The Indirect Costs of Deer Vehicle Collisions

Final report

Scottish Natural Heritage
All of nature for all of Scotland

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Executive Summary

Deer Vehicle Collisions (DVCs) are one of the main reasons for the unplanned interruption of network availability on Scotland's roads. In 2008, there were nearly 1,400 reported DVCs in Scotland, nearly 700 of which were on Trunk Roads. The volume of traffic and the number of wild deer in Scotland have increased significantly in recent decades, and the numbers of DVCs has been increasing accordingly.

The direct costs (of loss of life, injury and damage) of DVCs have been well documented in previous research. This report collates evidence of their indirect costs to people inconvenienced by a DVC.

This research focuses on Scotland's Trunk Road network. Whilst DVCs do occur on all classes of road, it is those on the Trunk Road that, in general, have the most severe consequences: traffic speeds are typically higher, so more serious crashes result, whilst the strategic nature of Trunk Roads means that the inconvenience to other road users is often greater.

Scotland's economy and the wellbeing of its population are dependent on its Trunk Road network. In more populous areas, many motorists rely on it to provide predictable journey times to deliver goods and meet work schedules. Surrounding communities rely on the network to ensure that strategic traffic adheres to main routes and does not adversely affect them. In more remote areas, Trunk Roads are often the only feasible routes, as such providing lifeline links for all goods and services to communities.

Types of Indirect Costs

Some DVCs will give rise to few indirect costs. If the road network is not blocked or otherwise significantly disrupted by the incident, indirect costs will be small. Many DVCs, however, will lead to a temporary blockage of, or significant disruption to, traffic flow on a link in the network. The location and nature of the collision will determine whether indirect costs occur to vehicles travelling in both or just one direction. This report considers those DVCs that will block or significantly disrupt traffic flow for a time.

The unplanned closure of Trunk Roads has substantial impacts. Trunk Road users, even if they are not involved in the incident, have their journey plans disrupted with resultant costs and inconvenience. Surrounding communities are blighted by diversionary traffic. In rural areas, communities can be severed from almost any form of connectivity, with significant impacts on residents, visitors and businesses.

Indirect costs of DVCs fall into a number of broad categories, as shown in Figure 1. These costs will accrue variously to the people travelling, their employers or residents of local communities. Not all costs will accrue to all travellers (productivity costs fall only on to hauliers or those travelling on business, for example).

Figure 1 Types of Indirect Costs

Travel time	•Time spent queuing behind DVC •Additional travel time on diversion route
Productivity costs	•Time wasted by traveller •Lost sales and business opportunities •Reduced value of goods delayed (particularly if perishable or time sensitive) •Production disruption at delivery sites for goods •Reduced custom for businesses (as potential customers delayed or turned back)
Financial costs	•Additional fuel used •Costs of rebooking missed appointments or onward connections •Sundry costs (including phone calls, food)
Environmental costs	•Increased congestion, noise and pollution on diversion routes •Increased pollution caused by queuing traffic
Other costs	•Stress/anxiety for travellers and others •Increased accident risk caused by queue or traffic on diversion route

Different people will value these costs differently. As examples, someone whose journey is particularly time critical will value any increased travel time highly but may be less concerned by limited additional financial expenses. Within surrounding communities, some residents may be particularly troubled by the increased pollution caused by diverting traffic whilst others may not.

Much of the sensitivity to these indirect costs will depend on the nature of the journey being undertaken, but will also be affected by the priorities and aptitude of the traveller.

Some indirect costs (particularly the value of time wasted because of delays, increased vehicle operating costs and increased accident risk on diversion routes) can be readily quantified using transport industry standard appraisal techniques.

Other costs (including stress and lost productivity) are much more difficult to quantify but are not considered to necessarily be less important.

Case Studies

The work has examined four case studies which explore the magnitude of indirect costs of DVCs. These case studies have been selected in order to demonstrate the diversity of the Trunk Road network in Scotland, and hence of the impacts of DVCs.

For each case study, quantitative information on the increased travel time, vehicle operating costs and increased accident risk arising from the disruption to traffic flow is presented. Other location-specific impacts are presented in a qualitative manner.

A summary of each case study is presented in Table 1. It should be noted that in each case we assume that the route is completely closed to traffic for a four-hour duration following the DVC. A DVC where the route remains open (even if delays occur) or which is closed for only a short period would have substantially lower indirect costs.

The case studies show that the extent of indirect costs will, in general, be dependent upon:

- The length of time for which the road is blocked;
- The volume of traffic on the affected route;
- The availability of convenient diversion routes; and
- The numbers of people living in communities affected on these diversion routes.

There are clear mechanisms to minimise the indirect costs of a DVC. The first of these is to prevent the DVC from occurring. Assuming that an incident has occurred, however, the indirect costs will be reduced in proportion to:

- The speed at which the network can be returned to normal operating performance; and
- The speed at which other road users, and potential users, can be informed of the incident.

Summary of the case studies

Table 1 shows a summary of the distinctive aspects of each case study.

Table 1 Case study summaries

Assumed scenario	A835 Garve – Corrieshalloch Closed in both directions for four hours, weekday from 0600	A9 Jubilee Bridge Closed in both directions for four hours, Saturday from 1100	A720 Hillend – Dreghorn Closed westbound for four hours, weekday from 0600	M8 Junctions 8 – 9 Closed westbound for four hours, weekday from 0600
Number of main route users directly affected	800	6,500	8,000	10,500
Anticipated delay per vehicle	80 minutes	>30 minutes northbound >40 minutes southbound	30 minutes	30 minutes
Quantified value of delay	£11,000	>£40,000	£80,000	£75,000
Quantified value of increased vehicle operating costs	£4,000	>£20,000	>£1,000	>£1,000
Quantified value of accident risk on diversion routes	£2,000	£15,000	£2,000	£5,000
Approximate number of residents affected by noise, poor air quality and severance on diversion routes	2,500	>10,000	17,000	Not quantified, but smaller than A720 case study

Assumed scenario	A835 Garve – Corrieshalloch Closed in both directions for four hours, weekday from 0600	A9 Jubilee Bridge Closed in both directions for four hours, Saturday from 1100	A720 Hillend – Dreghorn Closed westbound for four hours, weekday from 0600	M8 Junctions 8 – 9 Closed westbound for four hours, weekday from 0600
Main other indirect impacts	• Substantial increased costs for vehicles using diversion routes • Some road users will miss ferry sailings • Lost productivity • Reduced value of goods carried • Stress	• Diversionary routes highly unsuitable for traffic volumes • Substantial increased costs for vehicles using diversion routes • Tourist businesses to the north of the DVC likely to have significant reduction in income • Stress	• Delays caused to traffic on main routes throughout Edinburgh and beyond • Severe congestion and environmental problems in communities closest to the incident • Lost productivity • Reduced value of goods carried and delays in supply chains • Stress	Severe congestion and environmental problems on routes through east Glasgow and beyond Lost productivity Reduced value of goods carried and delays in supply chains Stress
Summary	Relatively few people affected, but very high indirect costs for each one	Many people affected on the A9 and surrounding communities. Substantially increased travel time. Likely that many people choose to travel to different destinations	Many road users affected, albeit relatively little inconvenience to each one (compared with A835 and A9 case studies). Many HGVs affected. Knock-on effects throughout much of Edinburgh and beyond	Many road users affected, albeit relatively little inconvenience to each one (compared with A835 and A9 case studies). Many HGVs affected. Knock-on effects throughout much of east Glasgow and beyond

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1 Introduction

1.1 Deer Vehicle Collisions (DVCs) are one of the main reasons for the unplanned interruption of network availability on Scotland's roads. In 2008, there were nearly 1,400 reported DVCs in Scotland. The volume of traffic and the number of wild deer in Scotland have increased significantly in recent decades, and the numbers of DVCs has been increasing accordingly.

1.2 The direct costs (of loss of life, injury and damage) of DVCs have been well documented in previous research. This report collates evidence of their indirect costs to people inconvenienced by a DVC.

1.3 This research focuses on Scotland's Trunk Road network. Whilst DVCs do occur on all classes of road, it is those on the Trunk Road that, in general, have the most severe consequences: traffic speeds are typically higher, so more serious crashes result, whilst the strategic nature of Trunk Roads means that the inconvenience to other road users is often greater.

1.4 Within this report, Chapter 2 provides the context for this research. Chapter 3 outlines what indirect costs occur and to whom they accrue, whilst Chapter 4 provides four case studies and Chapter 5 a summary.

2 Context

Scotland's Trunk Road Network

2.1 Scotland's economy and the wellbeing of its population are dependent on its Trunk Road network. In more populous areas, many motorists rely on it to provide predictable journey times to deliver goods and meet work schedules. Surrounding communities rely on the network to ensure that strategic traffic adheres to main routes and does not adversely affect them. In more remote areas, Trunk Roads are often the only feasible routes, as such providing lifeline links for all goods and services to communities.

2.2 In total, there are approximately 3,500km of Trunk Roads in Scotland. Although this represents just over 6% of the total Scottish road network, the network carries 37% of all traffic and 62% of heavy goods vehicles[1].

2.3 Those roads that are classified as Trunk are recognised to be the key strategic links, connecting Scotland's main communities with each other and to ports and the English border. The importance of maintaining these strategic links is recognised by Government, which retains control of Trunk Roads through its agency Transport Scotland, whereas responsibility for almost all other roads is passed to local authorities.

2.4 Scotland's Trunk Roads are highly diverse in their nature, from the busy motorways of the Central Belt to some relatively remote single carriageway roads in the Highlands and Argyll.

2.5 The importance of maintaining a good level of service on Trunk Roads is witnessed by the on-going investment by Government in ensuring safe and reliable journeys. Substantial investment has been made in recent years in systems to obtain timely information on road conditions and inform drivers when problems do occur.

2.6 Remote visual monitoring and automatic sensors are in place on most busy sections of the network to ensure that incidents are identified quickly. Drivers can then be informed by roadside variable message signs and by web-based information, enabling decisions to be made about journey routeing or retiming.

2.7 Transport Scotland also invests in its Incident Support Service on the busiest parts of the network. These are roving teams of staff that can "provide early support to the police and deal with emerging issues which may restrict the movement of traffic[2]".

2.8 Disruptions to levels of service on the Trunk Road network are inevitable from time to time. Any planned disruptions (mainly caused by maintenance requirements) can be designed and scheduled to minimise delay to road users. Unplanned disruptions can cause much more inconvenience (and hence indirect costs). Mainly caused by crashes and breakdowns, the nature of such incidents mean that it is difficult for other road users to plan how to respond.

2.9 DVCs cause unplanned interruption of traffic flow on Scotland's roads. In places, extensive investment has been made to reduce the likelihood of DVCs occurring.

[1] Source: Transport Scotland
[2] Ibid

DVCs and where they occur

2.10 The incidence of DVCs is being investigated thoroughly by others[3]. Interim findings from this work acknowledge that there are sometimes problems with identifying the total number of DVCs, as those recording road accidents may not always fully record the nature of the incident.

2.11 The best estimates show, however, that there were nearly 1,400 DVCs in Scotland in 2008. This is an almost identical number to the average in the six years to 2008.

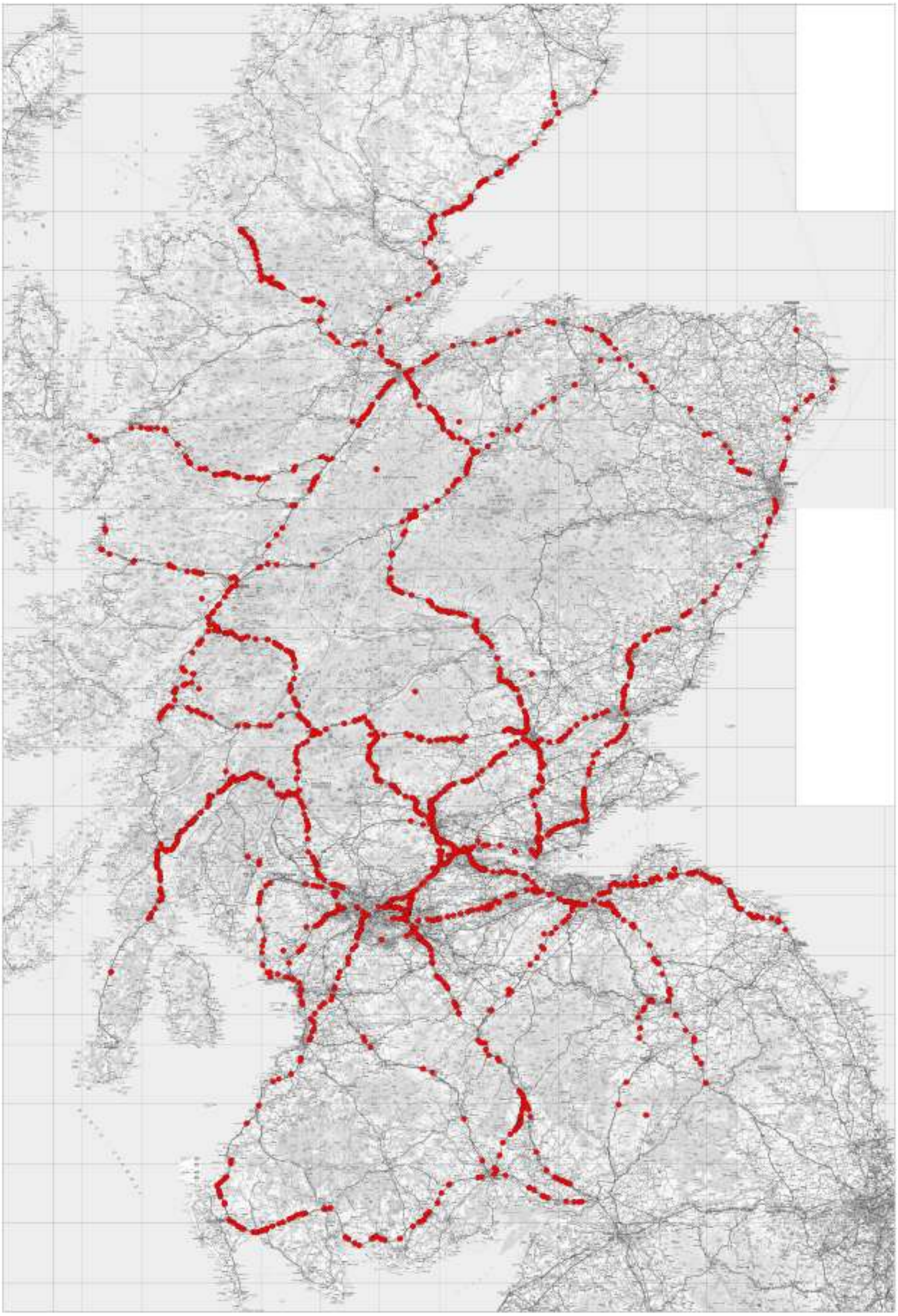
2.12 Nearly 700 DVCs occurred in 2009 on the Trunk Road network.

2.13 Figure 2.1 shows the locations of recorded DVCs on the Trunk Road network since 2001. It shows that DVCs occur on almost all parts of the network throughout Scotland, both in more relatively remote and populous areas.

2.14 The distribution of DVCs is described by the Monitoring Project: “In broad terms it is apparent that many of the highest concentrations of DVCs overall occur near major cities and conurbations, including the Central Belt around Glasgow, and near Perth, Aberdeen and Dundee. Here the relatively high traffic flows inevitably contribute to overall highest numbers of not only DVCs but road accidents in general. In other words this serves to highlight in the first instance that the risk for any one deer being hit is inevitably greater in areas with high traffic volumes, and such areas are likely to record overall highest numbers of deer road casualties. On the other hand the risk to individual motorists being in a collision with a deer will tend to be greatest where roads lead through areas of relative high deer population density.”

[3] Deer Vehicle Collisions in Scotland Monitoring Project 2008-2011, The Deer Initiative on behalf of Scottish Natural Heritage

Figure 2.1 Location of DVCs on Scottish Trunk Roads 2001-2009



Data collated by The Deer Initiative

3 How Indirect Costs Arise

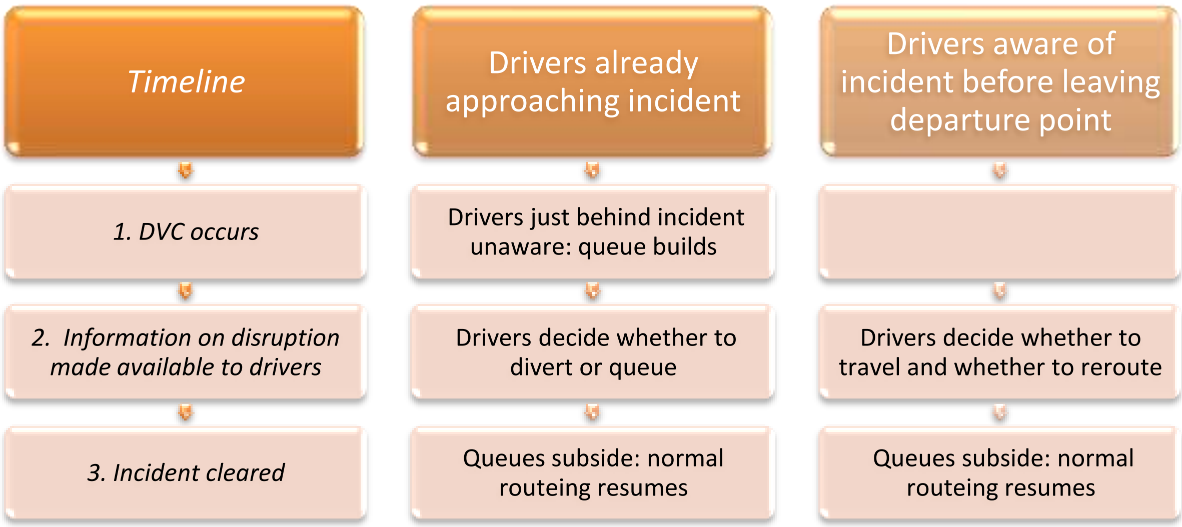
3.1 The direct costs to people involved in, or responsible for recovery operations from, DVCs have been well quantified previously. This review focuses on identifying the indirect costs to others. ‘Costs’ include financial impacts but also increased travel time or other forms of inconvenience.

3.2 Some DVCs will give rise to few indirect costs. If the road network is not blocked or otherwise significantly disrupted by the incident, indirect costs will be small. Many DVCs, however, will lead to a temporary blockage of, or significant disruption to, traffic flow on a link in the network. The location and nature of the collision will determine whether indirect costs occur to vehicles travelling in both or just one direction. This report considers those DVCs that will block or significantly disrupt traffic flow for a time.

3.3 The unplanned closure of Trunk Roads has substantial impacts. Trunk Road users, even if they are not involved in the incident, have their journey plans disrupted with resultant costs and inconvenience. Surrounding communities are blighted by diversionary traffic. In rural areas, communities can be severed from almost any form of connectivity, with significant impacts on residents, visitors and businesses.

3.4 Individual road users will be affected in different ways, depending on how soon after the occurrence of the incident they arrive at the scene and if they are aware of it before they do so. Figure 3.1 shows the three main stages of the incident and how drivers will be affected.

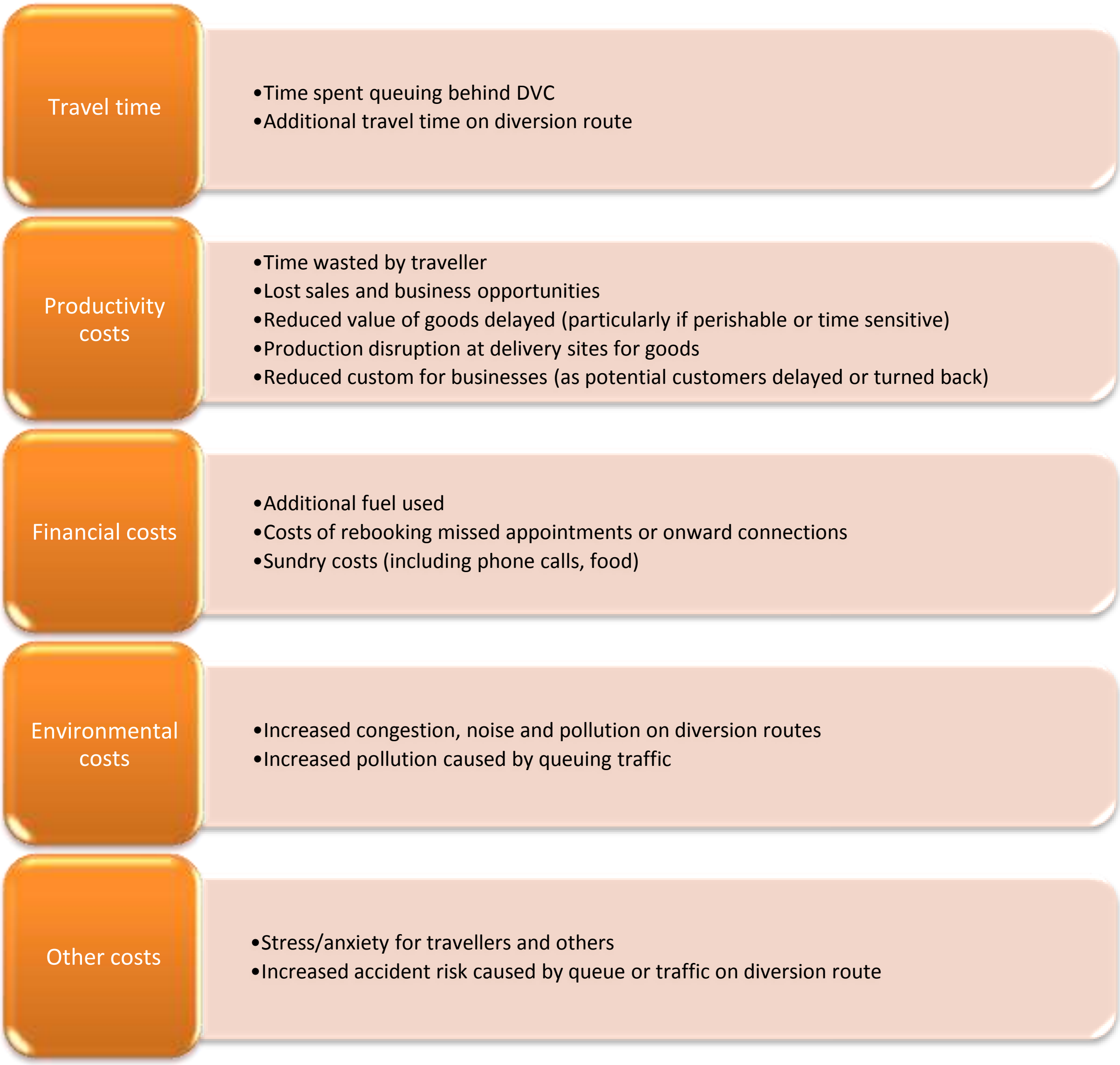
Figure 3.1 Timeline of a DVC



Types of Indirect Costs

3.5 Indirect costs of DVCs fall into a number of broad categories, as shown in Figure 3.2. Not all costs will accrue to all travellers (productivity costs fall only on to hauliers or those travelling on business, for example). Some costs do not occur to people travelling but to residents of neighbouring communities.

Figure 3.2 Types of Indirect Costs

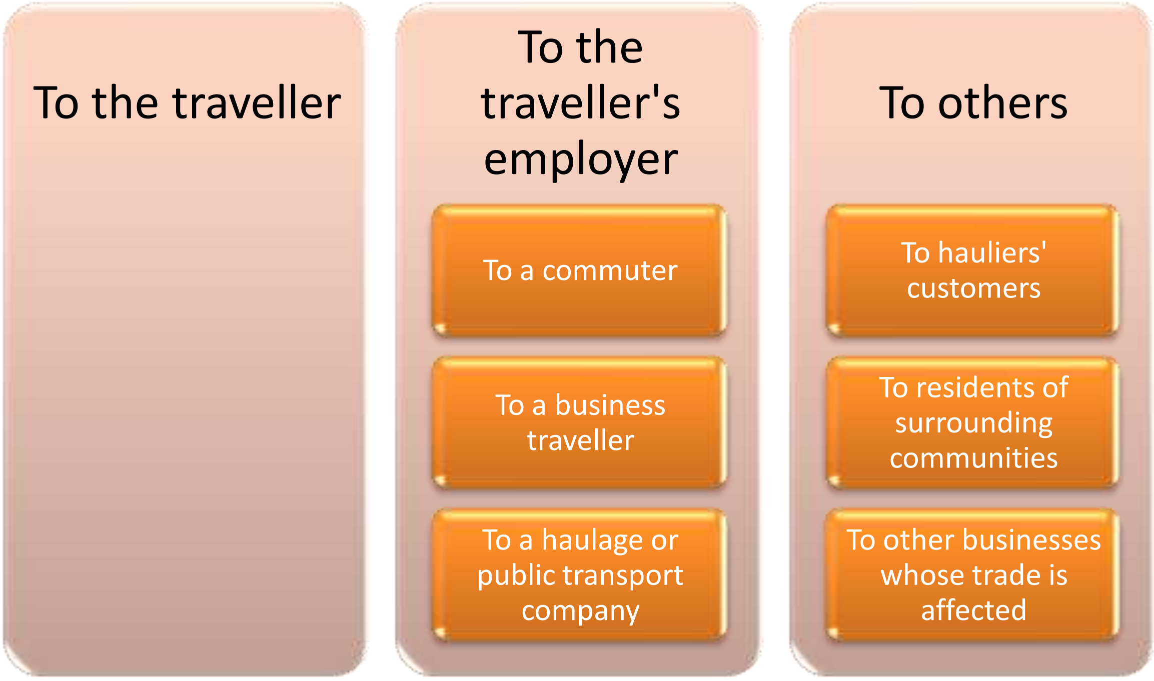


3.6 Most of these indirect costs accrue in the vicinity of the DVC. Some costs, however, are felt over a large area, as potentially the destination point for every journey.

To Whom Costs Accrue

3.7 Broadly, indirect costs affect three categories of people and businesses, as summarised in Figure 3.3:

Figure 3.3 To Whom Costs Accrue



3.8 Both the nature and magnitude of the indirect costs will depend upon when the traveller becomes aware of the incident, broadly categorised as:

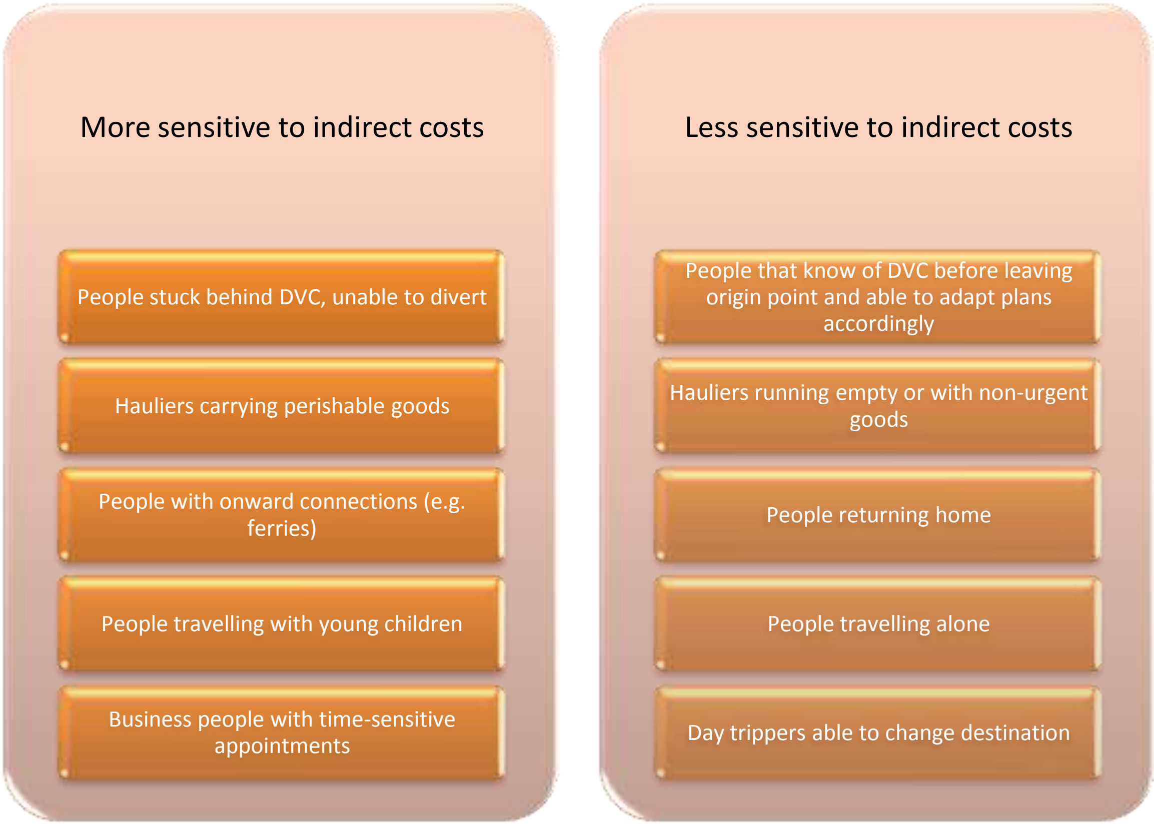
- Shortly after the DVC has occurred, so the traveller is stuck behind the incident, waiting for the road to be cleared;
- A little later, so that the traveller is *en route* before the incident occurs but is made aware of it, so can choose to reroute; of
- Before leaving the origin point, so a decision can be made as to whether to travel and, if so, by which route.

3.9 Furthermore, different people will value these costs differently.

3.10 As examples, someone whose journey is particularly time critical will value any increased travel time highly but may be less concerned by limited additional financial expenses. Within surrounding communities, some residents may be particularly troubled by the increased pollution caused by diverting traffic whilst others may not.

3.11 Much of the sensitivity to these indirect costs will depend on the nature of the journey being undertaken, but will also be affected by the priorities and aptitude of the traveller. Figure 3.4 provides examples of people more or less sensitive to indirect costs.

Figure 3.4 Sensitivity to Indirect Costs



Quantifying Indirect Costs

3.12 The diversity of indirect costs and that the same costs have different values to different people mean that it is unfeasible to attempt to fully quantify them. Furthermore, some costs (such as increased stress) cannot be reliably quantified.

3.13 However, there are some indirect costs for which industry-standard values are available and these are outlined below.

Value of Time

3.14 The value of travellers' time has frequently been used as a major justification for investment in transport schemes. The rationale for this is that people are seen to be able to do something more valuable than travelling with their time, so there is a benefit to them and to society at large if less time is spent travelling.

3.15 The Scottish Transport Appraisal Guidance (STAG)[4] provides values of time to be used in transport appraisals that require Scottish Government funding or approval. This suggests use of the following values of time (in 2002 prices) for people that are travelling during working time:

- For a car driver: £26.43 per hour
- For a car passenger: £18.94 per hour
- For a lorry or bus/coach driver: £10.18 per hour

[4] Available at http://www.transportscotland.gov.uk/stag/home

- For a bus/coach passenger: £20.22 per hour

3.16 For people that are travelling outwith work time, suggested values are independent of mode and are:

- For commuters: £5.04 per hour
- For other journeys: £4.46 per hour

3.17 STAG provides further information on typical vehicle occupancies (average number of people per vehicle) and proportion of travellers that are in work time, commuting or travelling for other purposes, in order that average values can be estimated for different vehicle types and at different times of day.

3.18 This provides, though, overall average figures for the value of delay (in 2002 prices) to a vehicle:

- Average car: £10.46 per hour
- Average light goods vehicle: £11.63 per hour
- Average other goods vehicle: £10.18 per hour
- Average bus/coach: £71.62 per hour.

3.19 Note that these figures relate only to the value of time of vehicle occupants; vehicle operating costs and the value of delays to goods carried are excluded.

3.20 It should also be noted that it is likely that these figures underestimate values of time in the case of DVCs. Evidence from public transport forecasting suggests that people value the time waiting due to an unexpected delay is around double that of anticipated journey time[5]. We anticipate that a similar proportion would apply to motorists. Nevertheless, in the case studies presented later in this report, we use the standard values from STAG in order to provide a robust assessment.

Vehicle operating costs

3.21 STAG provides a formula for estimating vehicle operating costs, based primarily on the speed at which the vehicle is travelling.

3.22 As examples, operating costs per kilometre for a car travelling at 60mph are stated to be 10.5 pence and 11.3 pence at 70 mph.

Environmental impacts

3.23 Environmental costs will occur within communities that may suffer from diversionary traffic in the event of a DVC. This traffic, and the resulting congestion, may cause problems for air quality, noise and severance (when traffic volumes and speeds mean that people are less able to move about within their communities).

3.24 The Institute of Environment Management and Assessment (IEMA) sets a 10% threshold for the increase (or decrease) in traffic causing a significant impact on air quality[6].

3.25 IEMA also states that a significant change in perceived noise levels will typically occur when traffic level change by 25%.

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[5] The Demand for Public Transport: a practical guide. TRL

[6] Guidelines for Environmental Impact Assessment, The Institute of Environment Management and Assessment (IEMA)

3.26 Quantification of these effects will depend largely on the populations of the communities affected, and also whether there are any particularly sensitive receptors (schools, for example) within them.

3.27 Whether community severance is affected significantly will depend on a complex range of local factors, including traffic flow, speed, road layout and availability of formalised pedestrian crossing facilities. However, the IEMA suggests that typically a 30% change in traffic flow on through a community will result in a significant change in severance.

3.28 Additionally, the increased congestion on diversion routes will increase travel time and inconvenience to users of these routes. This can spread the traffic impacts of the DVC far from the site of the incident.

Road Safety

3.29 Trunk Roads are, in general, much safer than other road types for a given volume of traffic. The closure of a Trunk Road (following a DVC, for example) is likely to result in the transfer of at least some traffic wishing to avoid the incident to less safe roads.

3.30 The likelihood of an accident occurring is commonly expressed in accidents per million vehicle-km[7]. Accidents that are appraised in transport investments relate predominantly to those in which personal injury is sustained by those involved (personal injury accidents, PIAs). Industry-standard accident rates (for all accidents, not just those involving deer) are:

- Motorway: 0.098 PIA per million veh-km
- Rural good single carriageway (typical of many non-motorway Trunk Roads): 0.190 PIA per million veh-km
- Rural poor single (typical of many potential diversion routes outwith settlements): 0.404 PIA per million veh-km
- Urban single carriageway (typical of many potential diversion routes through settlements): 0.844 PIA per million veh-km[8].

3.31 It can therefore be seen that transfer of traffic from Trunk Roads to typical diversion routes will result in a significantly increased likelihood of accidents occurring.

3.32 Industry standard values for the average financial costs of a PIA are £86,000 if it occurs on a motorway, £96,000 on a dual carriageway and £129,000 for other types of road[9].

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[7] This provides a measure of the risk of an incident occurring depending on the volume of traffic on a road and its length.
[8] Design Manual for Roads and Bridges. Volume 15: Economic Assessment of Road Schemes in Scotland. Section 1: the NESA Manual. July 2005.
[9] Ibid

Minimising Indirect Costs

3.33 The types and magnitude of indirect costs of DVCs are outlined above. The extent of these costs will be dependent upon:

- The length of time for which the road is blocked;
- The volume of traffic on the affected route;
- The availability of convenient diversion routes; and
- The numbers of people living in communities affected on these diversion routes.

3.34 In broad terms, it is anticipated that a typical DVC on a busy route in the vicinity of one of Scotland’s conurbations will affect a large number of road users, but the impact per user will be relatively small as information can be provided relatively readily and diversionary route options are available. In remote rural areas, many fewer road users will be affected but the lack of diversionary routes mean than the impact per user will be large.

3.35 There are clear mechanisms to minimise the impacts of a DVC. The first of these is to prevent the DVC from occurring. Assuming that an incident has occurred, however, the indirect costs will be reduced in proportion to:

- The speed at which the network can be returned to normal operating performance; and
- The speed at which other road users, and potential users, can be informed of the incident.

Summary

3.36 DVCs create a wide variety of indirect costs. These affect road users and non-users in a variety of often subtle ways. Moreover, different people will value the same indirect costs in different ways.

4 Case Studies

4.1 In this section, we present four case studies which explore the magnitude of indirect costs of DVCs. These case studies have been selected in order to demonstrate the diversity of the Trunk Road network in Scotland, and hence of the impacts of DVCs.

4.2 For each case study, quantitative estimates of the increased travel time, vehicle operating costs and increased accident risk arising from the disruption to traffic flow is presented. Other location-specific impacts are presented in a qualitative manner.

4.3 It should be noted that, whilst detailed traffic flow information for the roads where the DVC case studies are located has been used, we have not had access to detailed traffic models for this review. The impacts presented are, therefore, estimates only; more work would be required should the business case wish to be established for investing in measures to reduce the number or severity of DVCs at these, or any other, location. In every instance, however, we have tried to provide robust estimates; the full indirect costs of DVCs are likely to be greater than those shown.

4.4 It should be noted, however, that in each case we assume that the route is completely closed to traffic for a four-hour duration following the DVC. A DVC where the route remains open (even if delays occur) or which is closed for only a short period would have substantially lower indirect costs.

4.5 A list of the assumptions and calculations made for these case studies is contained in Appendix A.

A835: Garve – Corrieshalloch

Site description

4.6 The A835 links Inverness to Ullapool. As such, it provides the main link from the communities of Wester Ross, southern Sutherland and, by ferry, much of Lewis to the main service centre of Inverness and onwards to the rest of the UK. It is single carriageway throughout (to where it links with the A9 at Tore). Traffic flows are generally light and congestion rare, though platooning of traffic is common following arrival of a ferry at Ullapool.

4.7 For the 54km section of the A835 from Ullapool to the junction with the A834 near Strathpeffer, there are no convenient diversion routes; the only alternatives are to travel south via the A832 through Gairloch (adding around 110km to the journey) or north to Ledmore and the A837 (around 30km additional distance, but much of this is on single-track roads, highly unsuitable for carrying significant volumes of traffic).

4.8 The scenario being tested is that the road is closed in both directions for four hours following a DVC at 0600 on a weekday between Garve and Corrieshalloch.

Incidence of DVCs

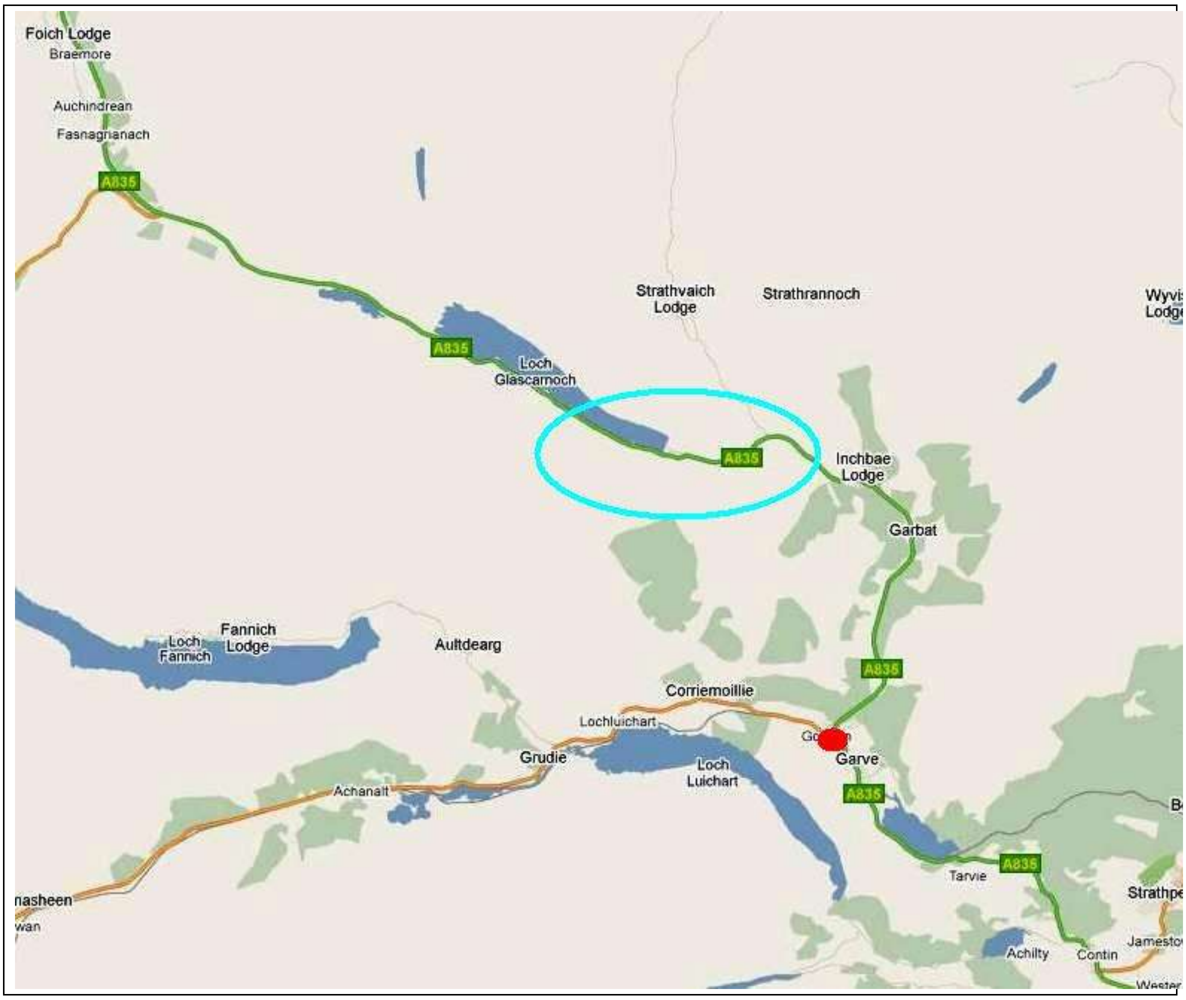
4.9 There were 103 DVCs on the A835 between 2001 and 2010; 10.3 DVCs per year.

Existing traffic flows

4.10 Traffic flow data for September 2010 was obtained for an automatic traffic counter (ATC) on the A835 to the north of Garve. The location of the ATC (red dot) is indicated in Figure 4.1. The location of the DVC case study is approximate (blue circle).

4.11 The average weekday traffic flow is just over 3,600 vehicles in both directions combined. The number of vehicles that would usually travel on the A835 between 0600 and 1000 on a weekday is estimated at around 800 in both directions combined.

Figure 4.1 A835 case study location



Costs of delay and diversion

4.12 For most vehicles that become aware of the incident, the most appropriate diversion route is via Gairloch. This adds an estimated 80 minutes to the journey time for each vehicle.

4.13 We recognise that not every vehicle will incur all of the delay time: some will be aware of the incident before commencing their journey. Other road users, however, will suffer delay greater than 80 minutes, if they arrive at the site of the incident without prior knowledge so either have to wait for it to be cleared or turn round then use the diversion route. We therefore take 80 minutes to be a reasonable average for the delay for each vehicle.

4.14 Total additional journey time for the 800 affected vehicles would be over 1,000 vehicle-hours.

4.15 Assuming an average value of time of vehicle occupants of £10.50 per hour per vehicle (using information presented in section 3 of this report) the value of time of this delay is therefore nearly £11,000 for this one DVC.

4.16 The increased travel distance of the diversion route will also increase vehicle operating costs. The estimated average increase in operating costs per vehicle that chooses to divert is approximately £11. Not all vehicles will divert, of course; some road users will retime their journeys, others will wait on the A835 for the incident to be cleared. If, however, half of the 800 vehicles did take the diversion route, total additional travel costs caused by the DVC would be approximately £4,000.

Accident risk

4.17 The length of the A835 between Garve and Corrieshalloch is around 32 km whilst the diversion route on the A832 is around in 140km. In addition to the longer route length, the A832 is a lower standard of road than the A835, both of these factors lead to an increased risk of accidents on the diversion route.

4.18 Using the standard rates for accidents per million vehicle-km presented in chapter 3, 400 vehicles[10] travelling between Garve and Corrieshalloch on the A835 could be expected to suffer 0.002 PIAs (so one accident affecting these vehicles every 500 days).

4.19 This same traffic on the longer and less safe diversion route would be expected to have 0.012 PIAs (one accident every 80 days).

4.20 The DVC is therefore expected to cause around 0.014 additional PIAs. The average cost of this equates to nearly £2,000.

Ferry Disruptions

4.21 Vehicles use the A835 to access the Ullapool ferry port for onward travel to Lewis. This ferry crossing has two crossings daily and therefore a significant delay on the A835 could potentially result in ferry passengers missing their boarding times. Closure of the A835 from 0600 – 1000 would impact on most of those passengers aiming to catch the 1025 sailing from Ullapool. Few of these passengers are likely to have sufficient spare time in their journey to complete the diversion route and still catch the boat.

4.22 Those that do miss the ferry will face a seven-hour delay, the next departure not being till 1735. Furthermore, the capacity of the next sailing is unlikely to be sufficient to cater for a large number of delayed vehicles; some passengers therefore potentially face a delay of a full day as a result of the DVC.

4.23 The closure of the A835 would also result in some delay for those people alighting from the ferry on the 0945 arrival at Ullapool.

4.24 A DVC at different times of day would have substantially different impacts on ferry traffic. The closure of the A835 in the late afternoon would significantly delay traffic arriving from the 1635 arrival at Ullapool. As well as the costs of delay occurring to all users, this sailing is commonly used by lorries carrying products from Lewis's aquaculture industry. A significant delay to these vehicles will result in their products missing scheduled delivery times at markets throughout Europe. At worst, this will result in the rejection of the entire load.

4.25 The impact of the road closure will vary depending upon the time of year and number of tourists using this route to access ferries.

[10] Assuming that half of the 800 vehicles affected make use of the diversionary route

Impacts on communities

4.26 The diversion of traffic onto the A832 would affect the populations of the towns and villages located on this route. The largest community to be affected by the route diversion is Gairloch with a population of around 2,300. There are approximately 20 other small communities located on this route, each with small populations.

4.27 We do not have existing traffic flow information through the communities to accurately determine the impacts of diversionary traffic upon them. However, we can establish that:

- Residents of these communities will suffer from significantly worsened air quality (as traffic is anticipated to increase by more than 10%);
- Some may be inconvenienced by increased traffic noise (as traffic may increase by more than 25%); and
- Some will suffer from increased severance (as traffic may increase by more than 30%).

Tourist Impact

4.28 During the summer months, a high proportion of the traffic on the A835 is tourists and therefore food establishments and hotel accommodation have opened along this route to service this trade. Temporary closure of this route due to DVCs potentially reduces the number of tourists using this route and then has a negative economic impact. However, there are relatively few businesses along the part affected by the closure in this case study, but more on the lengthy diversionary route.

4.29 Given that few tourists will be close enough to home to choose not to travel, there may in fact be a new increase in tourist expenditure in businesses on the mainland. The commensurate reduction may be felt by businesses further north and on Lewis.

Summary of Case Study

4.30 A DVC that closes the A835 to traffic for four hours on a weekday morning would inconvenience relatively few road users and relatively few residents of surrounding communities.

4.31 However, the impacts per person affected would be substantial. Road users would experience a delay of more than an hour, and those choosing to use diversion routes would incur significant additional travel costs and face an increased accident risk. The value of this delay, vehicle operating cost and the accidents would be over £15,000, assuming that the road is closed for four hours. Other indirect costs (including lost productivity, reduced value of goods and stress) are not accounted for in this total.

4.32 Motorists heading for the morning ferry departure from Ullapool would be most inconvenienced; there is a high probability that many would miss their sailing and face a delay of at least seven hours (this not quantified in the value of delay presented above).

4.33 People living in the communities on diversionary routes would be affected by increased air pollution from vehicles and may suffer from more noise or severance problems. Some businesses in these communities (particularly those selling fuel or food) may, however, benefit from increased sales.

A9 at Jubilee Bridge

Site description

4.34 The Jubilee Bridge enables the A9 to span the Tay just north of Dunkeld. The A9 is the main link from much of northern Scotland to the Central Belt. At this location, it is a wide single carriageway. Congestion is rare, but traffic volumes are relatively high for this standard of road.

4.35 The scenario being tested is that the road is closed in both directions at the junction of the A9 with the B898 Dalguise road (just south of the Jubilee Bridge) for four hours on a peak summer weekend.

4.36 Immediately following the recent tragic accident at this location, separate diversion routes were set up for north- and south-bound traffic. That for northbound was from Perth to Gilmerton on the A85, then north to Aberfeldy on the A822 and A826 and then to the A9 at Ballanluig. South-bound traffic was instructed to leave the A9 north of Pitlochry, pass through the town, then use the A924 and A93 to Perth, passing through Blairgowrie.

4.37 In each case, substantial delays were incurred by drivers due to the unsuitability of the routes to cater for large volumes of traffic, much of this being large vehicles. The northbound diversion adds 29km to the route of the A9; the south-bound around 34km.

Incidence of DVC

4.38 There were 198 DVCs along the A9 between Perth and Inverness between 2001 and 2010, i.e. 19.8 DVCs per year.

Existing traffic flows

4.39 Traffic flow data for September 2010 was obtained for an ATC counter on the A9 to the south of Ballanluig. The locations of the ATC (red dot) and the DVC case study (red arrow) are indicated in Figure 4.2.

4.40 The average total daily traffic flow (Monday to Sunday) at this location is just under 10,000 vehicles per direction. The proportion of HGVs is 29% of total traffic.

4.41 The number of vehicles that would usually travel on the A9 between 1100 and 1500 on a Saturday has been estimated at around 6,500 (in both directions combined).

Figure 4.2 A9 case study location

Costs of delay and diversion

4.42 Free-flow journey times from Dunkeld to Ballinluig on the A9 are typically around ten minutes for the 13km journey. Similar free-flow journey times on the 42km northbound diversionary route via Aberfeldy are around 40 minutes. Diversionary traffic would therefore face an increased journey time of at least 30 minutes[11].

4.43 The southbound diversion would present travellers with a journey of between Ballinluig and Perth of 76km taking at least 75 minutes, in comparison with 42km and around 35 minutes on the A9.

[11] Given the anticipated severe congestion that would arise on the diversion routes in this case study, it is likely that journey times would be substantially greater than the free-flow ones shown here. We use the free-flow times to calculate the costs of delay, however, in order to provide robust estimates.

4.44 Assuming 3,250 vehicles are affected in each direction, total additional delay to northbound travellers would be at least 1,600 hours of additional delay; that to southbound travellers over 2,000 hours.

4.45 The total value of this time (assuming £10.50 per hour per vehicle) is at around £40,000.

4.46 Further delays would occur to those vehicles not intending to use the A9, but delayed by congestion on the diversion routes. The extent of these delays could be significant, particularly where the southbound diversion route passes through Blairgowrie and Perth.

4.47 The increased vehicle operating costs of the vehicles taking the lengthy diversion routes as a result of the DVC would be over £20,000.

Accident Risk

4.48 The diversions will increase accident risk as trip distances are longer and also roads are of a lower standard.

4.49 The 6,500 vehicles travelling on the parts of the A9 that would be closed by the DVC would expect to incur an average of 0.04 PIAs in total. The same traffic using the longer and less safe diversion routes would be expected to have 0.16 PIAs.

4.50 The closure of the A9 due to the DVC would therefore be expected to generate an additional 0.12 PIAs. The value of these would be over £15,000.

Impacts on communities

4.51 Many communities would be affected by the diversion of A9 traffic onto the diversion routes. The largest community to be affected by the northbound route diversion is Aberfeldy, however there are seven other small villages along this route which would also be affected.

4.52 The largest community to be affected by the southern route diversion is Blairgowrie. The Dundee Road corridor in Perth (that part east of the river) would also be significantly affected.

Table 4.1 Population in major towns located on diversion routes

Town	Population affected by traffic on diversionary routes	Notes
Northbound diversion		
Aberfeldy	1,900	
Grandtully	750	
Southbound diversion		
Pitlochry	1,300	Estimated 50% of total population of 2,600
Blairgowrie	2,400	Estimated 30% of total population of 8,000
Perth	4,500	Estimated 10% of total population of 45,000

4.53 In total, at least 2,500 people would be affected by traffic using the northbound diversion route and a further 8,000 on the southbound diversion.

4.54 We do not have existing traffic flow information through the communities to accurately determine the impacts of diversionary traffic upon them. However, the traffic flows on the A9 will be greater than existing flows through all the communities affected, with the possible exception of the A93 through Perth. Therefore residents of these communities:

- Will suffer from significantly worsened air quality (as traffic is anticipated to increase by more than 10%);
- Will be inconvenienced by increased traffic noise (as traffic may increase by more than 25%); and
- Will suffer from increased severance (as traffic may increase by more than 30%).

4.55 Furthermore, the diverting traffic will cause substantial congestion in the communities, causing significant problems for road users.

4.56 Additionally, whilst this section has focussed on those communities on the anticipated recommended diversionary routes, there would be other, second order, impacts as traffic wishing to use these routes diverted elsewhere.

Tourist Impact

4.57 This section of the A9 is a key route for tourists travelling to Pitlochry, further north to access the Cairngorms National Park and other destinations in northern Scotland. A significant proportion of traffic on the A9 at summer weekends will comprise day-trippers from the Central Belt of Scotland. These people will have a large amount of discretion about where they travel available to them. If they find the A9 is closed, many will choose to go elsewhere, rather than wait for the road to reopen or face a lengthy delay to reach their intended destination.

4.58 Many tourist attractions, in particular those just north of the closure, could therefore see a substantial fall in visitor numbers on the day of the DVC. This could have a significant economic impact in Pitlochry, for example.

4.59 In part, this impact may be partly offset by southbound travellers stopping in the town. There would also be a commensurate increase in visitor numbers to the south of the blockage. In the instance of a DVC at Jubilee Bridge, tourist businesses near Dunkeld and Perth may expect to benefit.

4.60 This diversion away from the strategic route presented opportunities for more tourism spend along the diversion routes, therefore having positive impacts on the local economy, such as hotel and retail industries.

Summary of Case Study

4.61 A DVC occurring on the A9 at Jubilee Bridge would generate substantial indirect costs. Around 6,500 users of the A9 would be affected. The value of the delay, extra vehicle operating costs and accidents that they would incur would be at least £75,000 for the one DVC, assuming that the road is closed for four hours. As these estimates do not account for congestion or the impacts to users of other routes, the total cost is likely to be much greater than this. Other indirect costs (including lost productivity, reduced value of goods and stress) are also not accounted for in this total.

4.62 The inappropriateness of the diversion routes mean that the impacts on the communities affected would be severe. Over 10,000 people could be affected by problems with noise, air quality and severance within their communities.

4.63 The discretionary nature of many of the journeys being undertaken on the A9 at weekends means that many businesses (particularly those to the north of the incident that would suffer from a reduction in day-trippers from the central belt) could suffer from a significant reduction in takings. However, some businesses on the diversionary routes would receive a corresponding benefit.

4.64 The analysis undertaken in this study indicates that the number of people that are likely to be affected by a DVC on the A9 would be relatively high and that the impact on each road user is substantial.

4.65 A DVC on the A9 would also impose other negative impacts on road users and local communities. Use of the lower standard diversion route would add increased accident risk as would the increased travel distance. The increased traffic flow on the route could cause potential severance, noise and air quality problems, which add to the indirect costs.

A720: Hillend – Dreghorn

Site description

4.66 The A720 forms the Edinburgh City Bypass. It runs close to the outer suburbs of the city and links the main radial routes. It is dual carriageway with two lanes in each direction throughout. It forms a major strategic route (from eastern England, East Lothian and the Borders to all of north and west Scotland), but also acts as a regional distributor, linking parts of the city and nearby communities. The route is busy and often congested at peak times.

4.67 Junctions are relatively closely spaced throughout and nearby urban distributor roads mean that diversionary routes are readily available for most sections. These alternatives are highly unsuited to carrying large volumes of strategic traffic, however, and any incident on the A720 can cause significant traffic disruption elsewhere.

4.68 The scenario being tested is a DVC on the westbound A720 between the Hillend (A702) junction and Dreghorn (the next junction west), and assumes that the route is closed for four hours from 0600 on a weekday morning. We assume that eastbound traffic flow is unaffected.

4.69 The primary diversion route around this link (via the A702 and B701 Oxgangs Road) adds only approximately one kilometre to total travel distance. It is, however, entirely incapable of catering for the volume of traffic that would seek to use it. Congestion would result on many of the main routes through the city as drivers sought alternatives.

Incidence of DVCs

4.70 There were 21 DVCs along the A720 between 2001 and 2010, i.e. 2.1 DVCs per year.

Existing traffic flow

4.71 Traffic flow data for September 2010 was obtained for an ATC counter on the A720 between the two junctions. The locations of the ATC (red dot) and the DVC case study (red arrow) are indicated in Figure 4.3.

4.72 The average weekday westbound traffic flow is 38,000 vehicles. The average proportion of HGVs is 20%, though would be lower during the AM peak period. Average weekday AM peak hour flow is 3,000.

4.73 We estimate that flow in the four hours of the case study would be 8,000 vehicles.

Figure 4.3 A720 case study location

Costs of delay and diversion

4.74 The diversion route (via the A702 and B701 Oxgangs Road) adds only a short distance to total travel and therefore, if this route was clear of traffic, the diversion would increase the average journey time on the closed section from around one minute to approximately four minutes.

4.75 However, the low capacity of the diversion route means that much greater delay would be incurred in the event of closure of the A720.

4.76 Congestion would build rapidly following a closure. Given the availability of driver information systems (including motorway signs and radio announcements) we assume that many drivers on the A720 would be aware of the incident in advance. This, and that queues would rapidly tail back to the Straiton (A701) junction, would encourage many motorists to leave the bypass and take alternative routes through city streets.

4.77 Many thousands of road users on other streets in Edinburgh would then have their journeys delayed by the diverting traffic. This would create increased congestion on most main routes in the city for the duration of the incident.

4.78 A number of bus routes would also be affected. Parts of the primary diversion route are used by three Lothian Buses routes as well as those operating between Edinburgh and Dumfries. The delays to buses in the area of the city bypass would create knock-on delay to their operations, and so to passenger journeys, throughout their routes.

4.79 In order to understand the impacts of a closure of the A720 fully, a traffic model would be required, but estimates are made here.

4.80 It is our view that the average increase in journey times for bypass users would be at least 30 minutes. The value of this delay to the 8,000 such users (assuming £10.50 per vehicle per hour) would be over £40,000.

4.81 We estimate that the total travel time delay caused by diverting traffic to non-bypass users would be of at least the same order of magnitude as that to the bypass users; we therefore estimate the value of increased travel time to be at least £80,000.

4.82 The delay to journey time would be inconvenient to all those people affected. The nature of the traffic on the route at the time of the DVC is that it would predominantly be people making commute and escort (particularly to school) journeys that are affected.

4.83 An average delay of 30 minutes to these journeys will clearly have significant consequences for some of these travellers. Many others, however, will actually suffer little in the way of inconvenience. A large number of employers will suffer from a, mostly small, reduction in productivity as a result of the DVC.

4.84 A large number of freight vehicles will also be delayed. At this time of day, these delays may be particularly severe for those attempting to make deliveries to retail sites before the busiest part of the trading day.

4.85 There would be some increase in vehicle operating costs as a result of the congestion.

4.86 The increase in vehicle operating costs caused by increased travel distance is around £1,000. However, this is likely to be a significant underestimate of the total, as the costs of increased acceleration and deceleration by queuing traffic is not included.

Accident Risk

4.87 Estimation of the increased accident risk has been made assuming that all 8,000 vehicles transfer from the relatively safe 2km dual-carriageway A720 to the 3km diversion route on surrounding residential streets. Although we are aware that this diversion route does not have the capacity to cater for all this traffic, we consider this to be a reasonable proxy for traffic distribution throughout the urban network.

4.88 The diversion route is likely to increase accident risk as there will be more conflict with pedestrians and cyclists in the urban settlements. Accident rates for the A720 are anticipated to be around 0.098 PIA per million veh-km and those on the diversion route 0.844 PIA per million veh-km.

4.89 These vehicles travelling on the A720 would therefore expect to incur around 0.002 PIAs. If all transferred to the diversion route, 0.020 PIAs would be expected. The cost of these increased accidents is approximately £2,000.

Impact on communities

4.90 The closure of the Edinburgh city bypass in the morning peak period would cause traffic disruption and diversion on many of the main routes in the city. Those streets in the vicinity of the closure are likely to experience severe congestion problems.

4.91 Diversion of traffic onto the A702 and B701 Oxgangs Road will particularly affect communities located on these routes, including residents of Oxgangs, Fairmilehead and Colinton. The combined population of the wards of the primary diversion routes (Fairmilehead and Colinton) is approximately 17,000. We take this to be a reasonable proxy for the number of people across the city that would be inconvenienced by significant changes in traffic flow and therefore estimate this to be the number of people living in areas that could be affected by increased traffic noise, air pollution and severance.

4.92 Some sensitive receptors would be affected. Pentland Primary School and Colinton Primary school are located nearby the primary diversion route and therefore congestion on this route could impact on road safety for the local school children. Congestion would also affect journey times for parents dropping off/ picking up school children.

Summary of Case Study

4.93 The analysis undertaken in this study indicates that the number of people that are likely to be affected by a DVC on the A720 would be large. Disbenefits would occur to a variety of individuals, their employers and to other companies wishing to move freight. These disbenefits would be distributed over a large geographic area. The level of inconvenience to each individual affected is anticipated to be lower than in the case studies described earlier, as the extent of the average delay per vehicle is less.

4.94 The diversion route is relatively short but it could experience severe congestion due to the high volume of traffic diverted by the DVC. This would cause a significant increase in delay on the diversion route and throughout many parts of Edinburgh's road network.

4.95 It is recognised that a traffic model would be required to understand the full impacts of the closure, however the total value of delay, increased vehicle operating costs and increased accident risk is estimated to be at least £80,000, assuming that the road is closed for four hours. Other indirect costs (including lost productivity, reduced value of goods and stress) are not accounted for in this total.

4.96 The increased traffic flow on the diversion route could cause significant severance, noise and air quality problems for a large number of Edinburgh city residents.

M8: Junctions 8 – 9

Site description

4.97 The M8 is the busiest motorway in Scotland. It connects Glasgow and Edinburgh and also many other locations.

4.98 The scenario being tested is a DVC on the westbound M8 between junctions 8 and 9, immediately to the west of the Baillieston interchange, assuming that the route is closed for four hours from 0600 on a weekday morning.

4.99 In this area, the M8 runs through the eastern suburbs of Glasgow and links to the M80 and M73.

4.100 The primary diversion route (via the A8 Edinburgh Road and Stepps Road) would take traffic from the M8 at junction 8, for it to rejoin at junction 11. This adds only around one kilometre to the total travel distance. In this section, the A8 passes through suburban Baillieston, Easterhouse and Dennistoun under a 40 mph restriction often as a three-lane dual-carriageway.

Incidence of DVCs

4.101 There were 119 DVCs along the full length of the M8 between 2001 and 2010, i.e. 11.9 DVCs per year.

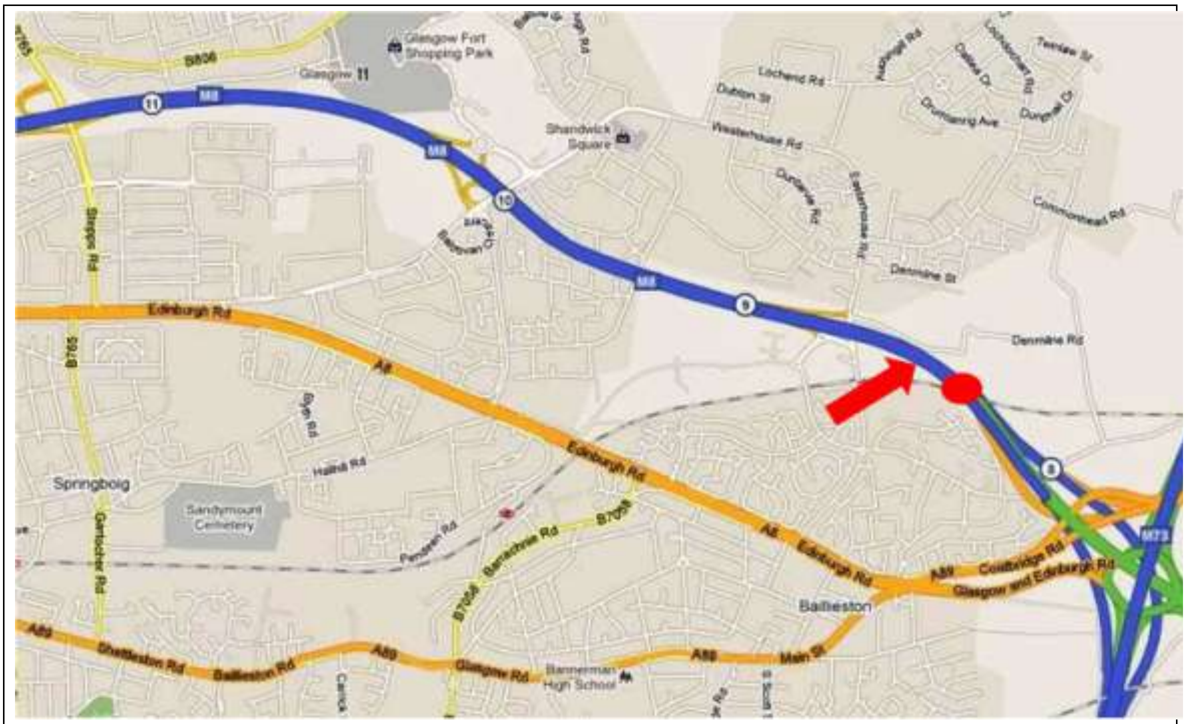
Existing traffic flows

4.102 Traffic flow data for September 2010 was obtained for an ATC counter on the M8 to the north of junction 8. The locations of the ATC (red dot) and the DVC case study (red arrow) are indicated in Figure 4.4.

4.103 The average weekday westbound traffic flow is 46,000 vehicles. The percentage of HGVs is 17%, though would be lower during the AM peak period. Average weekday AM peak hour flow is 3,800.

4.104 We estimate that flow in the four hours of the case study would be 10,500 vehicles.

Figure 4.4 M8 case study location



Costs of delay and diversion

4.105 In periods of free flow, the diversion from the motorway onto the A8 increases travel time by approximately six minutes from the typical four minutes from junction 8 to junction 11 of the M8. However, if the DVC incident occurs in the AM Peak hour, the vehicle delay will be much higher.

4.106 However, the low capacity of the diversion route means that much greater delay would be incurred in the event of closure of the M8.

4.107 Congestion would build rapidly following a closure. Given the availability of driver information systems (including motorway signs and radio announcements) we assume that many drivers on the M8 would be aware of the incident in advance. Queues would rapidly tail back on the westbound M8 and this would encourage many motorists to leave the main and take alternative routes other through local streets and other parts of the strategic route network (notably the A725).

4.108 Many thousands of road users on these other routes would have their journeys delayed by the diverting traffic. This would create increased congestion on most main routes in the area for the duration of the incident.

4.109 A number of bus routes would also be affected, in particular those linking Cumbernauld and Easterhouse to Glasgow. The delays to buses in the area of the DVC would create knock-on delay to their operations, and so to passenger journeys, throughout their routes.

4.110 In order to understand the impacts of a closure of the M8 fully, a traffic model would be required, but estimates are made here.

4.111 It is our view that the average increase in journey times for M8 users would be at least 30 minutes. The value of this delay to the 10,500 such users (assuming £10.50 per vehicle per hour) would be over £50,000.

4.112 We estimate that the total travel time delay caused by diverting traffic to other road users would be at least half as much as that to the bypass users[12]; we therefore estimate the value of increased travel time to be at least £75,000.

4.113 The delay to journey time would be inconvenient to all those people affected. The nature of the traffic on the route at the time and locations of the DVC is that it would predominantly be people making commute journeys that are affected.

4.114 An average delay of 30 minutes to these journeys will clearly have significant consequences for some of these travellers. Many others, however, will actually suffer little in the way of inconvenience. A large number of employers will suffer from a, mostly small, reduction in productivity as a result of the DVC.

4.115 A large number of freight vehicles will also be delayed. At this time of day, these delays may be particularly severe for those attempting to make deliveries to retail sites before the busiest part of the trading day.

4.116 There would be some increase in vehicle operating costs as a result of the congestion.

4.117 The increase in vehicle operating costs caused by increased travel distance of vehicles transferring from the M8 to the primary diversion route is less than £1,000. However, this is likely to be a significant underestimate of the total, as the costs of increased acceleration and deceleration by queuing traffic is not included.

Accident Risk

4.118 Estimation of the increased accident risk has been made assuming that all 10,500 vehicles transfer from the relatively safe 5km motorway to the 6km diversion route on surrounding urban distributor roads. Although we are aware that this diversion route does not have the capacity to cater for all this traffic, we consider this to be a reasonable proxy for traffic distribution throughout the urban network.

4.119 The diversion route is likely to increase accident risk as there will be more conflict between vehicles at the junctions. Accident rates for the M8 are anticipated to be around 0.098 PIA per million veh-km and those on the diversion route 0.844 PIA per million veh-km.

4.120 These vehicles travelling on the M8 would therefore expect to incur around 0.005 PIAs. If all transferred to the diversion route, 0.05 PIAs would be expected. The cost of these increased accidents is approximately £5,000.

[12] A lower ratio than the Edinburgh city bypass case study, as we anticipate that a smaller number of other road users would be affected.

Impacts on communities

4.121 The A8 passes through the populated areas of Baillieston, Easterhouse and Dennistoun. For much of its length, the main road is relatively distant from housing and therefore, whilst substantial increased traffic will result, the environmental impacts on most local residents will not be too severe. Any motorists in this area are likely to be significantly delayed by diverting traffic.

4.122 A higher number of properties will be affected by environmental impacts in localities further east (such as Coatbridge and Bellshill) and on other diversionary routes in east Glasgow (particularly those around the London Road and Shettleston Road corridors) as traffic reroutes away from the DVC.

Summary of Case Study

4.123 The analysis undertaken in this study indicates that the number of people that are likely to be affected by a DVC on the M8 would be large. Disbenefits would occur to a variety of individuals, their employers and to other companies wishing to move freight. These disbenefits would be distributed over a large geographic area.

4.124 The diversion route is relatively short but it could experience severe congestion due to the high volume of traffic diverted by the DVC. This would cause a significant increase in delay on the diversion route and throughout many parts of the road network in east Glasgow and surrounding areas.

4.125 It is recognised that a traffic model would be required to understand the full impacts of the closure, however the total value of delay, increased vehicle operating costs and increased accident risk is estimated to be at least £80,000, assuming that the road is closed for four hours. Other indirect costs (including lost productivity, reduced value of goods and stress) are not accounted for in this total.

4.126 The increased traffic flow on the diversion route could cause significant severance, noise and air quality problems for a large number of residents of east Glasgow.

Summary of the case studies

4.127 Table 4.2 shows a summary of each case study.

Table 4.2 Case study summaries

Assumed scenario	A835 Garve – Corrieshalloch Closed in both directions for four hours, weekday from 0600	A9 Jubilee Bridge Closed in both directions for four hours, Saturday from 1100	A720 Hillend – Dreghorn Closed westbound for four hours, weekday from 0600	M8 Junctions 8 – 9 Closed westbound for four hours, weekday from 0600
Number of main route users directly affected	800	6,500	8,000	10,500
Anticipated delay per vehicle	80 minutes	>30 minutes northbound >40 minutes southbound	30 minutes	30 minutes
Quantified value of delay	£11,000	>£40,000	£80,000	£75,000
Quantified value of increased vehicle operating costs	£4,000	>£20,000	>£1,000	>£1,000
Quantified value of accident risk on diversion routes	£2,000	£15,000	£2,000	£5,000
Approximate number of residents affected by noise, poor air quality and severance on diversion routes	2,500	>10,000	17,000	Not quantified, but smaller than A720 case study

Assumed scenario	A835 Garve – Corrieshalloch Closed in both directions for four hours, weekday from 0600	A9 Jubilee Bridge Closed in both directions for four hours, Saturday from 1100	A720 Hillend – Dreghorn Closed westbound for four hours, weekday from 0600	M8 Junctions 8 – 9 Closed westbound for four hours, weekday from 0600
Main other indirect impacts	• Substantial increased costs for vehicles using diversion routes • Some road users will miss ferry sailings • Lost productivity • Reduced value of goods carried • Stress	• Diversionary routes highly unsuitable for traffic volumes • Substantial increased costs for vehicles using diversion routes • Tourist businesses to the north of the DVC likely to have significant reduction in income • Stress	• Delays caused to traffic on main routes throughout Edinburgh and beyond • Severe congestion and environmental problems in communities closest to the incident • Lost productivity • Reduced value of goods carried and delays in supply chains • Stress	• Severe congestion and environmental problems on routes through east Glasgow and beyond • Lost productivity • Reduced value of goods carried and delays in supply chains • Stress
Summary	Relatively few people affected, but very high indirect costs for each one	Many people affected on the A9 and surrounding communities. Substantially increased travel time. Likely that many people choose to travel to different destinations	Many road users affected, albeit relatively little inconvenience to each one (compared with A835 and A9 case studies). Many HGVs affected. Knock-on effects throughout much of Edinburgh and beyond	Many road users affected, albeit relatively little inconvenience to each one (compared with A835 and A9 case studies). Many HGVs affected. Knock-on effects throughout much of east Glasgow and beyond

5 Summary

5.1 Collisions between deer and vehicles are an increasing problem on Scotland's roads. The direct costs of such deer vehicle collisions (DVCs) have been quantified elsewhere; this review has focussed on assessing the indirect costs. The indirect costs will be the financial or other disbenefits to people that are in some way affected by the DVC, even though they were not involved in it.

5.2 Indirect costs will include a variety of elements including additional financial cost, wasted time, lost productivity, reduced value of goods carried and environmental disbenefits.

5.3 These costs will accrue variously to the people travelling, their employers or residents of local communities. Those businesses supplying or receiving goods carried or dependent on the business of people travelling will also be affected.

5.4 The magnitude of the indirect costs will depend significantly on the journey purpose and attitudes of the people travelling. Furthermore, those aware of the incident before commencing their journeys may have scope to reduce the costs of disruption to them.

5.5 There are well established techniques to quantify the value of wasted time, increased accident risks and to estimate the increased vehicle operating costs. Other costs (such as stress or lost productivity) require a detailed understanding of the nature of each individual's journey; beyond the scope of this review.

5.6 We have applied the quantification factors to four case study examples. These have shown, amongst other information, that a single DVC occurring on a busy part of Scotland's road network can have substantial consequences. Three of the case studies examined would generate quantified indirect costs following a four-hour closure of a main link of the Trunk Road network of at least £75,000.

5.7 In more remote areas, where traffic flows are less, the value of quantified indirect costs tends to be lower. However, the disbenefit per person affected can be much greater; it is entirely possible that the closure of the A835 between Inverness and Ullapool would result in some people heading for Lewis facing a total delay of 24 hours.

5.8 The case studies show that the extent of indirect costs will, in general, be dependent upon:

- The length of time for which the road is blocked;
- The volume of traffic on the affected route;
- The availability of convenient diversion routes; and
- The numbers of people living in communities affected on these diversion routes.

5.9 There are clear mechanisms to minimise the indirect costs of a DVC. The first of these is to prevent the DVC from occurring. Assuming that an incident has occurred, however, the indirect costs will be reduced in proportion to:

- The speed at which the network can be returned to normal operating performance; and
- The speed at which other road users, and potential users, can be informed of the incident.

Appendix A

Case Study Assumptions and Calculations

Appraisal Assumptions

The WEB Transport Analysis Guidance (WEBTAG) "Transport User Benefit Calculation TAG Unit 3.5.3", "Values of Time and Operating Costs TAG 3.5.6" and the "Design Manual for Roads and Bridges (DMRB) Volume 13, Section 1, COBA Manual" was used in calculating the equations within this study for Travel Time Cost and Vehicle Operating Cost.

Based on the data available to the study, the following assumptions were made when calculating value of time and vehicle operating costs:

- The cost for the individual accident has not been annualised or projected forward over an appraisal period.
- During this period it has been assumed that traffic volumes attempting to travel between the points at either end of the corridor will remain unchanged.
- Any impact on queues and delay caused by the extra traffic on the diversionary route has not been included in the calculation of costs.
- We have not quantified the costs on public transport users, walkers or cyclists for the DVC.
- Information on vehicle type is unavailable therefore average values from WEBTAG have been used in the calculation of travel time costs and vehicle operating costs.
- Average trip purpose figures from the STAG guidance have been used within the appraisal.
- The analysis is based on 2002 prices and values.

Calculations

Case study 1: A835

Value of time

Vehicles affected	800	
Average increased travel time per vehicle	1.33	hours
So total increased travel time	1064	vehicle-hours
Average value of time per vehicle	£ 10.50	
So total value of increased travel time	£ 11,172	

Vehicle operating cost

Vehicles affected	400	
Operating cost/km on original route	£ 0.10	
Distance of original route	32	km
Operating cost on original route	£ 1,279	
Operating cost/km on diversion route	£ 0.10	
Distance of diversion route	140	km
Operating cost on diversion route	£ 5,594	
Increase in operating cost	£ 4,316	

Accident risk

Vehicles affected	400	
Accident rate on original route	0.19	per Mveh-km
Distance of original route	32	km
Estimated accidents on original route	0.002	
Accident rate on diversion route	0.2115	per Mveh-km
Distance of diversion route	140	km
Estimated accidents on diversion route	0.012	
Increase in accidents	0.009	

Case study 2: A9

Value of time	Northbound	Southbound	Total	
Vehicles affected	3,250	3,250	6500	
Average increased travel time per vehicle	0.50	0.67		hours
So total increased travel time	1,625	2,178	3,803	vehicle -hours
Average value of time per vehicle	£ 10.50	£ 10.50		
So total value of increased travel time	£ 17,063	£ 22,864	£39,926	

Vehicle operating cost	Northbound	Southbound	Total	
Vehicles affected	3,250	3,250	6,500	
Operating cost/km on original route	£ 0.11	£ 0.11		
Distance of original route	13	42		km
Operating cost on original route	£ 4,445	£ 14,360	£18,805	
Operating cost/km on diversion route	£ 0.11	£ 0.11		
Distance of diversion route	42	76		km
Operating cost on diversion route	£ 14,360	£ 25,984	£ 40,344	
Increase in operating cost	£ 9,915	£ 11,625	£ 21,540	

Accident risk	North-bound	South-bound	Total	
Vehicles affected	3250	3250	6500	
Accident rate on original route	0.19	0.19		per Mveh-km
Distance of original route	13	42		km
Estimated accidents on original route	0.008	0.026	0.034	
Accident rate on diversion route	0.404	0.404		per Mveh-km
Distance of diversion route	42	76		km
Estimated accidents on diversion route	0.055	0.100	0.155	
Increase in accidents	0.047	0.074	0.121	

Case study 3: A720

Value of time

Vehicles affected	8,000	
Average increased travel time per vehicle	0.5	hours
So total increased travel time	4000	vehicle-hours
Average value of time per vehicle	£ 10.50	
So total value of increased travel time	£ 42,000	

Vehicle operating cost

Vehicles affected	8,000	
Operating cost/km on original route	£ 0.11	
Distance of original route	2	km
Operating cost on original route	£ 1,683	
Operating cost/km on diversion route	£ 0.10	
Distance of diversion route	3	km
Operating cost on diversion route	£ 2,498	
Increase in operating cost	£ 815	

Accident risk

Vehicles affected	8000	
Accident rate on original route	0.098	per Mveh-km
Distance of original route	2	km
Estimated accidents on original route	0.0016	
Accident rate on diversion route	0.844	per Mveh-km
Distance of diversion route	3	km
Estimated accidents on diversion route	0.0203	
Increase in accidents	0.0187	

Case study 4: M8

Value of time

Vehicles affected	10,500	
Average increased travel time per vehicle	0.5	hours
So total increased travel time	5,250	vehicle-hours
Average value of time per vehicle	£ 10.50	
So total value of increased travel time	£ 55,125	

Vehicle operating cost

Vehicles affected	10,500	
Operating cost/km on original route	£ 0.11	
Distance of original route	4.8	km
Operating cost on original route	£ 5,302	
Operating cost/km on diversion route	£ 0.10	
Distance of diversion route	5.6	km
Operating cost on diversion route	£ 5,733	
Increase in operating cost	£ 431	

Accident risk

Vehicles affected	10,500	
Accident rate on original route	0.098	per Mveh-km
Distance of original route	4.8	km
Estimated accidents on original route	0.0049	
Accident rate on diversion route	0.844	per Mveh-km
Distance of diversion route	5.6	km
Estimated accidents on diversion route	0.0496	
Increase in accidents	0.0447	