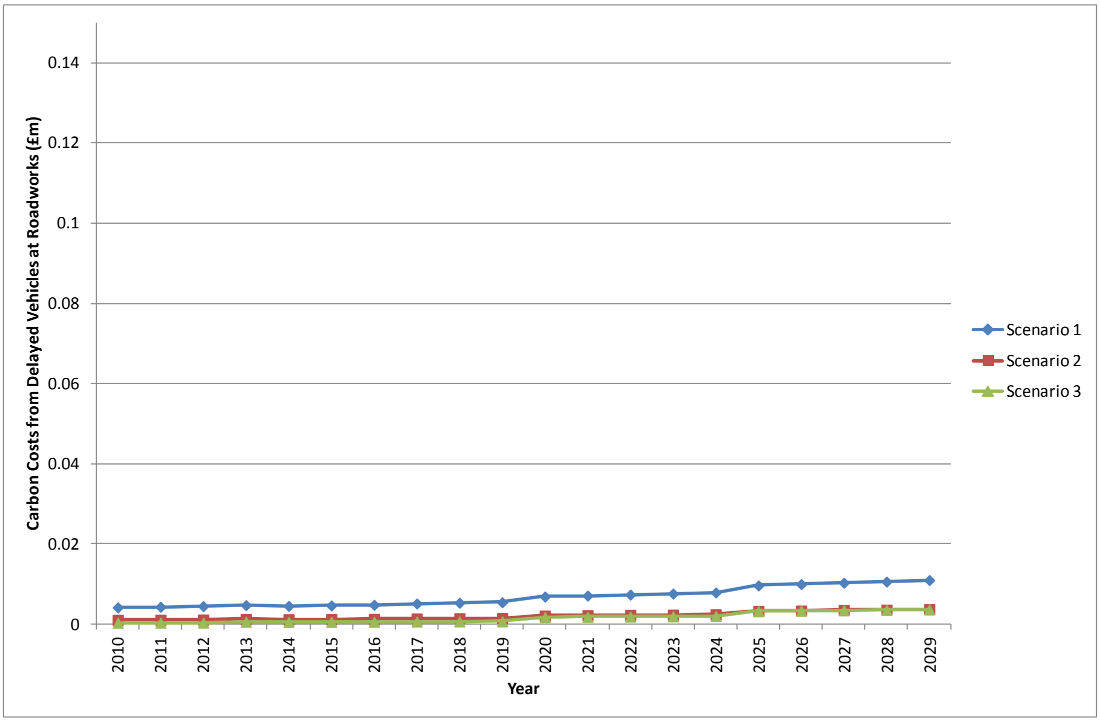


Figure I.10 Dumfries and Galloway carbon costs from vehicles delayed at roadworks

(2002 prices undiscounted)

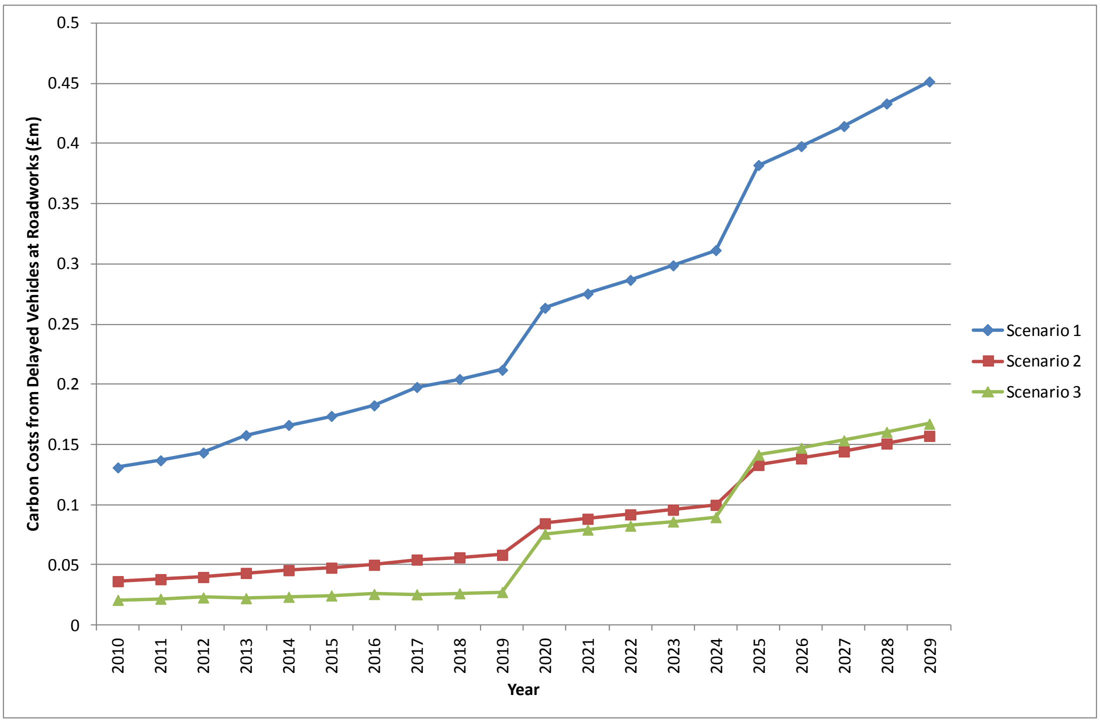


Figure I.11 City of Edinburgh carbon costs from vehicles delayed at roadworks

(2002 prices undiscounted – Note changed scale for costs in Figure I.11)

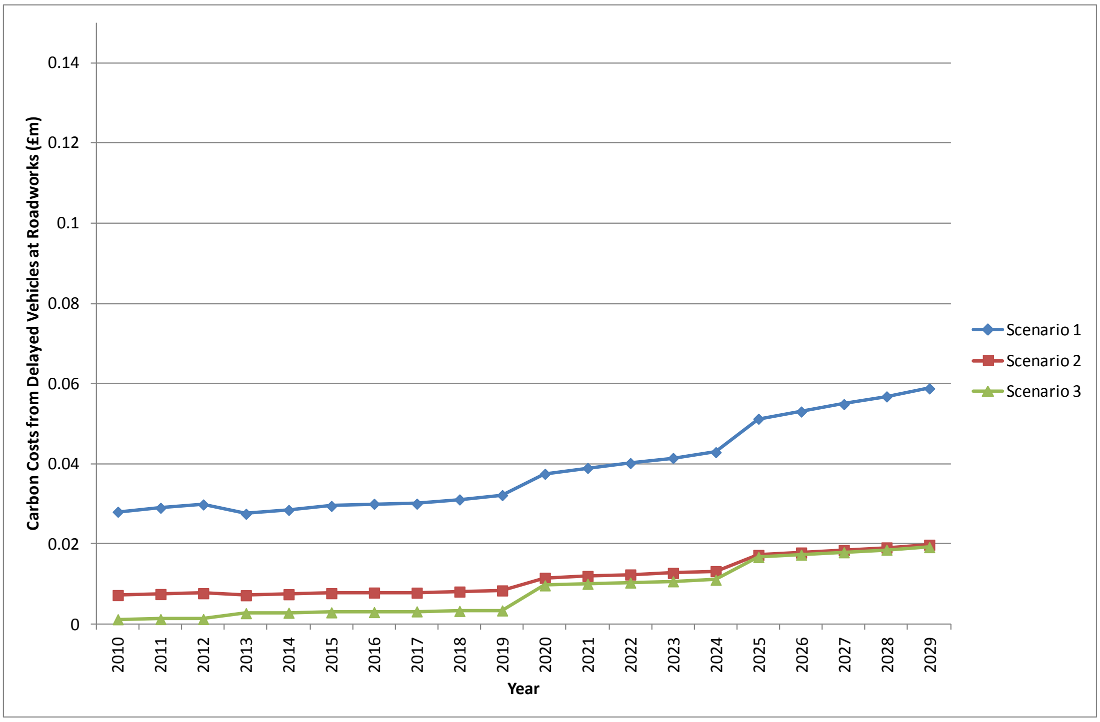


Figure I.12 Fife carbon costs from vehicles delayed at roadworks

(2002 prices undiscounted)

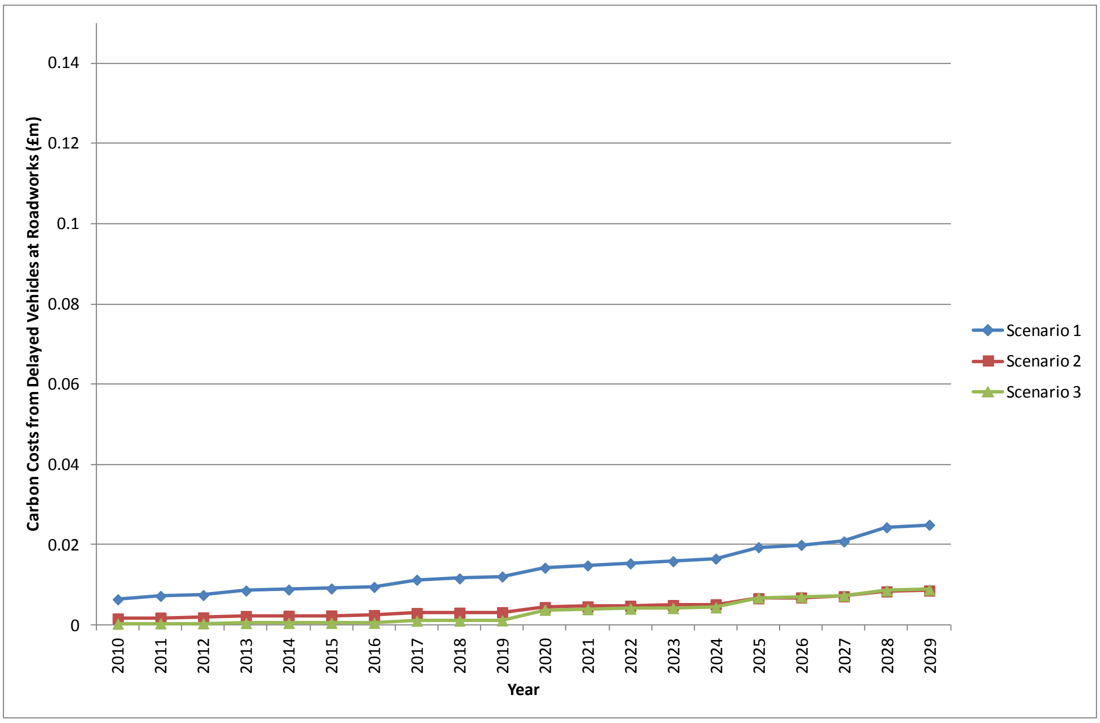


Figure I.13 Glasgow City carbon costs from vehicles delayed at roadworks
(2002 prices undiscounted)

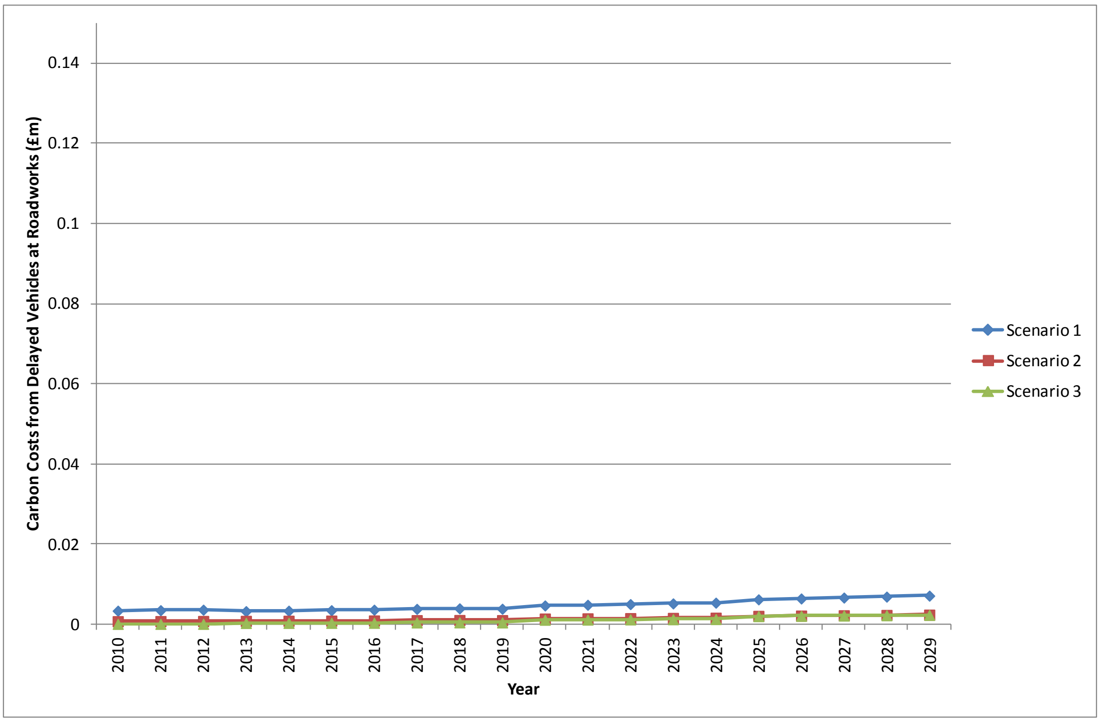


Figure I.14 Highland carbon costs from vehicles delayed at roadworks
(2002 prices undiscounted)

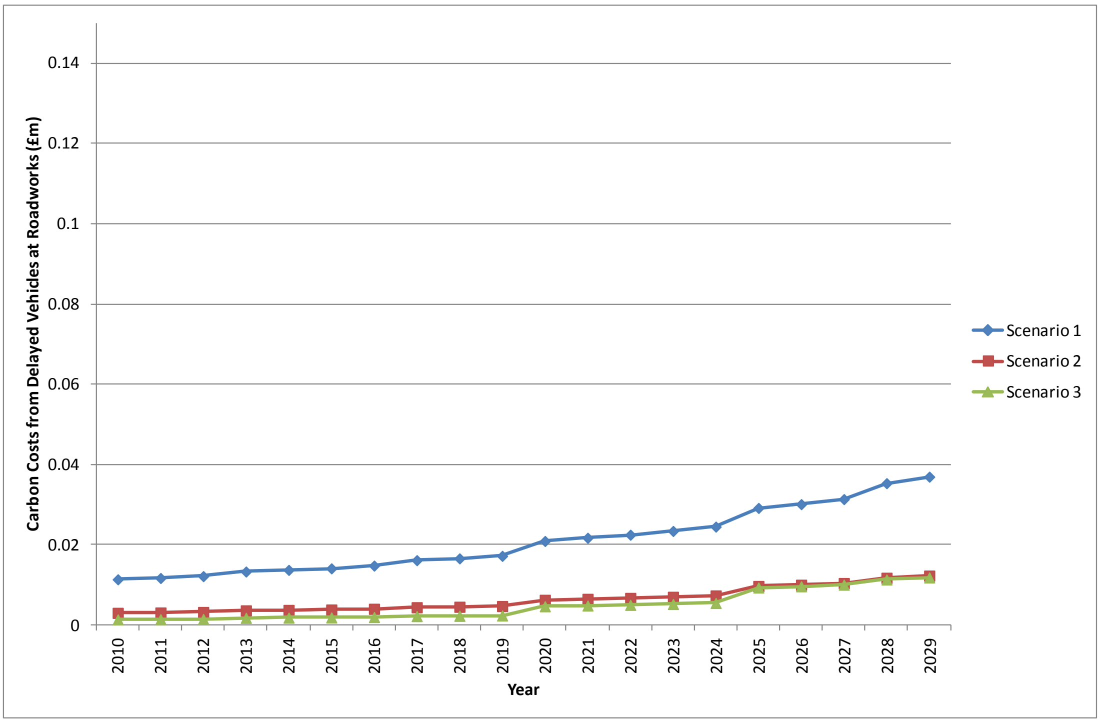


Figure I.15 North Lanarkshire carbon costs from vehicles delayed at roadworks *(2002 prices undiscounted)*

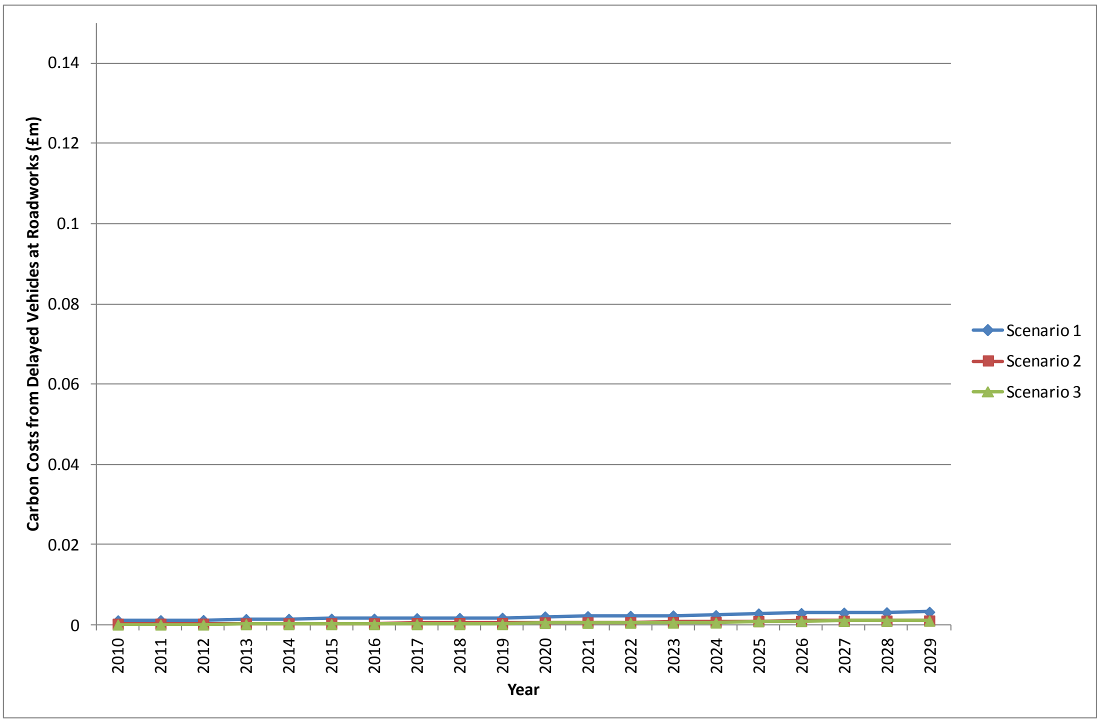


Figure I.16 South Ayrshire carbon costs from vehicles delayed at roadworks *(2002 prices undiscounted)*

I.2.3 Carbon costs from maintenance works (embodied CO_2)

Maintenance works include embodied CO2 from the use of plant and materials. Therefore, as maintenance budgets are reduced and less maintenance is carried out the amount of embodied CO2 reduces. The results of the embodied CO2 analysis are shown in Figure I.17 to Figure I.24.

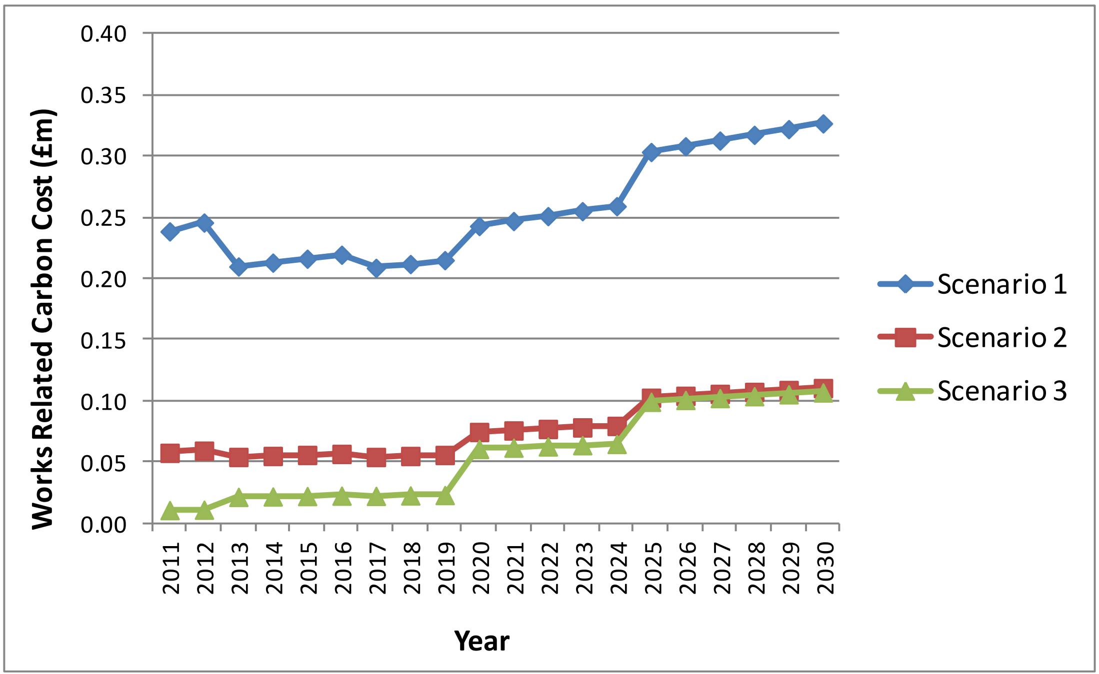


Figure I.17 Aberdeenshire carbon costs from embodied CO_2

(2002 prices undiscounted)

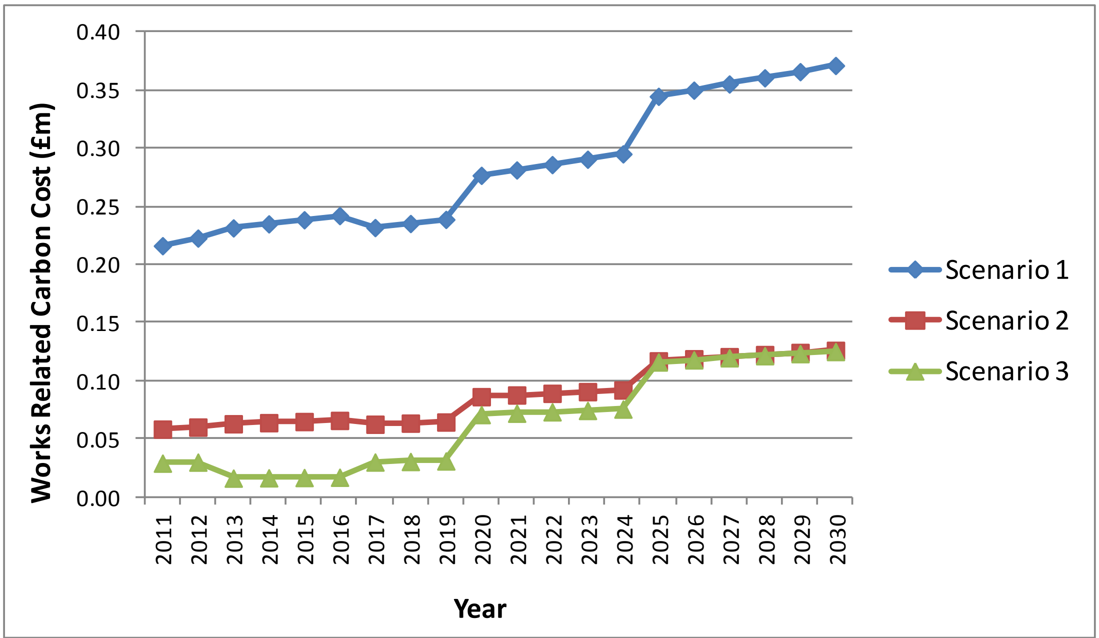


Figure I.18 Dumfries and Galloway carbon costs from embodied CO_2

(2002 prices undiscounted)

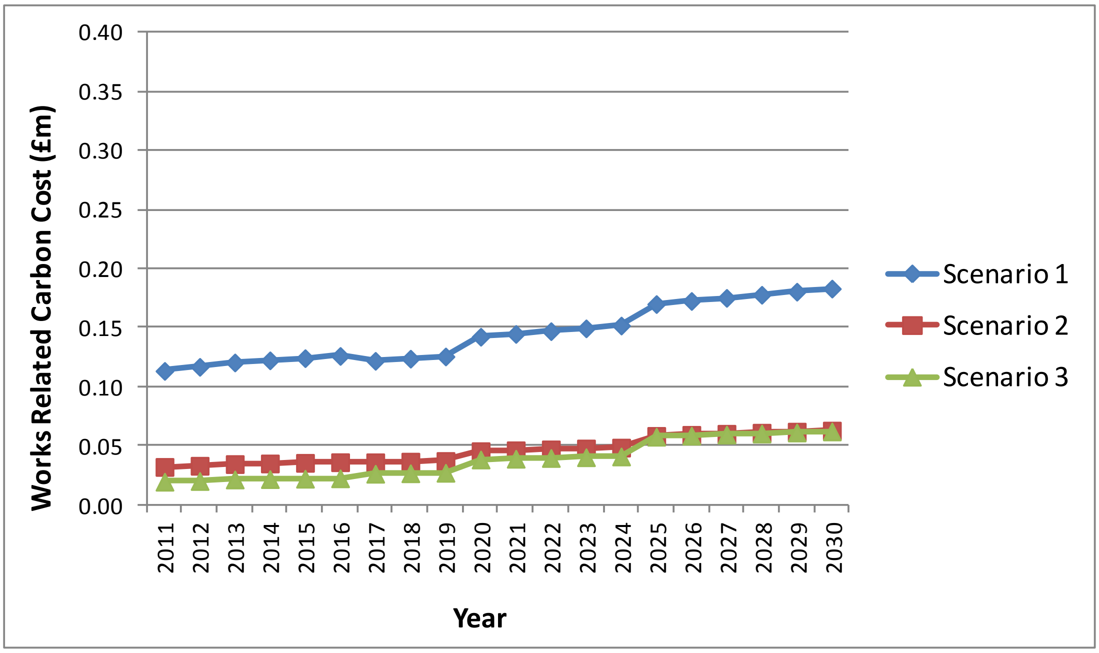


Figure I.19 City of Edinburgh carbon costs from embodied CO_2

(2002 prices undiscounted)

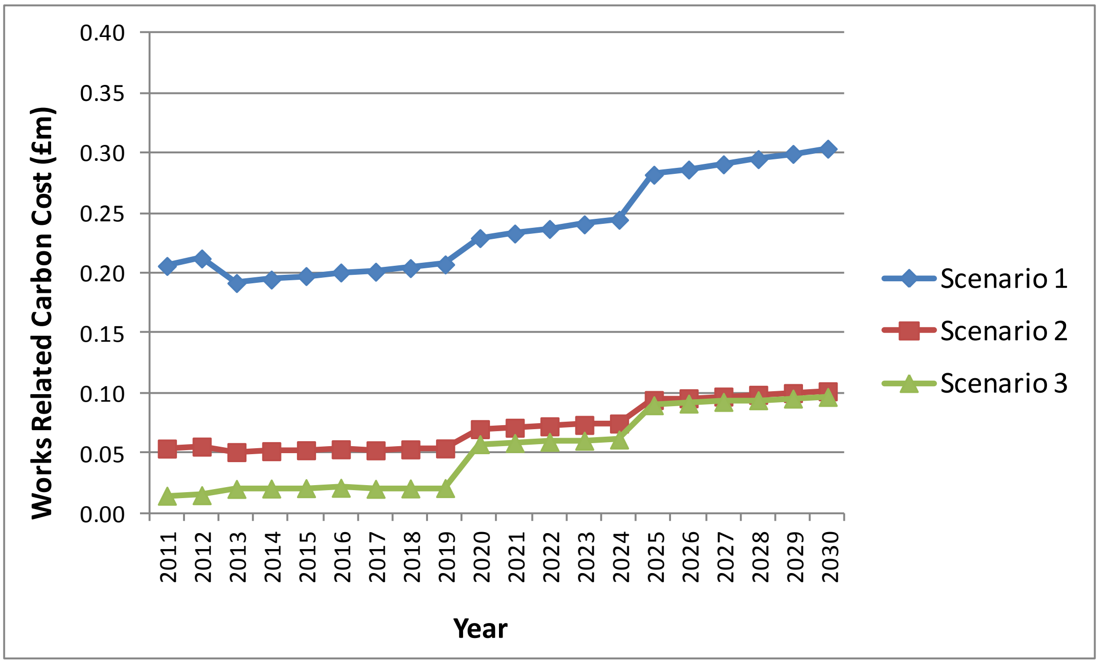


Figure I.20 Fife carbon costs from embodied CO_2

(2002 prices undiscounted)

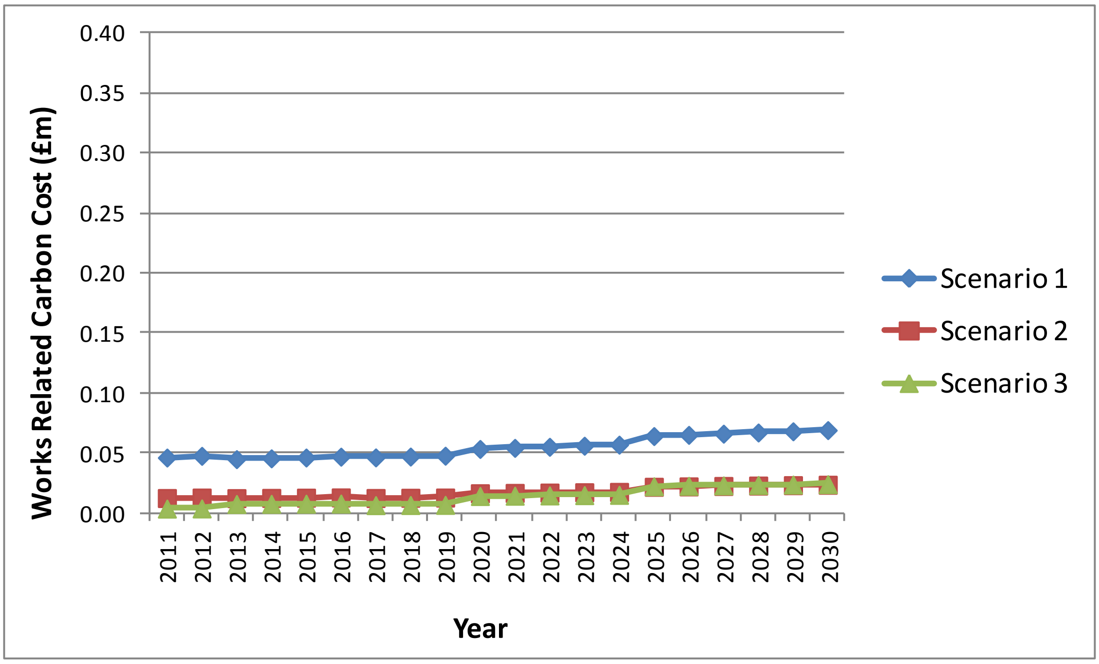


Figure I.21 Glasgow City carbon costs from embodied CO_2
(2002 prices undiscounted)

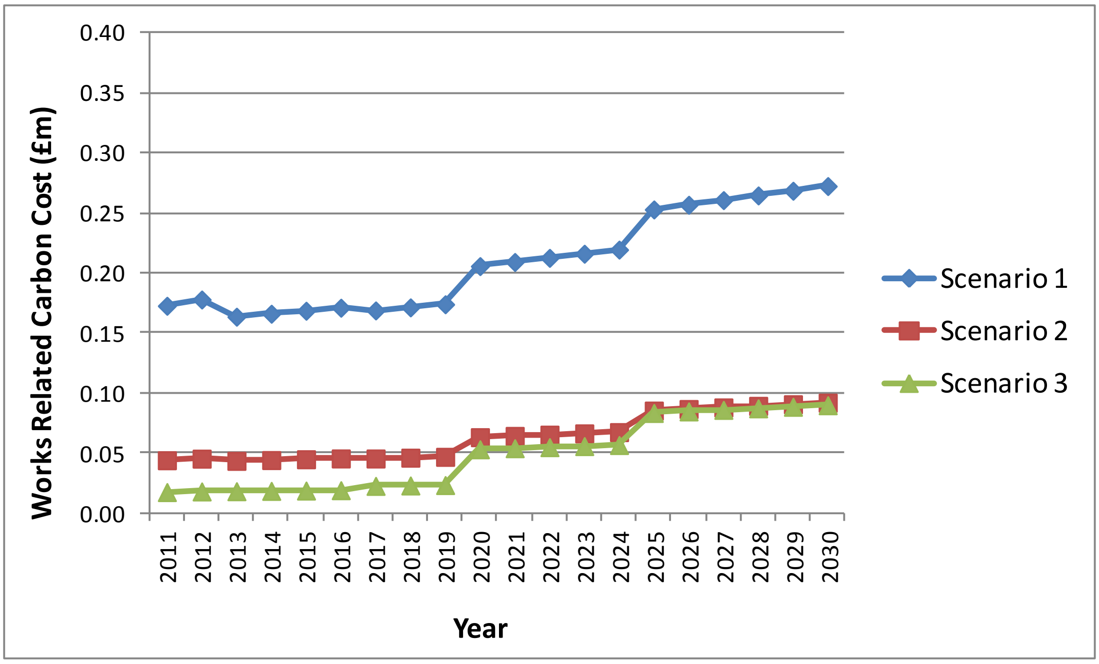


Figure I.22 Highland carbon costs from embodied CO_2
(2002 prices undiscounted)

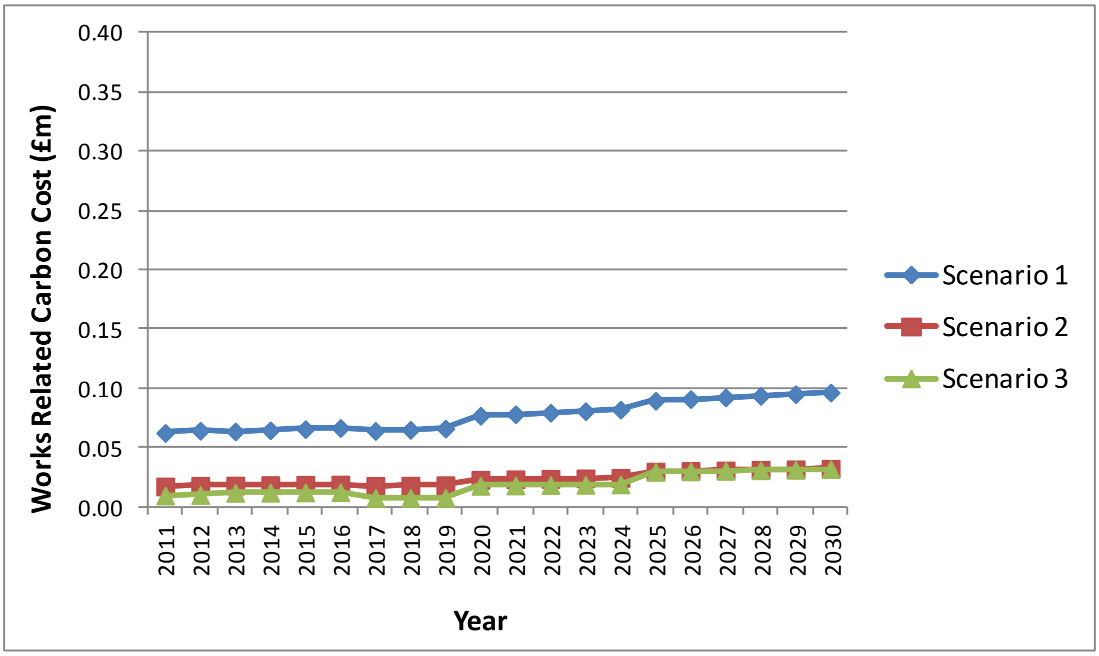


Figure I.23 North Lanarkshire carbon costs from embodied CO_2
(2002 prices undiscounted)

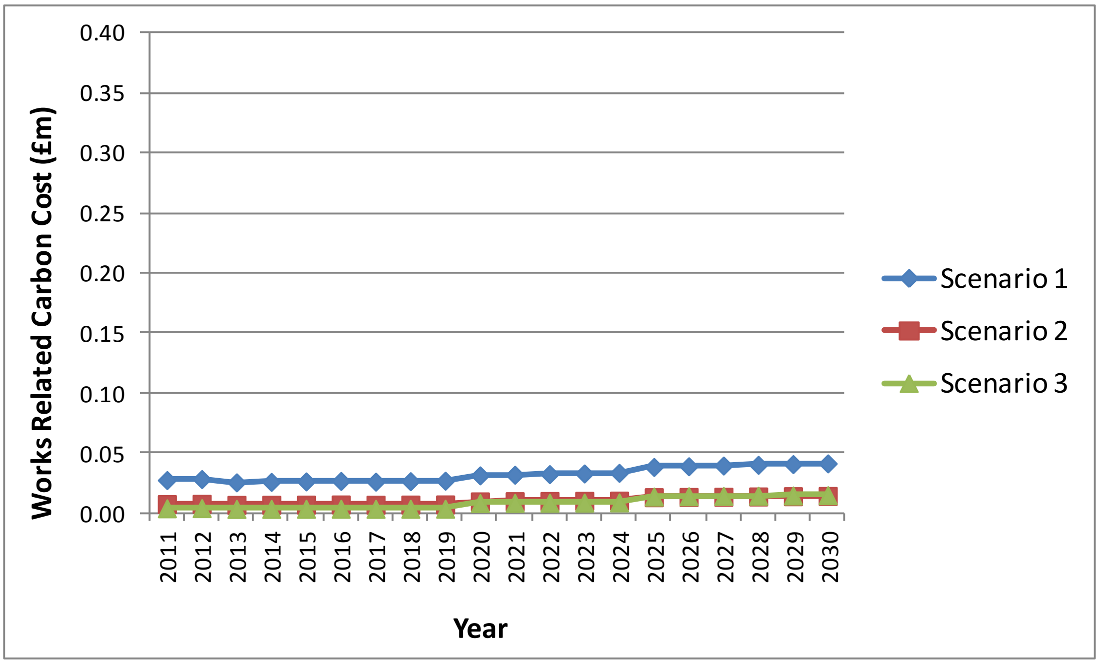


Figure I.24 South Ayrshire carbon costs from embodied CO_2
(2002 prices undiscounted)

I.3 Effect of discounting

The results of taking the data from Fife and discounting the costs at 3.5% per year to 2010 (in 2002 prices) are shown in Figure I.25 to Figure I.27.

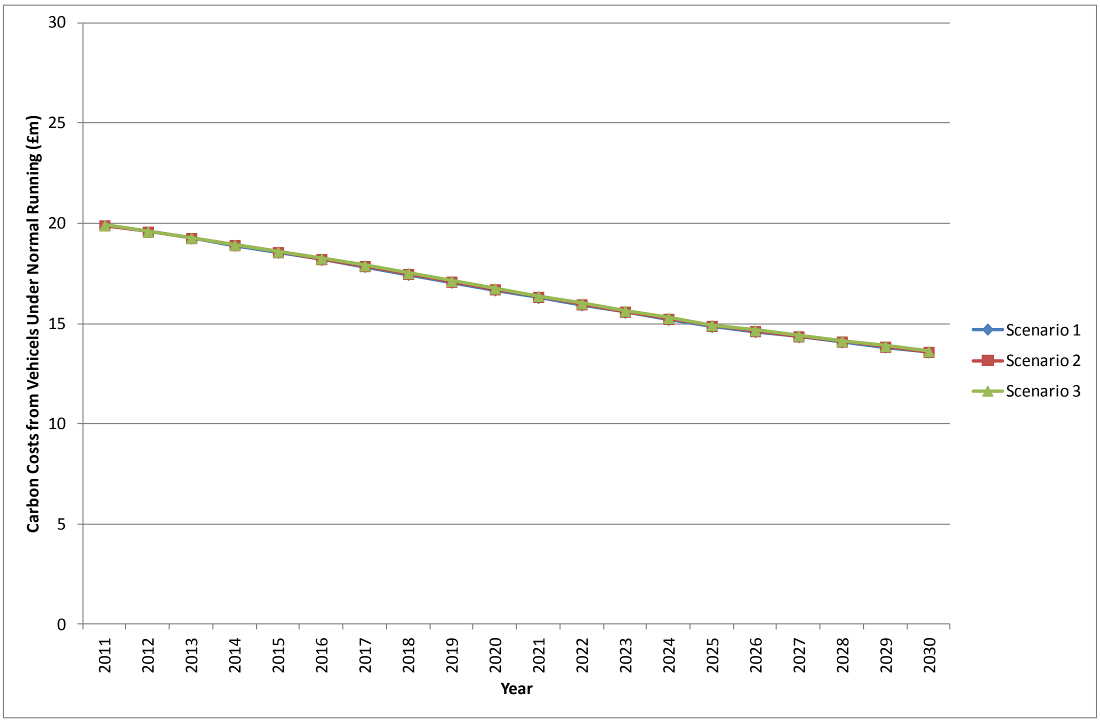


Figure I.25 Fife carbon costs for vehicle normal running
(2002 prices discounted)

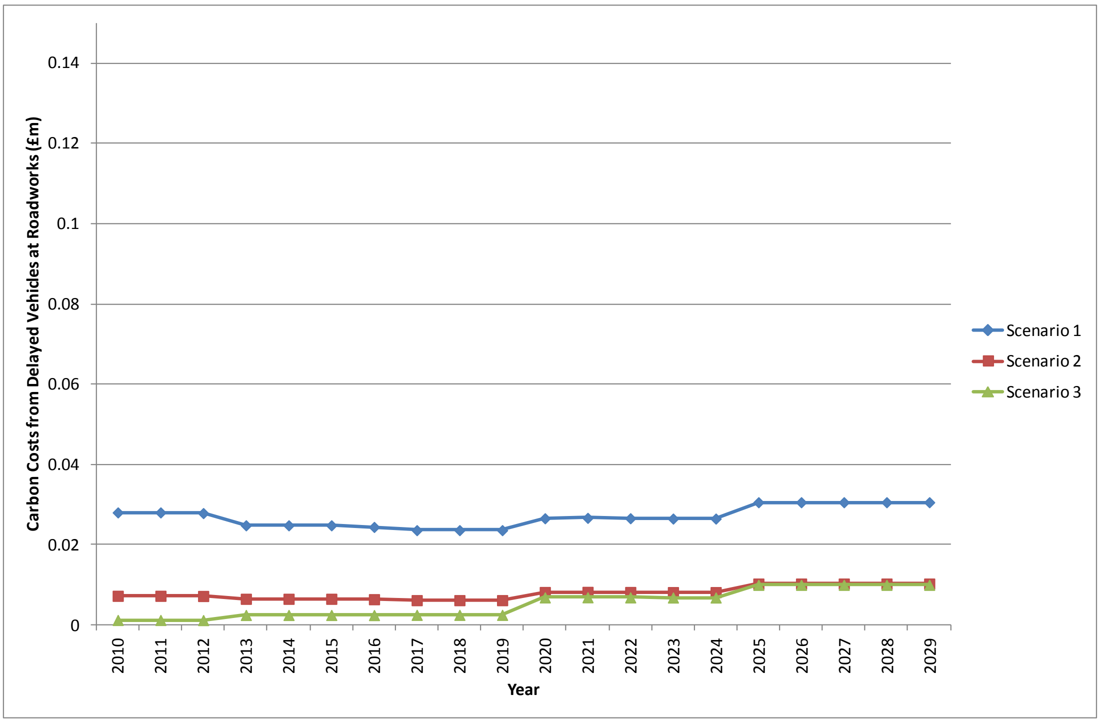


Figure I.26 Fife carbon costs from vehicles delayed at roadworks
(2002 prices discounted)

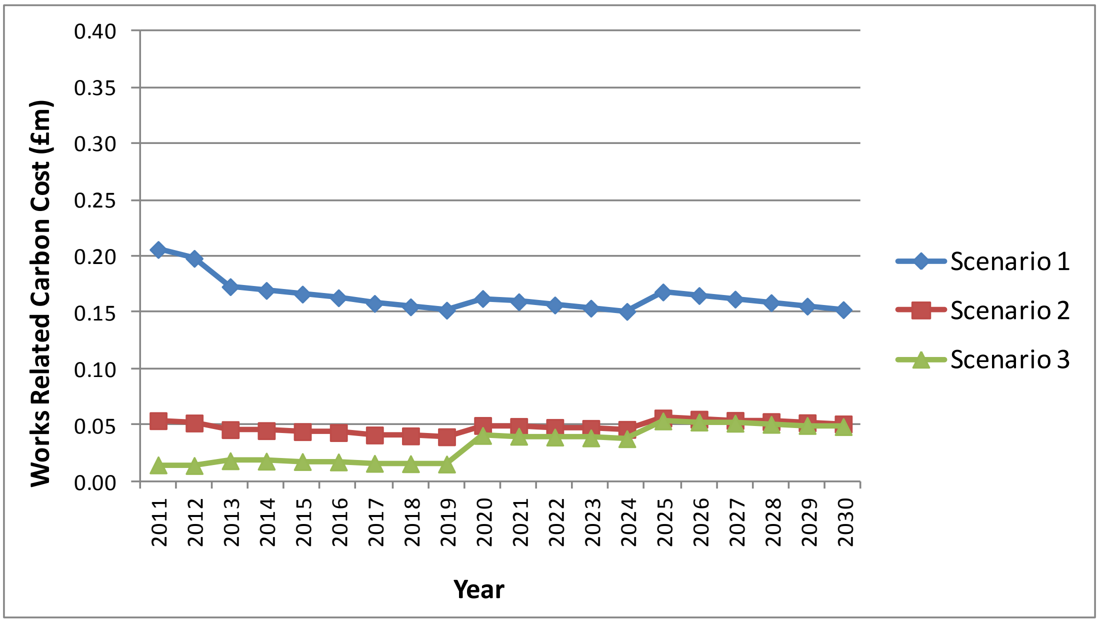


Figure I.27 Fife carbon costs from embodied CO_2
(2002 prices discounted)

I.4 Air quality

Results from the air quality assessment are summarised in Table I.3 and Table I.4.

Table I.3 Nitric Oxide and Nitrogen Dioxide (NOx) and Hydrocarbon emissions

Year	NOx (tonnes)			Hydrocarbon (tonnes)		
	Scenario 1	Scenario 2	Scenario 3	Scenario 1	Scenario 2	Scenario 3
2011	0.0472	0.0471	0.0469	0.0090	0.0090	0.0089
2012	0.0474	0.0473	0.0472	0.0090	0.0090	0.0090
2013	0.0476	0.0475	0.0474	0.0091	0.0090	0.0090
2014	0.0477	0.0476	0.0475	0.0091	0.0091	0.0090
2015	0.0478	0.0477	0.0476	0.0091	0.0091	0.0091
2016	0.0478	0.0477	0.0477	0.0091	0.0091	0.0091
2017	0.0479	0.0478	0.0477	0.0091	0.0091	0.0091
2018	0.0479	0.0478	0.0478	0.0091	0.0091	0.0091
2019	0.0478	0.0477	0.0477	0.0091	0.0091	0.0091
2020	0.0476	0.0476	0.0476	0.0091	0.0091	0.0091
2021	0.0475	0.0475	0.0475	0.0090	0.0090	0.0091
2022	0.0473	0.0473	0.0473	0.0090	0.0090	0.0090
2023	0.0471	0.0471	0.0471	0.0090	0.0090	0.0090
2024	0.0469	0.0469	0.0469	0.0089	0.0089	0.0089
2025	0.0467	0.0467	0.0467	0.0089	0.0089	0.0089
2026	0.0465	0.0465	0.0466	0.0089	0.0089	0.0089
2027	0.0466	0.0466	0.0467	0.0089	0.0089	0.0089
2028	0.0467	0.0467	0.0468	0.0089	0.0089	0.0089
2029	0.0468	0.0468	0.0469	0.0089	0.0089	0.0089
2030	0.0469	0.0469	0.0470	0.0089	0.0089	0.0089
Total	0.9455	0.9446	0.9446	0.1800	0.1799	0.1798

Table I.4 Particulate Matter (PM2.5 and PM10) emissions

Year	PM2.5 (tonnes)			PM10 (tonnes)		
	Scenario 1	Scenario 2	Scenario 3	Scenario 1	Scenario 2	Scenario 3
2011	0.0028	0.0028	0.0028	0.0041	0.0040	0.0040
2012	0.0028	0.0028	0.0028	0.0041	0.0041	0.0041
2013	0.0028	0.0028	0.0028	0.0041	0.0041	0.0041
2014	0.0028	0.0028	0.0028	0.0041	0.0041	0.0041
2015	0.0028	0.0028	0.0028	0.0041	0.0041	0.0041
2016	0.0028	0.0028	0.0028	0.0041	0.0041	0.0041
2017	0.0028	0.0028	0.0028	0.0041	0.0041	0.0041
2018	0.0028	0.0028	0.0028	0.0041	0.0041	0.0041
2019	0.0028	0.0028	0.0028	0.0041	0.0041	0.0041
2020	0.0028	0.0028	0.0028	0.0041	0.0041	0.0041
2021	0.0028	0.0028	0.0028	0.0041	0.0041	0.0041
2022	0.0028	0.0028	0.0028	0.0041	0.0041	0.0041
2023	0.0028	0.0028	0.0028	0.0041	0.0041	0.0041
2024	0.0028	0.0028	0.0028	0.0040	0.0040	0.0040
2025	0.0027	0.0027	0.0027	0.0040	0.0040	0.0040
2026	0.0027	0.0027	0.0027	0.0040	0.0040	0.0040
2027	0.0027	0.0027	0.0027	0.0040	0.0040	0.0040
2028	0.0027	0.0027	0.0027	0.0040	0.0040	0.0040
2029	0.0027	0.0027	0.0028	0.0040	0.0040	0.0040
2030	0.0028	0.0028	0.0028	0.0040	0.0040	0.0040
Total	0.0555	0.0555	0.0555	0.0814	0.0813	0.0813

Notes: PM10 – Particulate Matter < 10 μm
PM2.5 – Particulate Matter < 2.5 μm

Appendix J Time Series Information of Economic Costs and Benefits

This Appendix provides tabulated network results (scaled up from the 8 sample Authorities) of all quantitative economic analyses carried out on the Scottish Local Authority road network as part of the study. Where appropriate, data has been tabulated to show the non-discounted and discounted costs in each year of the analysis (2010 – 2030) at 2002 prices.

Note that time series results derived from maintenance works data (i.e. treatment lengths are only available from 2010 to 2029). This is because the modelling applies treatments in year and then projects the resulting condition for the next year in the analysis. Therefore 2029/30 is the last year of treatment and 2030 is the last year of projected condition information.

Full tabulated time series results can be found in Table J.1 to Table J.8.

Table J.1 Maintenance works costs

Year	Agency Costs: Maintenance Works Costs (£m 2002 prices)					
	Undiscounted			Discounted		
	Scenario 1	Scenario 2	Scenario 3	Scenario 1	Scenario 2	Scenario 3
2011	399	320	240	386	309	232
2012	399	320	240	373	298	224
2013	399	320	240	360	288	216
2014	399	320	240	348	278	209
2015	399	320	240	336	269	202
2016	399	320	240	325	260	195
2017	399	320	240	314	251	188
2018	399	320	240	303	243	182
2019	399	320	240	293	234	176
2020	399	320	240	283	227	170
2021	399	336	272	274	230	186
2022	399	352	304	264	233	201
2023	399	368	336	255	235	215
2024	399	383	368	247	237	227
2025	399	399	399	238	238	238
2026	399	409	409	230	236	236
2027	399	420	420	223	234	234
2028	399	430	430	215	232	232
2029	399	441	441	208	229	229
2030	399	452	452	201	227	227
Total	7989	7185	6227	5677	4988	4218

Table J.2 Vehicle operating costs

Year	Vehicle Operating Costs (£m 2002 prices)					
	Undiscounted			Discounted		
	Scenario 1	Scenario 2	Scenario 3	Scenario 1	Scenario 2	Scenario 3
2011	17,047	17,059	17,070	16,470	16,482	16,493
2012	17,278	17,302	17,324	16,129	16,151	16,172
2013	17,508	17,544	17,578	15,792	15,824	15,854
2014	17,809	17,859	17,906	15,519	15,563	15,604
2015	18,109	18,174	18,235	15,248	15,302	15,353
2016	18,410	18,489	18,563	14,976	15,040	15,101
2017	18,710	18,803	18,892	14,706	14,779	14,849
2018	18,987	19,096	19,201	14,419	14,502	14,581
2019	19,265	19,388	19,510	14,135	14,226	14,315
2020	19,542	19,681	19,819	13,854	13,952	14,050
2021	19,790	19,935	20,078	13,555	13,654	13,753
2022	20,037	20,188	20,338	13,260	13,360	13,460
2023	20,285	20,442	20,598	12,970	13,071	13,171
2024	20,532	20,696	20,858	12,684	12,786	12,886
2025	20,780	20,950	21,118	12,403	12,505	12,605
2026	21,049	21,212	21,378	12,139	12,233	12,329
2027	21,317	21,475	21,638	11,878	11,966	12,057
2028	21,586	21,737	21,898	11,621	11,702	11,789
2029	21,855	22,000	22,158	11,368	11,443	11,526
2030	22,124	22,262	22,418	11,119	11,188	11,266
Total	392,020	394,292	396,578	274,246	275,731	277,212

Table J.3 User delay costs

Year	User Delay Costs (£m 2002 prices)					
	Undiscounted			Discounted		
	Scenario 1	Scenario 2	Scenario 3	Scenario 1	Scenario 2	Scenario 3
2011	81	45	11	81	45	11
2012	87	49	12	84	47	12
2013	90	50	12	84	47	12
2014	83	51	19	75	46	18
2015	86	52	20	75	46	17
2016	89	54	21	75	46	18
2017	92	56	21	75	46	17
2018	94	58	25	74	45	20
2019	97	60	26	73	45	20
2020	100	62	27	73	45	20
2021	104	86	70	73	61	49
2022	107	89	72	73	61	49
2023	110	91	74	73	60	49
2024	113	94	76	72	60	49
2025	115	96	78	71	59	48
2026	120	125	123	71	75	73
2027	123	129	126	71	74	73
2028	126	132	130	70	74	72
2029	128	134	132	69	72	71
2030	131	138	135	68	72	70
Total	2,073	1,650	1,212	1,480	1,126	768

Table J.4 Travel time costs

Year	Increase in Travel Time Costs (£m 2002 prices)					
	Undiscounted			Discounted		
	Scenario 1	Scenario 2	Scenario 3	Scenario 1	Scenario 2	Scenario 3
2011	61	62	62	59	60	60
2012	66	67	69	62	63	64
2013	71	73	75	64	66	68
2014	77	80	83	67	70	72
2015	83	87	90	70	73	76
2016	89	94	98	73	76	80
2017	95	101	106	75	79	83
2018	102	108	114	77	82	86
2019	108	115	121	79	84	89
2020	114	122	129	81	86	92
2021	120	128	136	82	88	93
2022	127	135	143	84	89	95
2023	133	142	150	85	90	96
2024	140	148	157	86	92	97
2025	146	155	164	87	92	98
2026	152	160	169	88	92	97
2027	158	166	174	88	92	97
2028	164	171	179	88	92	96
2029	170	176	184	88	92	96
2030	176	182	189	88	91	95
Total	2,352	2,469	2,592	1,572	1,651	1,730

Table J.5 Carbon emissions costs due to network unevenness

Year	Carbon Emissions Costs due to Network Condition (£m 2002 prices)					
	Undiscounted			Discounted		
	Scenario 1	Scenario 2	Scenario 3	Scenario 1	Scenario 2	Scenario 3
2011	920	920	920	889	889	889
2012	937	937	938	875	875	875
2013	954	955	956	861	861	862
2014	970	971	971	845	846	847
2015	986	986	987	830	831	831
2016	1,001	1,002	1,003	814	815	816
2017	1,017	1,018	1,019	799	800	801
2018	1,029	1,031	1,032	782	783	784
2019	1,042	1,044	1,045	764	766	767
2020	1,055	1,057	1,058	748	749	750
2021	1,067	1,069	1,071	731	732	734
2022	1,080	1,082	1,084	715	716	717
2023	1,093	1,095	1,097	699	700	701
2024	1,105	1,108	1,110	683	684	686
2025	1,118	1,120	1,123	667	669	670
2026	1,138	1,140	1,142	656	657	659
2027	1,157	1,159	1,162	645	646	647
2028	1,177	1,179	1,181	634	635	636
2029	1,196	1,198	1,200	622	623	624
2030	1,216	1,218	1,220	611	612	613
Total	21,258	21,289	21,321	14,870	14,890	14,911

Table J.6 Carbon emissions costs due to maintenance works (plant and materials)

Year	Carbon Costs due to Maintenance Works (£m 2002 prices)					
	Undiscounted			Discounted		
	Scenario 1	Scenario 2	Scenario 3	Scenario 1	Scenario 2	Scenario 3
2011	6.006	3.213	1.187	6.006	3.213	1.187
2012	6.096	3.261	1.205	5.890	3.151	1.164
2013	6.187	3.310	1.223	5.776	3.090	1.141
2014	5.572	3.210	1.263	5.025	2.896	1.139
2015	5.656	3.259	1.282	4.929	2.840	1.117
2016	5.740	3.308	1.301	4.833	2.785	1.096
2017	5.826	3.357	1.321	4.740	2.731	1.075
2018	5.729	3.241	1.486	4.503	2.547	1.168
2019	5.815	3.290	1.508	4.416	2.498	1.146
2020	5.902	3.339	1.531	4.331	2.450	1.123
2021	6.048	4.425	3.639	4.287	3.137	2.580
2022	6.149	4.499	3.700	4.212	3.082	2.534
2023	6.249	4.573	3.760	4.136	3.026	2.488
2024	6.350	4.647	3.821	4.060	2.971	2.443
2025	6.451	4.720	3.882	3.985	2.916	2.398
2026	6.731	5.981	5.842	4.018	3.570	3.487
2027	6.834	6.072	5.932	3.941	3.502	3.421
2028	6.938	6.165	6.022	3.866	3.435	3.356
2029	7.042	6.257	6.112	3.791	3.368	3.290
2030	7.145	6.349	6.202	3.717	3.302	3.226
Total	124.466	86.474	62.220	90.460	60.510	40.580

Table J.7 Carbon emissions costs due to vehicle delays through roadworks

Year	Carbon Costs due to Delayed Vehicles Through Roadworks (£m 2002 prices)					
	Undiscounted			Discounted		
	Scenario 1	Scenario 2	Scenario 3	Scenario 1	Scenario 2	Scenario 3
2011	0.549	0.249	0.079	0.549	0.249	0.079
2012	0.570	0.258	0.082	0.551	0.249	0.079
2013	0.592	0.268	0.085	0.553	0.250	0.079
2014	0.571	0.277	0.122	0.515	0.250	0.110
2015	0.591	0.286	0.126	0.515	0.249	0.110
2016	0.612	0.296	0.130	0.515	0.249	0.110
2017	0.634	0.306	0.135	0.516	0.249	0.110
2018	0.666	0.323	0.150	0.523	0.254	0.118
2019	0.688	0.334	0.155	0.522	0.254	0.118
2020	0.706	0.342	0.159	0.518	0.251	0.117
2021	0.797	0.480	0.400	0.565	0.341	0.283
2022	0.829	0.499	0.415	0.568	0.342	0.285
2023	0.860	0.517	0.430	0.569	0.342	0.285
2024	0.893	0.537	0.446	0.571	0.343	0.285
2025	0.927	0.557	0.464	0.573	0.344	0.286
2026	1.049	0.732	0.728	0.626	0.437	0.434
2027	1.087	0.758	0.754	0.627	0.437	0.435
2028	1.130	0.787	0.783	0.629	0.438	0.436
2029	1.189	0.828	0.824	0.640	0.446	0.443
2030	1.235	0.859	0.855	0.643	0.447	0.445
Total	16.175	9.493	7.322	11.288	6.421	4.648

Table J.8 Net lighting and accident costs

Year	Costs of lighting and changes in numbers of accidents (£m 2002 prices)					
	Undiscounted			Discounted		
	Scenario 1	Scenario 2	Scenario 3	Scenario 1	Scenario 2	Scenario 3
2011	142	142	142	142	142	142
2012	142	143	145	137	138	140
2013	142	143	145	132	134	135
2014	142	143	145	128	129	131
2015	142	143	145	123	125	126
2016	142	143	145	119	121	122
2017	142	143	145	115	117	118
2018	142	143	145	111	113	114
2019	142	143	145	108	109	110
2020	142	143	145	104	105	106
2021	142	143	145	100	102	103
2022	142	143	145	97	98	99
2023	142	143	144	94	95	95
2024	142	143	144	91	91	92
2025	142	143	144	88	88	89
2026	142	142	143	85	85	86
2027	142	142	143	82	82	82
2028	142	142	143	79	79	79
2029	142	142	142	76	76	77
2030	142	142	142	74	74	74
2031	142	142	142	71	71	71
Total	2975	2998	3023	2155	2173	2192

Appendix K Asset Valuation

K.1 Methodology

Depreciation of the road network for each road type, for each of the sample Authorities has been calculated based on the projected carriageway conditions in each of the modelled years (2010, 2013, 2017, 2020, 2025 and 2030) and for each budget scenario. This data was provided by WDM in 2011 prices so these figures were deflated to 2002 prices.

The accumulated depreciation costs for each of the modelled years under the 20% and 40% budget cut scenarios were then linearly interpolated and extrapolated to represent a 35% and 69% budget cut to account for the fact that the WDM model runs were carried out using a 20% and 40% budget cut, but the subjective budget analysis identified that these would be equivalent to a 35% and 69% budget cut in carriageway maintenance respectively.

The accumulated depreciation values were not discounted to a 2010 base. The consideration of the accumulated depreciation in the analysis results has been included as a separate analysis to the main economic analyses. Therefore discounting of the depreciation values was not required for this study.

K.2 Results

The accumulated depreciation results for the 8 sample Authorities are shown in Figure K.1 to Figure K.8.

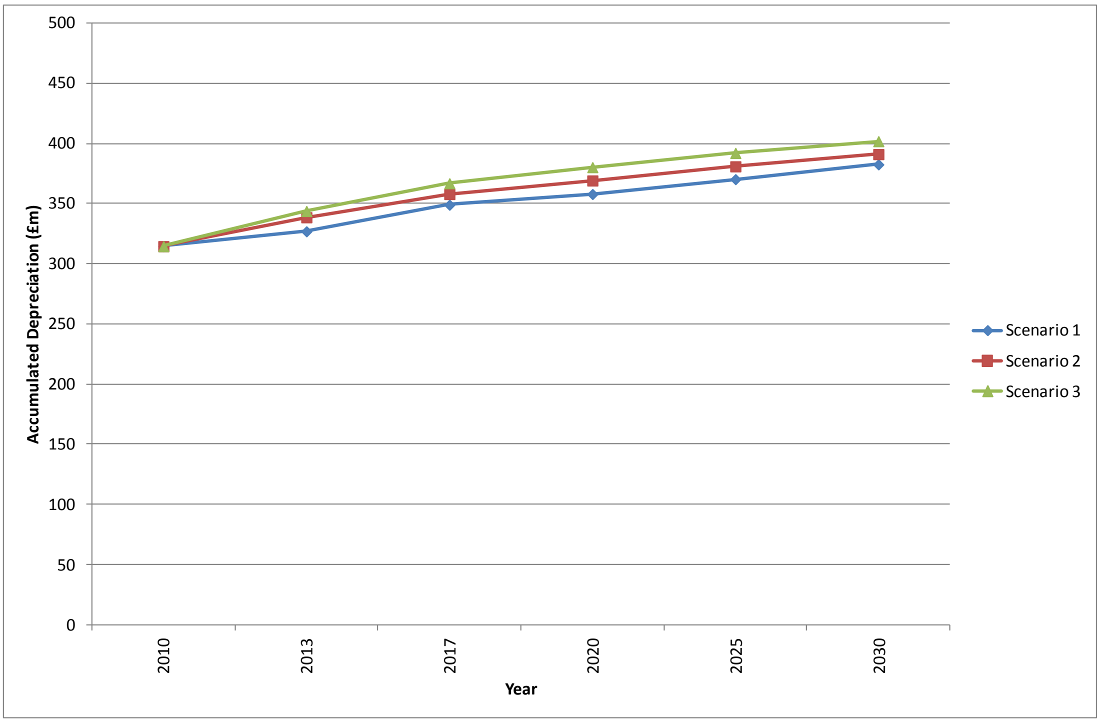


Figure K.1 Aberdeenshire accumulated depreciation

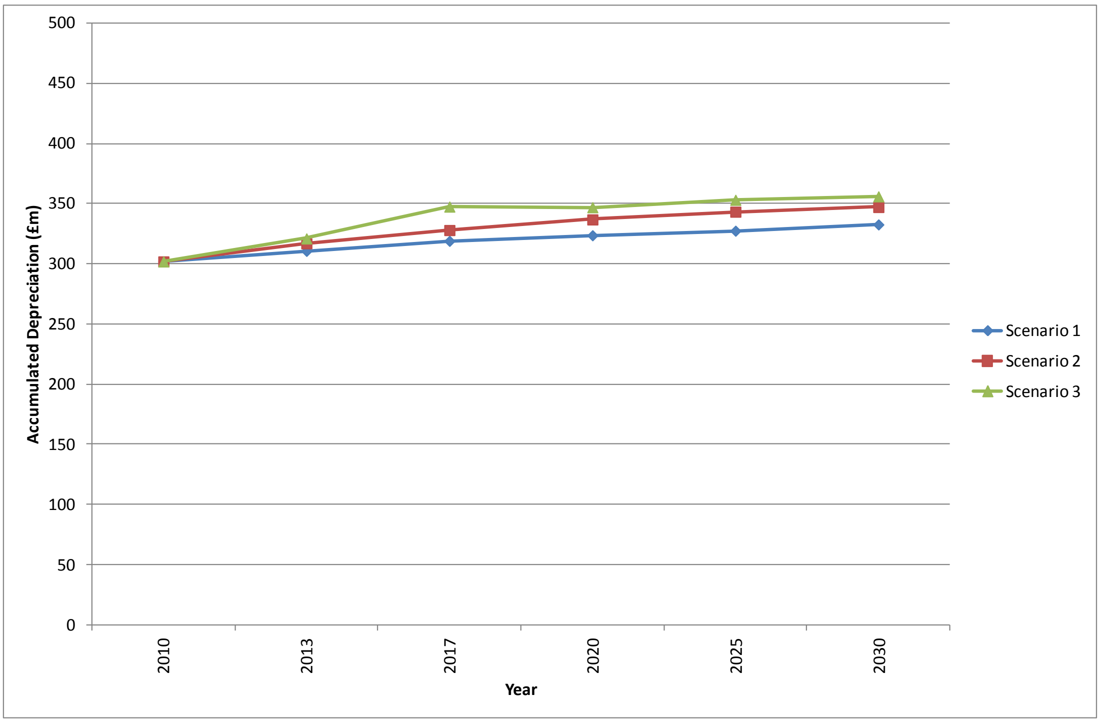


Figure K.2 Dumfries and Galloway accumulated depreciation

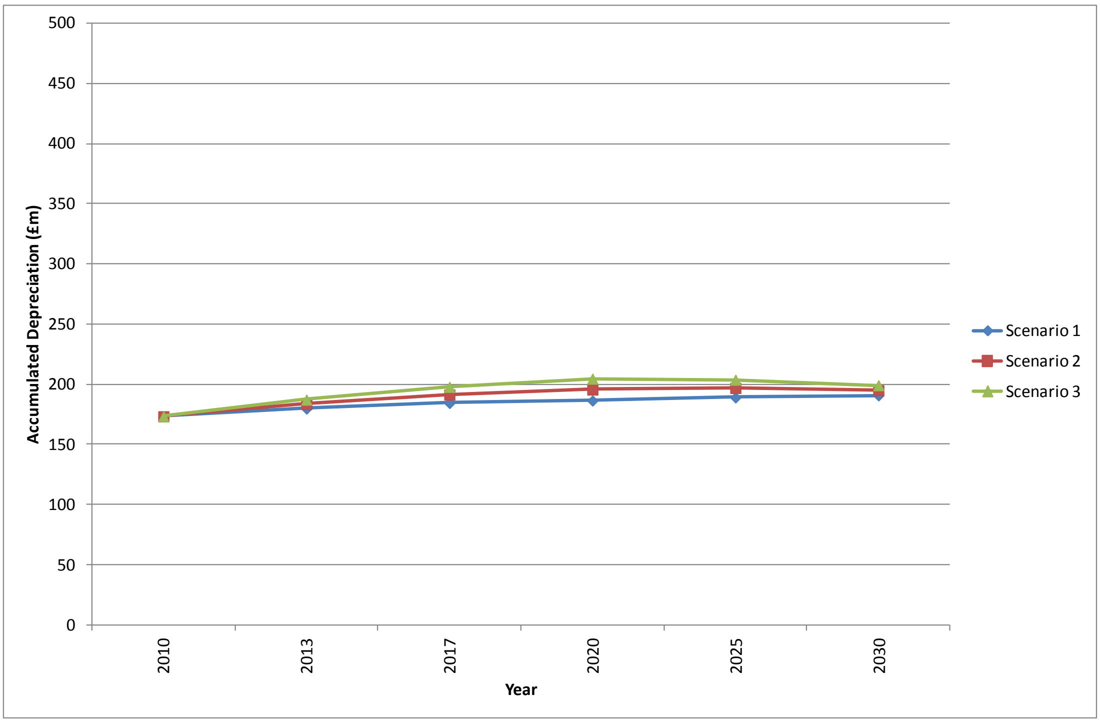
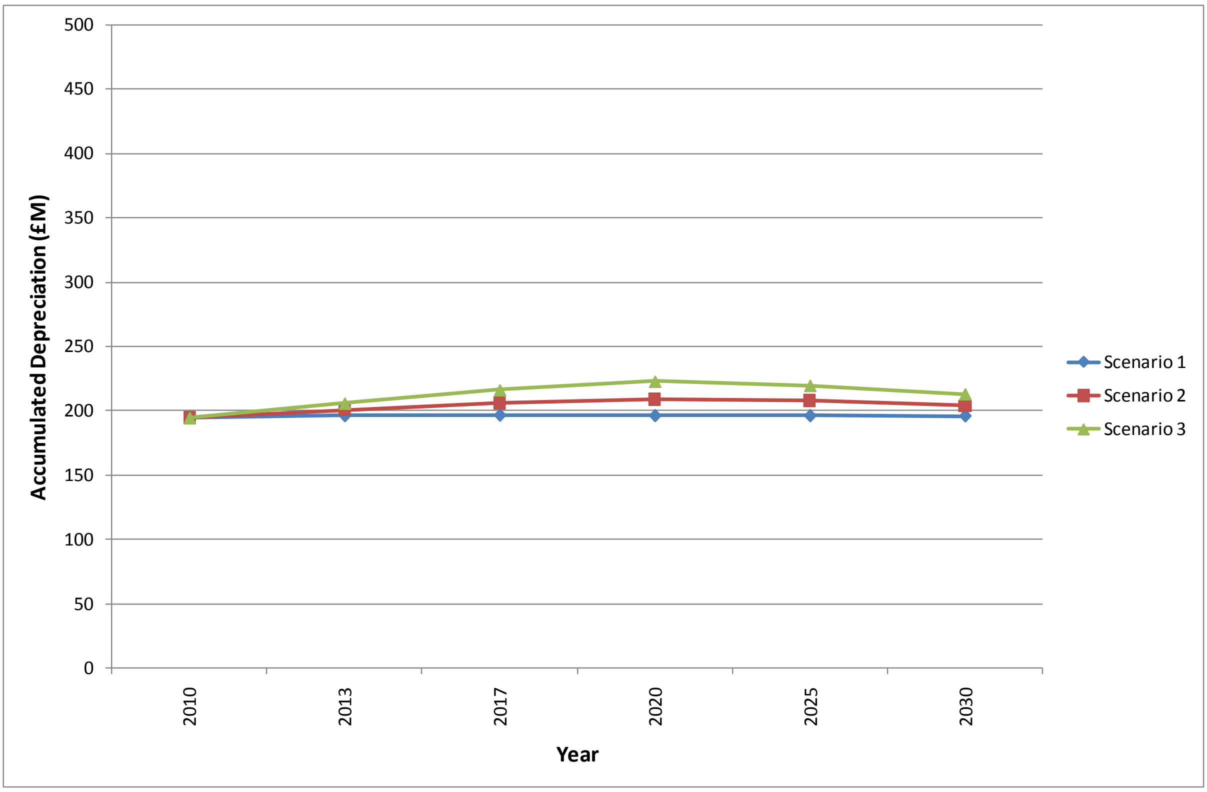


Figure K.3 City of Edinburgh accumulated depreciation



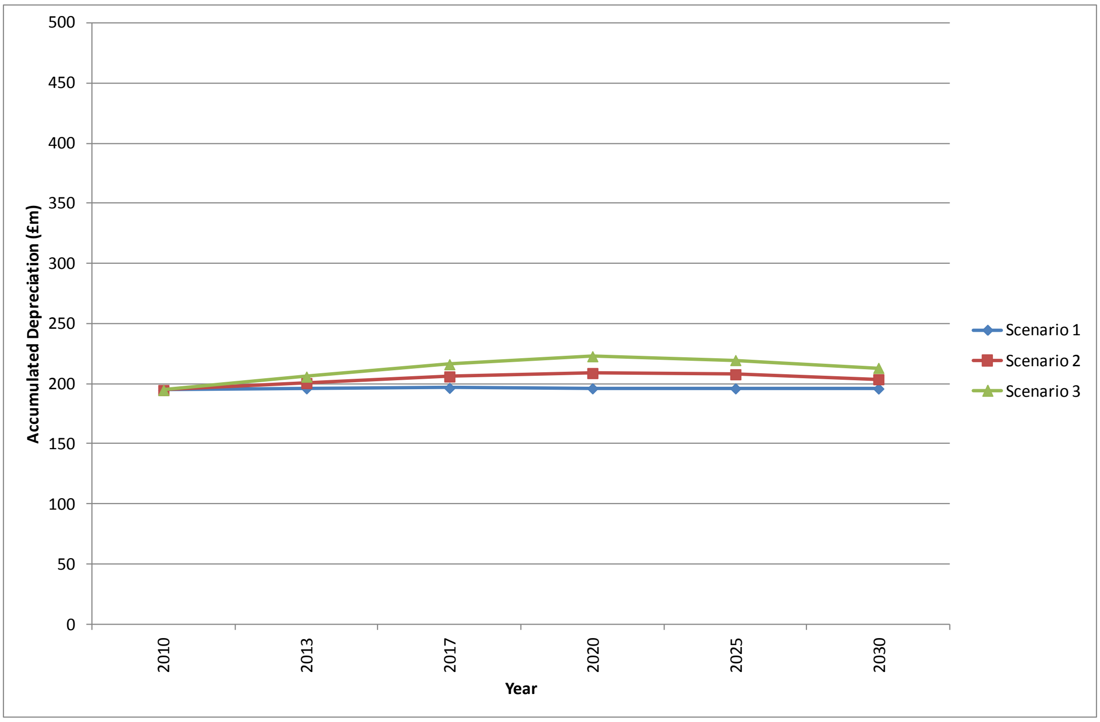


Figure K.4 Fife accumulated depreciation

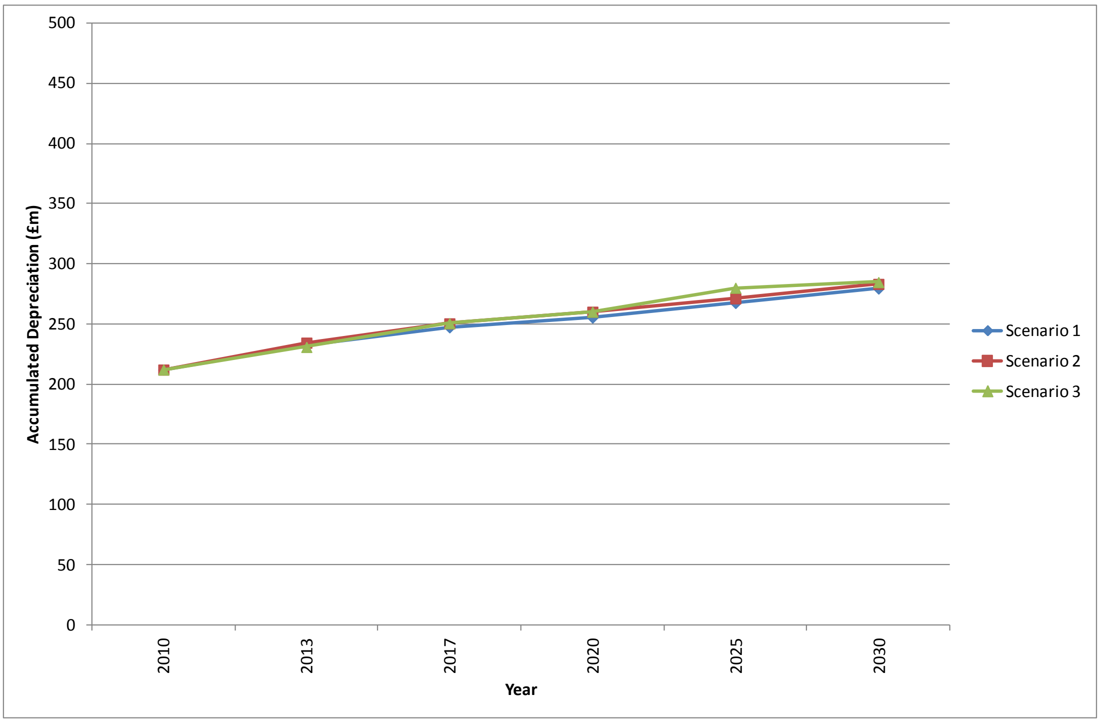


Figure K.5 Glasgow City accumulated depreciation

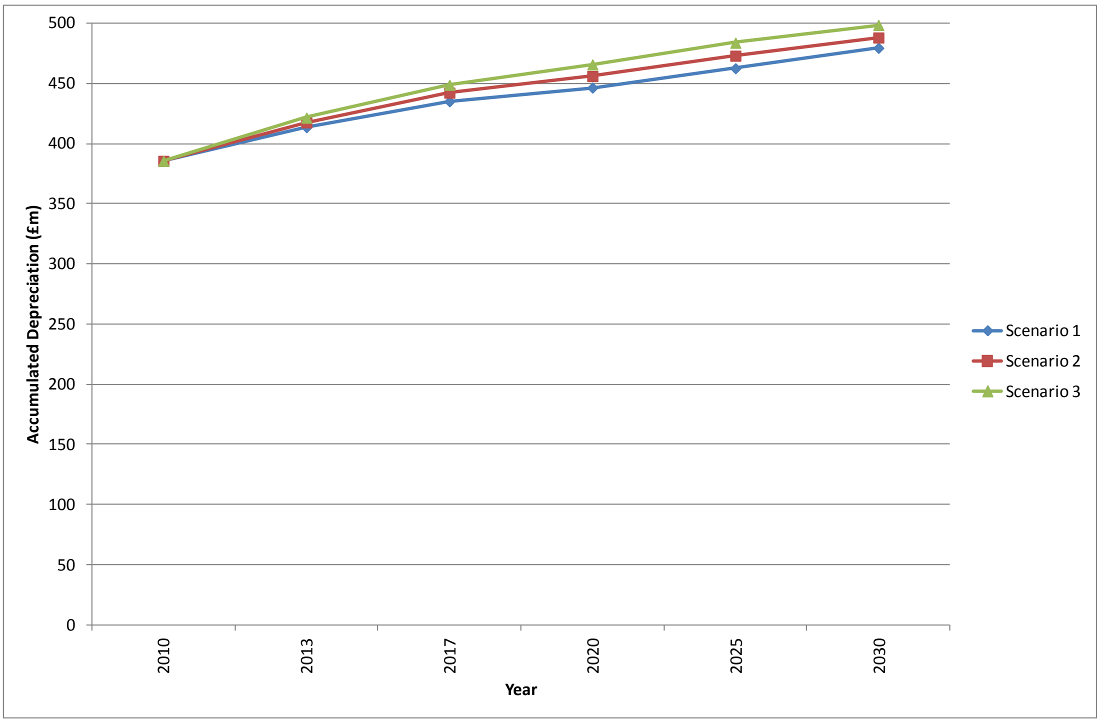


Figure K.6 Highland accumulated depreciation

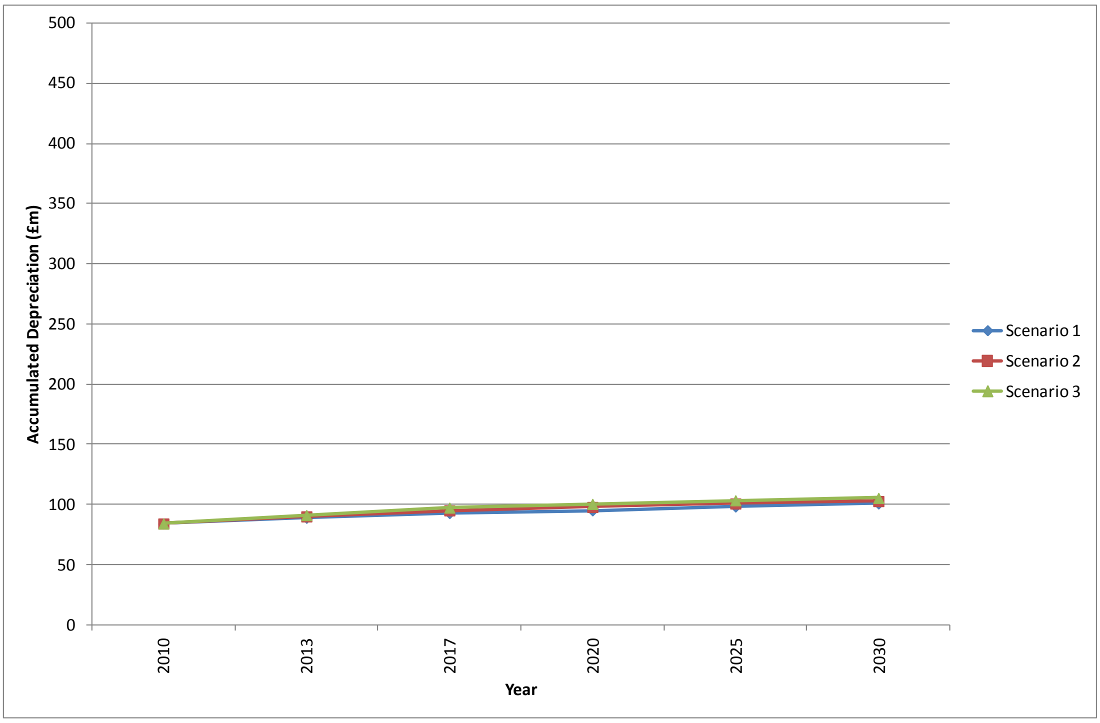


Figure K.7 North Lanarkshire accumulated depreciation

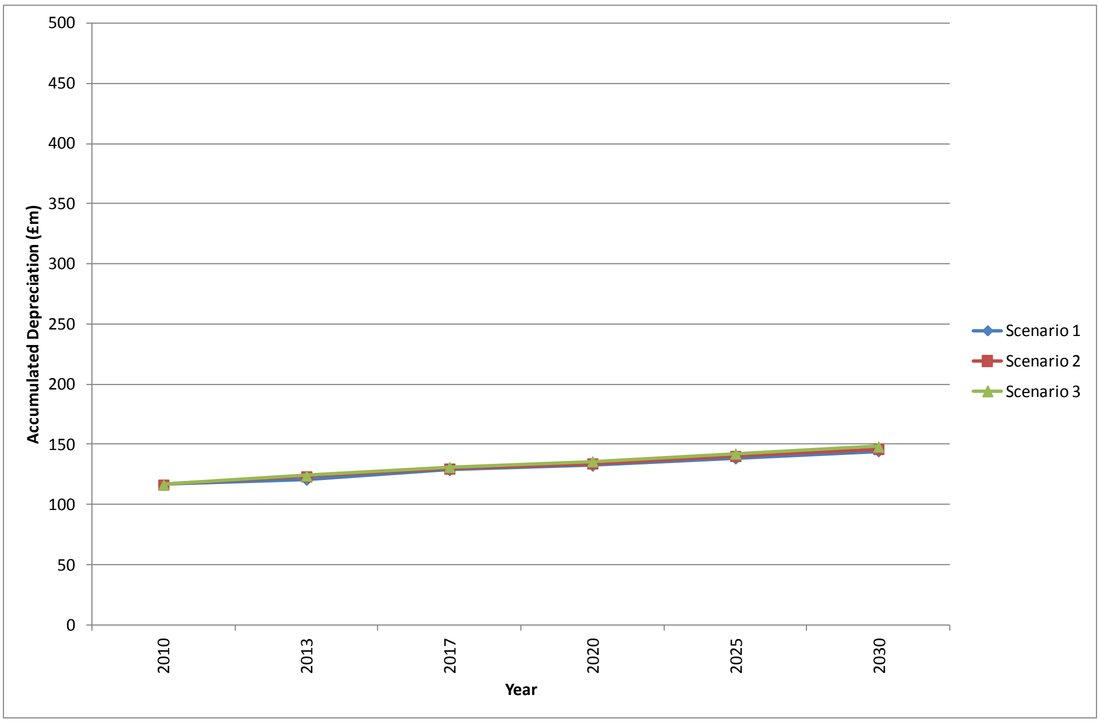


Figure K.8 South Ayrshire accumulated depreciation

Appendix L Scaling-up the Sample Analyses

L.1 Vehicle operating costs due to reduced carriageway condition

For each sample Authority, the vehicle operating cost was calculated for each vehicle type (i.e. HGV, bus, car and van) and road type (i.e. A, B, C and U roads) for urban and rural areas.

The representative factor, for vehicle operating cost, for each vehicle type and each road type was calculated as shown in equation (K1).

$$f = 1 / [(T/L_T)(L_R/L_T)] \quad \text{(K1)}$$

where is the traffic (vehicle km) in 2009 for that vehicle type on that road type, is the total length of that road type and is the length of that road type in poor condition (i.e. categorised as red in the SRMCS report for 2009/10).

Where there is more than one sample Authority of the same type, to calculate the factor for that Authority type, the values are the total for all sample Authorities of that type.

To calculate the fingerprint for the Authority type for vehicle operating costs, for each road type and vehicle type:

1. Divide the total traffic by the total length of road to give the number of vehicles (A)
2. Divide the total length of road in 'red' condition by the total length of road to give the proportion of the network in poor condition (B)
3. Multiply A by B to give C, the inverse of the factor (i.e. C=)
4. Divide the vehicle operating cost by C to give the fingerprint, D, for the road type and vehicle type

To scale the values for each new Authority of that type not in the sample of 8 Authorities, for each road type and vehicle type:

5. Calculate the inverse of the factor C_N for the new Authority, following steps 1 to 3
6. Multiply D by C_N to give the vehicle operating cost for the new Authority.

The change in vehicle operating cost for the network is the sum of the change in vehicle operating costs for all Authorities, all road types and all vehicle types.

The total vehicle operating cost for the network was the sum of each of the costs for all road types and vehicle types in all Authorities (where the sample Authorities included more than one Authority of the same type, the results from each sample Authority were used in the total cost for the network, not costs derived using the representative factors for that Authority type).

L.2 Journey time costs due to reduced carriageway condition

The increase in journey time due to deterioration of the road condition has been calculated for the urban and rural A roads and each vehicle type in each of the sample Authorities. The scaled values for the entire network are therefore also estimated only for A roads in the network. For each Authority not in the sample Authorities, the representative factors for the costs, for each road type and vehicle type are calculated in the same way as the vehicle operating costs described in Section L.1.

L.3 Costs of vehicle emissions due to reduced carriageway condition

As the condition of the road surface changes, there are changes in vehicle speeds and this leads to changes in the amount of emissions (e.g. CO_2) from the vehicles. Analysis of the traffic and road conditions in the 8 sample Authorities has estimated the cost/benefit of the changes in the emissions for each combination of vehicle type and road type in each Authority type.

The effect of the change in emissions for the Authorities not in the 8 sample Authorities was estimated using the same approach as described for vehicle operating costs in Section L.1.

L.4 Journey time costs due to roadworks

In each of the 8 sample Authorities, the length treated on a road type divided by the assumed (notional) scheme length for the treatment type and road type gave an estimate of the number of schemes of that treatment type on that road type in each sample Authority.

The result from the analysis of the cost of increased journey time associated with each maintenance scheme is then used with the numbers of schemes to give the total cost of the change in journey time due to maintenance for each treatment type on each road type in each of the 8 sample Authorities. For the scaling up of these costs, the total costs for all treatment types were used for each road type.

To determine the total cost for all road types in all Authorities, an approach similar to that used for the change in vehicle operating costs due to change in road surface condition, described in Section L.1. However, rather than using the level of traffic as a prime factor in the scaling, the amount of maintenance (i.e. the number of schemes) is assumed to be related to the maintenance budget for structural maintenance.

The representative factor, for journey time costs due to roadworks, for each road type was calculated as shown in equation (K2).

$$f = 1 / [(S/L_T)(L_R/L_T)] \qquad \text{(K2)}$$

where is the structural maintenance budget (£) for 2009/10, is the total length of the road type and is the length of that road type in poor condition (i.e. categorised as red in the SRMCS report for 2009/10).

Calculation of the fingerprint for the Authority type for the costs of increased journey time for each road type was carried out as described in steps 1 to 6 in Section L.1 but using the total structural maintenance budget instead of traffic in the calculation of B in step 2.

The total cost of increased journey times due to maintenance for the network was the sum of each of the costs for all road types and vehicle types in all Authorities (where the sample Authorities included more than one Authority of the same type, the results from each sample Authority were used in the total cost for the network, not costs derived using the representative factors for that Authority type).

L.5 Costs of CO_2 from roadworks

In addition to the costs of increased journey time due to maintenance, the costs of CO_2 associated with maintenance works was also estimated for the whole network based on the results of the analyses for the 8 sample Authorities.

The amount of CO_2 is assumed to be related to the number of maintenance schemes and the costs for each road type in each of the Authorities not included in the sample Authorities was calculated in the same way as the costs of increased journey times due to maintenance described in Section L.4.

L.6 Depreciated replacement cost

The accumulated depreciation for each road type in the network in each of the 8 sample Authorities has been provided by WDM Ltd using the approach adopted for the estimate of depreciation of the road asset for the Spending review analysis in 2010.

The effect of the depreciation of the road networks in each of the Authorities not included in the 8 sample Authorities was estimated in a similar way to the approaches adopted for the other aspects of costs.

The representative factor, for the accumulated depreciation costs, for each road type was calculated as shown in equation (K3).

$$f = 1 / L_R \qquad \text{(K3)}$$

where is the length of that road type in poor condition (i.e. categorised as red in the SRMCS report for 2009/10).

To calculate the fingerprint for each road type in the Authority type divide the total depreciation cost by the total length of road in poor condition, to give the cost per kilometre of road in poor condition (D) for that Authority type.

To calculate the depreciation cost for each road type in each Authority not in the sample Authorities multiply D by the length of road in poor condition to give the depreciation cost for the non-sample Authority.

The total depreciation cost for the network was the sum of each of the costs for all road types in all Authorities (where the sample Authorities included more than one Authority of the same type, the results from each sample Authority were used in the total cost for the network, not costs derived using the representative factors for that Authority type).

Appendix M Workshop on Wider Economic Issues of Road Maintenance

Record of Meeting

Roads Maintenance Review - Wider Economic issues, impacts, costs and benefits

Workstream Meeting 7 – 18 August 2011, Perth Museum

Present Karl Johnston (KJ) Economic Adviser; Donald Morrison (DM) Head of Asset Management, Finance and Technical; Raymond Convill (RC), Trunk Roads Policy (All Transport Scotland); Jim Valentine (JV) Perth and Kinross Council, SCOTS Chair SCOTS Vice-Chair; Jane Horsburgh (JH) Mobility and Access Committee for Scotland; Iain Docherty (ID), Professor of Public Policy and Governance, University of Glasgow; John Lauder (JL), Sustrans; Keith Irving (KI) Living Streets, Scotland; Neil Greig (NG) Director of Policy and Research, Institute of Advanced Motoring; George Mair, Confederation of Passenger Transport (CPT) (part 2 only)

Richard Abell (RA), TRL

Apologies: Ewan Wallace, Aberdeenshire Council; George Eckton and Mirren Kelly (COSLA); Professor Stephen Glaister (SG), Director RAC Foundation and Professor of Transport and Infrastructure, Imperial College London; and David Eaglesham (DE), Road Haulage Association

Item 1: Welcome and Introductions

JV welcomed to Perth members of the Workstream as well as specially invited guest speakers. This meeting would have a different format with a series of presentations on roads and public realm, and Richard Abell of TRL would provide a presentation on TRL's report on "Economic Impacts of Changes in Maintenance Spend on Local Roads in Scotland". JV explained that up to this point the Workstream had had difficulty in identifying the non-measurable aspects of roads maintenance, since relatively few quantified examples exist. The purpose therefore was to seek to address this, gather examples if possible, and allow TRL to include such outcomes in its final reports for the Workstream.

The following provides a short summary of points made by each speaker. Each presentation has been forwarded to TRL for consideration in its work for the Workstream. Several common themes emerged around public involvement, "broken windows theory", and that although evidence for the benefits of public realm is lacking, this does not prevent a strong argument being put forward.

Item 2: Presentations

1. Keith Irving (KI) – Living Streets Scotland

KI said that relevant campaigning charities welcomed the Scottish Government's aim of tackling deterioration of roads and pavements due to the detrimental impact on people's quality of life, particularly as walking is the most common physical exercise, and is becoming more pertinent for Scotland's ageing population. Customer Satisfaction is a challenge. The 2006/07 Audit Commission Report showed Clean Streets 3rd and Road and Pavement Repair 13th in list of 5 most important thing for deciding where to live.

KJ pointed out that the Best Value Performance Indicator survey showing areas of public concern in the Presentation was for clean streets (graffiti and lack of cleanliness) rather than poor road surfaces. (The UK Audit Commission discontinued this data set in 2009.)

KI cited “broken windows” theory whereby as small areas of public realm deteriorate, this often leads to much greater subsequent costs, and illustrates one approach to the value placed on maintenance. As overall condition deteriorates, people feel unsafe and this deters walking. Research from Groningen, Netherlands, shows that well kept public areas had fewer incidents of dishonesty. Separately, in Edinburgh trips and falls leading to liability claims are almost ten times that of defective roads, and quantifying the impact on the NHS would be worthwhile. The Royal Mail also collects similar information on this topic. (TS Note: Do Local Authorities have similar details for staff who routinely walk, eg Traffic Wardens?)

Over 10 years, Edinburgh Council paid out £2.3m in claims from footway incidents but only £250k for claims for car damage. Compensation payments for pedestrian falls are more than £3m for 23 of the 32 Councils in Scotland.

KI said that there is also good anecdotal evidence that improved public realm leads to increases in residential and commercial property values, retailers value good footways and argued that even without firm evidence, as all appear to agree on the assertion, a strong case should be made for continued investment in roads maintenance.

2. Robert Huxford (RH) – Urban Design, Director

RH explained that walking is under-reported in survey data which excludes journeys that begin and end in the same place. He said that there is no reason why maintenance should be treated differently from other public realm policies which explicitly state that they do not just consider movement. Since design and safety are implicit in Scottish Government public realm policy, then there is no reason to exclude maintenance which performs a similar function. Roads are the “glue” that keep communities together. There are also strong connections to policies on health and obesity , as well as equalities since women will often view their public realm differently from men, primarily because of fear of crime and being alone in an unsafe environment. He said that Blackburn with Darwen Local Authority has shifted some health spend to roads winter maintenance spend to reduce accident costs. (Note: Quality of Life Section of its Local Transport Plan provides some information on the links identified between maintenance and walking:

http://www.blackburn.gov.uk/server.php?show=ConWebDoc.22943

He also suggested that existing powers for untidy buildings should be extended to roads, as there is evidence that if a private sector company owns a public realm area the maintenance rates are higher, and upkeep is to a much higher standard. Similar to the Broken Windows thesis, RH said people judge security on cues such as (roads) maintenance, and if people think others are investing in their area, this impacts on their behaviour (e.g. recycling rates are often higher in short streets).

There is good physiological evidence that a person’s brain is hard wired to appreciate green space. Evidence shows property values are higher and people are healthier near green space. The hypothesis, scientific explanation and evidence therefore combine to make the case, and without the need for surveys, individuals do have a clear impression of their local area.

RH commented on a survey that showed the public judge the need for maintenance on appearance (e.g. a heavily patched road). He also supported the 'broken windows' theory described by KI.

RH also proposed that public behaviour followed the Central Normal Theory – people adopt the behaviour of others (e.g. levels of recycling, riots).

3. Andy Clegg (AC) – Perception, Landscape and Opportunities, Perth and Kinross, Parks Development

AC highlighted how high quality public place is crucial to an area with before and after depictions of regenerated spaces. New techniques and training are required to meet standards found elsewhere in Europe, where the approach to achieving high standards of public realm appears implicit. He also considered that the value for money of maintenance works is high, but agreed this is difficult to prove and he had not seen examples where quantified benefits had been provided.

He referred to the Centre for Built Architecture's (CABE) 2007 report "Paved with Gold" which asserted that "investment in design quality brings quantifiable financial returns and that people value improvements to their streets."

http://webarchive.nationalarchives.gov.uk/20110118095356/http:/www.cabe.org.uk/publications/paved-with-gold

It also includes evidence from retailers regarding improved footfall following improvements, and additional health benefits.

Other CABE studies (2008, 2007, 2004 and 2001) had all promoted the benefits to quality of living from improved streets. A survey had shown 85% of people felt the quality of public space and the built environment had a direct impact on their lives. Design improvements are not limited to the quality of carriageways and footways but can include pedestrianisation, clearer signing, better placing for street furniture, CCTV and alcohol free zones.

AC quoted health benefits from increased walking (e.g. 1 less death per year for males aged 61-80 years with heart disease would save the NHS in Scotland £85m per year.

He then discussed landscape / scenery, formally recognised in the European Landscape Convention. Surveys confirm that Scotland's landscape is particularly important in attracting visitors, and with benefits for (and from) tourists, good quality roads are essential to reach many areas, which themselves must be in good condition. In 2009, Scottish National Heritage (SNH) has suggested a link between car tourism and visual experience but there is little evidence and this has not been quantified.

(TRL Note: The Landscape institute (2011) has looked at quantifiable benefits from the landscape but this did not separate out the effects of roads.)

Willingness to Pay criteria might be one option to explore further, though this is often related to higher value schemes, and is complex. (TRL Note: There is no evidence of completed analyses that may be relevant for this study.)

One option is to remove street clutter and replace traffic management with planted out areas that communities can manage. Shared space which focuses on essential road lines and signs helps to minimise costs, and by investing in quality and not style, there is scope to reduce long term maintenance costs. One important lesson is that the 'wants' of local people may differ from the view of planners and designers and may be cheaper.

4. John Thomson (JT) – Institute of Civil Engineers, Municipal Group

JT argued that "Effective infrastructure is invisible" and that, while in some contexts and places, low standards are acceptable, as a public area is improved, people take greater pride in their area. This in turns leads to inward migration and more successful businesses. The converse is even more significant because of the potential negative impacts. He acknowledged that it is difficult to identify when these shifts happen, and there is no clear evidence to prove the case (particularly if that case has to be made within a Finance Division of a Council) despite it being intuitively correct. JT suggested that studies had shown that when infrastructure quality has deteriorated, the costs of recovering from the deteriorated (poor) quality are much greater than the cost of maintaining the existing good quality.

RH suggested this chimed well with Public Motivation-Hygiene theory, one interpretation of which argues that "People are made dissatisfied by a bad environment, but they are seldom made satisfied by a good environment."

(TRL Note: An Australian Government website (reference not given) states a direct impact on well being from the quality of the infrastructure, but no valuation is given.)

(TS note: Not all members of the public will agree on when these points are reached on the proposed spectrum. However, there may be certain factors around which most people can agree and when a tipping point has been reached.)

5. Lindsay McGregor (LM) – SCOTS Lighting Group, Chair

LM started by expressing surprise at the apparent lack of quantified evidence for the Review.

LM explained first that Local Authorities are not legally required to provide lighting, but once installed, there is a duty to maintain it on both public and private roads. He said that there was limited evidence to demonstrate the benefits of lighting, though the assumed benefits are well accepted, and case studies do exist. For example, evidence suggests that lighting prevents road accidents, and also has spin off benefits, such as improving security and extending amenity and commercial viability of an area. Furthermore, 40% of fatal and serious accidents occur between 7pm and 8am, yet only 25% of journeys are made at this time. This suggests a correlation with darkness. (TS note: This may also be due to tiredness and alcohol.) The Cochrane Collaboration reported that a reduction of 30% in Road Traffic Accidents follows improved lighting. LM noted that 2.6% of accidents are fatal with lighting present but this rises to 4.3% without lighting.

Lighting is also considered to have an important effect in crime prevention. Painter and Farrington (2002) reported in Dudley, West Midlands, improved street lighting led to a 41% fall in recorded crime (a similar study in Stoke-on-Trent showed a decrease of 43%), which was not displaced. The regeneration of Whitehaven, Cumbria, is also considered to be related to significant improvements in lighting, and a light festival now takes place with 300,000 people attracted to the area, with commercial benefits.

It was acknowledged that there is contradictory evidence on this topic, particularly in respect of Motorways and other Trunk Roads in England from which the Highways Agency had seen no impact on accident rates from switching off lighting. (TS Note: Where traffic flows are low and safety may not be compromised. The Highways Agency applies a Midnight Switch Off in order to reduce carbon emissions rather than to achieve accident savings.)

(TRL Note: A new guidance document on street lighting (ACPO and Institute of Lighting) supports the benefits of street lighting but does not provide quantified benefits.)

6. Bruce Reekie (BR) – Perth and Kinross, Waste Services

Local authorities have a duty to keep its own land tidy by picking up litter, etc. Like others on the day, BR also cited evidence from the USA of analysis of "broken windows" theory, such as less littering behaviour, and a high correlation between clean pavements and safety. There is, however, a low association between how clean "downtown" pavements and visits to the area. Cigarettes, litter from fast food outlets as people eat on the go, fly-posting and graffiti are all recognised as negatives for the perception of an area (including to tourists). Cleaner streets formed part of the 'zero tolerance' approach in New York, USA, but in a follow-up survey, people thought too much had been spent on street cleaning and the money would have been better spent on property improvements.

BR commented on the cost impacts of maintaining good quality carriageways and footways. For example, there is also a direct link between street sweeping and grit used to keep roads and footways open during severe winter weather, and costs incurred in removing it.

BR said that when aggregated with other maintenance and management issues, street cleaning and cleanliness can impact on how attractive residents view their local areas and amenities, with impacts on business footfall and economic development.

7. John Lauder (JL) – SUSTRANs

JL said that he was greatly encouraged by the positive views that he had heard about the significance of maintaining public spaces, though presentation of the case would be important. He pointed to three of the Scottish Government's own policy objectives as making the case for road maintenance: Cycling Action Plan for Scotland (Scottish Government, 2010a); Route Map to Healthy Weight (Scottish Government, 2010c); and Climate Change Act and its 2020 Milestones (Department of Energy and Climate Change, 2008).

In his view, meeting cycling target of 10% for all trips by 2020 (currently it is 2%), and daily active travel via well maintained pavements, are needed to achieve the ambitious climate change targets set for Scotland. As to whether public realm can be maintained to existing standards, JL argued that it must, even with forthcoming budget constraints.

8. David Ubaka (DU) – Transport for London

DU said that the UK Government in 1980's made a fundamental error in failing to invest in Britain's infrastructure, and many negative consequences resulted from not taking design seriously. This lead to a determination to create a mechanism to value urban realm. The "Pedestrian Environment Review System" (PERS) is a walking audit tool that uses a qualitative system to assess the level of service and quality provided for pedestrian access across a range of pedestrian environments. It considers "links" (ie any footway, pathway or highway), crossings, routes (made up of links and crossings), public transport waiting areas, interchanges and public spaces. It also takes into account factors such as security and maintenance.

This tool enabled a monetary value to be established. One point on the PERS scale (-3 to +3 where higher scores are positive) was found to be equivalent to a 5.2% (£13,600) increase in residential prices, or 4.9% (£25 per square metre) on retail rents. Generally, property prices were found to go up by between 5% and 7% if adjacent to a park, a phenomenon termed 'value uplift'. (TRL Note These changes do not directly fit into the STAG criteria but nevertheless are economic consequences of changes in maintenance funding.)

PERS provides the evidence base for much of the maintenance and public realm work carried out by TfL. It also ascribes a value to paying for infrastructure which relates to the notion of investment by local authorities in an area, which the private sector will match. He also said work is ongoing to add an asset management aspect to PERS.

As for individual projects, TfL emphasises 3-dimensionality to ensure that utilities will first be repaired properly and require little subsequent maintenance. All disciplines involved must notify a central Board of planned works, and any related utility works are, ideally, deferred to fit the same timescale to avoid duplication (TRL Note: 45% of the cost of an improvement scheme in London was for utilities works). As lead official DU also insists that new works can be readily maintained, often with materials that can be locally sourced, and residents are consulted to determine their preferences and requirements.

DU pointed to how a downward spiral of neglect, leads to extra costs later to put right an area.

Item 3: Discussion and Questions

The Steering Group members and those who had provided presentations went onto discuss some issues raised.

In response to KJ, DU said that TfL's evaluation of the benefits of its public realm projects had been very positive (typically yielding ratios of 2.5 – 5.5) and with any indirect benefits stripped out. He also confirmed that investments are decided upon strategically to prevent nearby areas being impacted negatively; designed to get maximum benefits for London as a whole; and that policy decisions about which areas need to be targeted first are also considered. "The Cut" at Waterloo was cited as an example of a previously run down area that is now much improved after investment, and which had a beneficial ripple effect on surrounding areas to improve standards generally.

KJ asked whether any research has been carried out into whether any towns or cities where quality public realm and other cycling / walking policies have been introduced provide evidence of the benefits of the approach. RH said that it is not possible to experiment by allowing an area to deteriorate, but suggested ongoing research by Oxford Brooks University might prove useful, with DfT's sustainable travel towns - Worcester, Peterborough and Darlington - providing some evidence, as well as London where, for instance, the number of cycling journeys has increased significantly since 2000 with investment in cycle ways as well as Bike Hire schemes.

KI questioned why cycling and walking needed to prove their case. KJ said that evidence on the effects of cars and HGVs is simply more widely available. JT suggested that the question be turned round to ask what is the impact of reducing spend on maintenance / public realm. It can be difficult to separate out the impact of poor maintenance in a town or city from other negative effects which occur at the same time, say, a factory closure. Others pointed to the fact that Government policies and plans often proceed without clear evidence, such as why people in Scotland are more obese than others in the UK.

The discussion closed and JV and KJ thanked all guests for taking time to provide such valuable presentations to the Group.

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