JACOBS®

A83 Trunk Road Route Study

Part A - A83 Rest and Be Thankful

Final Report

TRANSPORT SCOTLAND

February 2013

JACOBS

Document Control Sheet

BPP 04 F8
Version 14 July 2012

Project:	A83 Trunk Road Route Study	Project No:	B1557610
Client:	Transport Scotland		
Document Title:	Part A – A83 Rest and Be Thankful		
Ref. No:			

	Originated by	Checked by	Reviewed by	Approved by
ORIGINAL (Draft)	NAME **Charles Macklin**	NAME **Graeme Herd**	NAME **Stuart Turnbull**	NAME **Helen Bradley**
DATE	INITIALS CMM	INITIALS GMH	INITIALS ST	INITIALS EHB
07/12/2012	**Published Draft for Consultation**			

REVISION (Final)	NAME **Charles Macklin**	NAME **Graeme Herd**	NAME **Stuart Turnbull**	NAME **Helen Bradley**
DATE	INITIALS CMM	INITIALS GMH	INITIALS ST	INITIALS EHB
22/02/2013	**Published Final Report**			

REVISION	NAME	NAME	NAME	NAME
DATE	INITIALS	INITIALS	INITIALS	INITIALS

REVISION	NAME	NAME	NAME	NAME
DATE	INITIALS	INITIALS	INITIALS	INITIALS

Cover Photo – Glen Croe, Photo © Copyright Aerial Solutions

Document Changes from Draft Report to Final Report

Reference	Description of change
Summary (page i)	Description of current preventative measures revised
Summary (page viii)	Next Steps section removed
Section 2.4 (pages 6-9)	Reference to Colonsay removed Additional information provided about the following sectors of the economy: accommodation and food services; food and drink, and; energy. Paragraph added with information on the Islay ferry crossing figures
Section 2.7 (page 18)	Additional bullet point added under “Tourism”
Section 2.8 (pages 20-21)	Paragraph added with further anecdotal evidence of wider economic impacts
Section 4.3 (page 28)	Additional information provided for the description of the red option
Section 6.4 (pages 54-55)	Three additional paragraphs relating to the effectiveness of debris flow barriers
Section 9.4 (page 185)	Additional paragraph related to other impacts
Section 9.7 (page 189)	Paragraph added with further anecdotal evidence of wider economic impacts
Section 10.1 (page 191)	Description of current preventative measures revised
Section 10.3 (page 193)	Next Steps section removed

This page is blank

SUMMARY

Jacobs was appointed by Transport Scotland to undertake a study of the A83 Trunk Road to identify and appraise potential options to minimise the effects of road closures, investigate the feasibility of removing traffic pinch points and improve pedestrian safety in villages along the route.

The Part A report examines the issues at the Rest and Be Thankful and presents the results of the transport appraisal in accordance with Scottish Transport Appraisal Guidance and Stage 1 scheme assessment in accordance with the Design Manual for Roads and Bridges.

Analysis of Problems and Opportunities

The section of the A83 between Ardgartan and the Rest and Be Thankful car park has a history of hillside instability, in particular the slopes above the Rest and Be Thankful. This has led to road closures on six separate occasions between 1 January 2007 and 31 October 2012, resulting in the road being closed for a total period of 34 days.

Following a number of landslides in 2004, Transport Scotland undertook the Scottish Road Network Landslides Study. As part of the Implementation Study a hazard assessment and ranking was undertaken for debris flow. From this assessment the A83 Ardgartan to Rest and Be Thankful is amongst the most highly ranked debris flow hazard sites in Scotland.

As part of the current hazard reduction approach, some preventative measures have already been implemented including upgrading some culverts and the installation of approximately 168m of debris flow barriers and fences. A further 90m of debris flow barrier and a large catch pit will be completed during the early part of 2013. An Emergency Diversion Route has been created along the Old Military Road to provide a short-term alternative route in the event of road closures at Rest and Be Thankful due to landslides.

Glen Croe looking towards the Rest and Be Thankful [1].

[1] Image Copyright Iain Thompson licensed under the Creative Commons Attribution-Share Alike 2.0 Generic Licence (http://creativecommons.org/licenses/by-sa/2.0/)

Consultation undertaken during this study enabled stakeholders to share their views about the issues experienced by road users. This included the wider impacts of road closures due to landslides, based on using the diversion route via the A82/A85/A819. The consultation exercise has informed the identification of the evidence-based transport problems in the study area.

A review has been undertaken on the socio-economic impact of the road closures due to landslides at the Rest and Be Thankful. The outcomes from this review provide evidence in addition to, and not in place of, the standard economic appraisal which has been undertaken.

Using evidence from this review, drawn from several key stakeholders, the additional annual costs to the A83 economy from previous landslide episodes at the Rest and Be Thankful are estimated to be £286,300 (in 2010 prices) for the road being closed for 5½ days over the year (the average duration of the past six events). Sensitivity analysis shows that the additional annual costs to the A83 economy from previous landslide episodes at the Rest and Be Thankful are in the range £130,200 (2½ day closure) to £676,800 (13 day closure).

Transport Planning Objectives

Transport appraisal in accordance with Scottish Transport Appraisal Guidance requires five main areas of impact to be considered: Environment, Economy, Safety, Integration and Accessibility & Social Inclusion. In addition, specific Transport Planning Objectives were developed to reflect the local situation and these were set as follows:

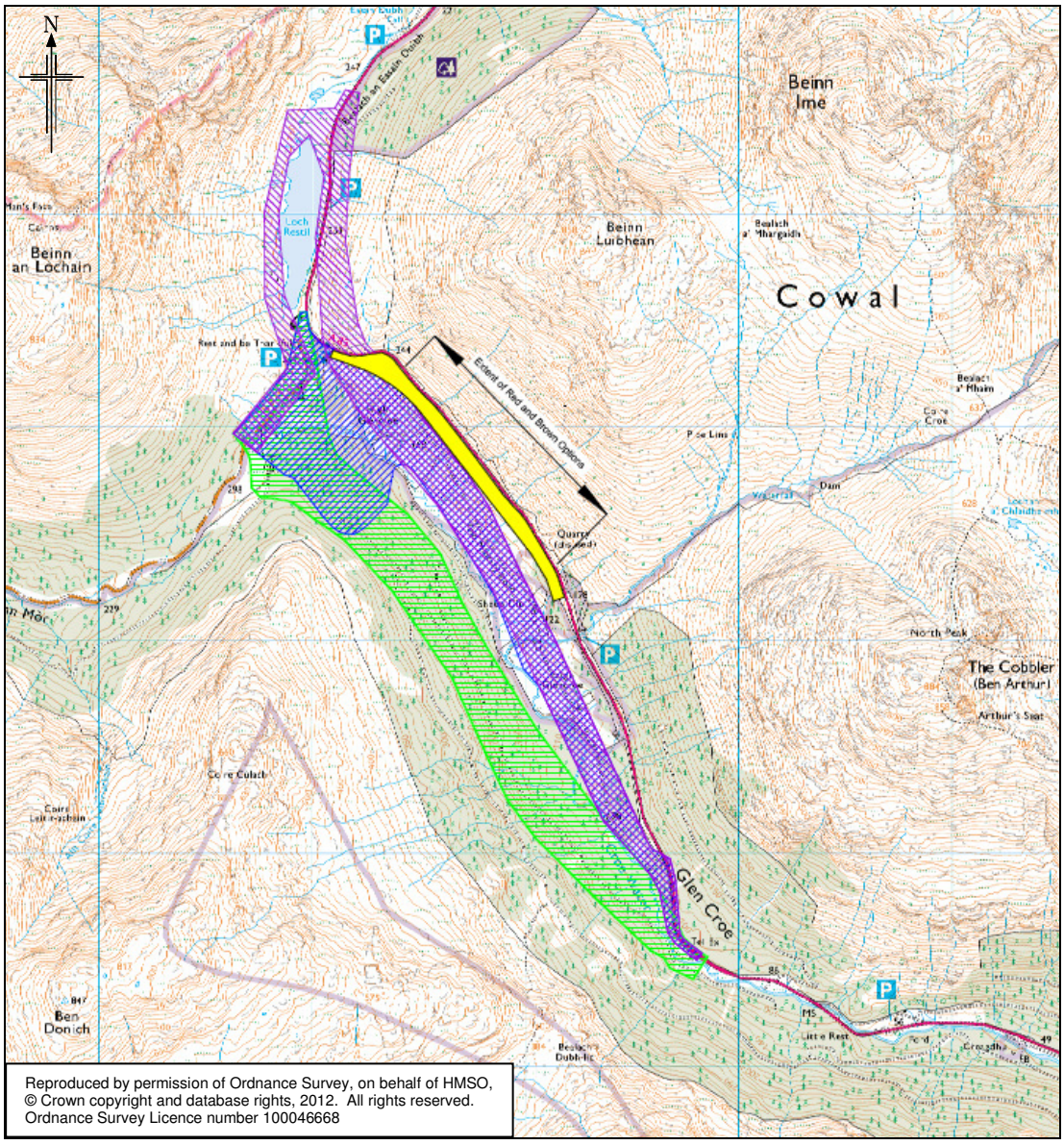
- Reduce the **impact on journey times** by reducing the frequency and duration of road closures caused by landslides, and;
- Reduce the **economic impact to the A83 study area** by reducing the frequency and duration of road closures caused by landslides.

Option Generation and Sifting

This study examined a range of potential long-term solutions in the form of alternative routes for access to the A83 study area. Route corridors remote from the Glen Croe valley were rejected at an early stage in the appraisal process since these options did not meet the transport planning objectives of the study. They resulted in increased journey times and the anticipated cost and potential environmental impacts of such routes were considered disproportionate to the identified problems on the existing A83 Rest and Be Thankful.

Six route options in the Glen Croe valley were identified for assessment. These potential options range from new route corridors within the valley, including options which incorporate a debris flow shelter or a multi-span viaduct or a tunnel or less heavily engineered hazard reduction measures on the existing A83 corridor.

The following section summarises the assessment of these six route options. It should be noted that, in principle, these options represent corridors within which variations are possible in terms of route alignment and/or structural form. For assessment purposes an appropriate outline alignment and/or structural form has been assumed which may be subject to refinement at a later stage, for any option(s) taken forward for further stages of DMRB assessment.



Glen Croe Route Corridor Options

Engineering and Environmental Assessment

The **Red Corridor Option** maintains the existing alignment of the A83 and includes a range of landslide mitigation measures such as: additional 440m of debris flow barriers at locations where the landslide hazard is considered highest; improved hillside drainage adjacent to and under the road, and; introduction of vegetation and planting on the slope. This option would significantly reduce the frequency of occurrence of landslide debris reaching the A83 Trunk Road causing a full road closure and offers the potential for implementation in phases. It is not considered to have any significant environmental effects. The cost estimate for this option is in the range £9-10 million (2012 prices, excluding VAT).

The **Brown Corridor Option** closely follows the alignment of the existing A83 and involves the construction of a debris flow shelter over a length of 1km to protect the road and road users in the event of future debris flow events. With this option the likelihood of landslide debris reaching the road, over the length of the debris flow

shelter, would be negligible. The introduction of debris flow shelters could have impacts on the local landscape and views, although the significance of these impacts would depend on the appearance and extent of the shelters. The cost estimate for this option is in the range £105 – 120 million (2012 prices, excluding VAT) and there would be significant disruption during construction, including periods of full road closures.

The **Yellow Corridor Option** provides a new 1.5km single carriageway alignment offset slightly from the existing A83. Around 1.2km of the new alignment is constructed on viaduct following a similar profile to the existing road with an average climbing gradient of 5%. The viaduct structure would be set at a sufficient level to permit debris flow events to pass below the A83 and the likelihood of road closures due to landslides, over the length of the viaduct, would be negligible. The introduction of a viaduct could have impacts on the local landscape and views, although the significance of these impacts would depend on the appearance of the viaduct and how well it is integrated with the surrounding landscape from a visual perspective. The cost estimate for this option is in the range £83 – 95 million (2012 prices, excluding VAT).

The Purple and Blue Corridor Options begin further down Glen Croe and generally run parallel to the Old Military Road until they reach the property at High Glencroe. The **Purple Corridor Option** continues northwards in tunnel and rejoins the existing A83 in the vicinity of Loch Restil. A short 600m single bore tunnel was initially considered, however the steep gradient of this design was considered unacceptable. A route alignment with a maximum gradient of 4% is considered feasible, resulting in a 1.9km long twin bore tunnel. With this option, the likelihood of road closures due to landslides is considered to be negligible. Potentially significant environmental impacts are anticipated in relation to ecology, landscape and visual intrusion. The cost estimate for this option is in the range £460 – 520 million (2012 prices, excluding VAT).

The **Blue Corridor Option** runs generally parallel to the Old Military Road and curves and climbs steeply at a maximum gradient of 8% around the top of the glen before joining the alignment of the green option which passes to the west of the Rest and Be Thankful car park and rejoining the existing road before Loch Restil. The road alignment of this option is below desirable minimum standards for a new Trunk Road and potentially significant environmental impacts are anticipated in relation to ecology, landscape and visual intrusion. With this option, the likelihood of road closures due to landslides is considered to be negligible. The cost estimate is in the range £66 – 75 million (2012 prices, excluding VAT).

The **Green Corridor Option** provides a new 4.0km single carriageway and follows the opposite side of the valley to the existing A83. While the alignment generally follows the line of existing forestry tracks, significant engineering measures would be required to form a new single carriageway road on this hillside, including measures to reduce the landslide hazard in this corridor. The cost estimate range for the Green option is £27 – 91 million (2012 prices, excluding VAT). This is a wide cost range and reflects a varying level of protection to landslides. At the low end of the cost range (£27 – 30 million), without significant landslide protection measures, the route may be as susceptible to closure due to landslides as the existing A83. The higher end of the cost range (£81 – 91 million) represents the expected cost to provide a route where the likelihood of closure due to landslides is negligible (comparable to the Brown and Yellow corridor options). This option may result in impacts on ecology and the local landscape and views, although the significance of these impacts would depend on the form and alignment of this route.

In addition to the six route options in the Glen Croe valley presented above, the study considered the landslide hazard of other sections of the A83 Trunk Road between Tarbet and Kennacraig, providing a wider context for issues at Rest and Be Thankful. There are nine other locations on the A83 with a landslide hazard ranking classification of High/Very High covering a route length of around 31km. The proposed options to address ground related hazards at Rest and Be Thankful should be accompanied by actions to address the ground related hazards to those other parts of the A83 Trunk Road, in particular at Glen Kinglas, Cairndow and Loch Shira, if the whole route length is to achieve comparable levels of risk reduction.

Appraisal Summary

The results of the engineering and environmental assessment were collated into a series of Appraisal Summary Tables which provide a mainly qualitative comparison of the potential options.

The Red Option is expected to significantly reduce the frequency of occurrence of landslide debris reaching the A83 Trunk Road at a much lower cost than the other options.

The viaduct option (Yellow) performs better against the appraisal criteria in comparison to the debris shelter or tunnel options (Brown and Purple). The viaduct option has lower cost than both the debris shelter and tunnel options with lower environmental impact than the tunnel option and lower construction impact than the debris shelter option.

The Blue and Green corridor options have comparable estimated costs, in the range £27-91 million excluding VAT. For both of these options the residual risk of road closures due to landslides is considered to be negligible, as the options include appropriate mitigation measures in the form of engineering structures, in particular lengths of viaduct. The Green option however performs better against the safety criteria due to a more desirable route alignment and is therefore taken forward for further consideration.

As a result of this appraisal of options, the Brown, Purple and Blue options were sifted out of the appraisal and the Red, Yellow and Green options were taken forward to a more detailed economic appraisal.

Traffic and Economic Assessment

The economic appraisal has been conducted using standard economic welfare techniques, as set out in the Scottish Transport Appraisal Guidance. In this analysis the change in economic welfare can be approximated using the change in travel time and vehicle operating costs. In the case of the landslides at the Rest and Be Thankful site this change in costs is determined by the number of journeys affected, the type of journeys affected (e.g. car, bus, freight) and whether or not they use the diversion route.

The benefits of each of the options appraised will be dependent on the level of disbenefits associated with a landslide, which in turn is determined by the number of journeys affected and the proportion of trips that use the diversion route rather than travel to an alternative destination. The disbenefits associated with a landslide, calculated for the purposes of the economic appraisal, differ from those highlighted in the problems and opportunities section above, as the appraisal has taken into account the future use of the Old Military Road. The alternative analysis is a

snapshot of the estimated costs of previous landslide episodes, when the Old Military Road was not available.

The results of the analysis show that the Benefit Cost Ratio (BCR)s range from 0.04 to 0.43, with the best performing option the Red option. Under this core analysis none of the options provide a level of benefits greater than the present value of costs. The Red option results in a similar level of benefits over the appraisal period as the Yellow and Green options, for significantly less capital costs over the same period.

Performance of the Red, Yellow and Green options against the appraisal criteria are summarised in the following table:

Performance of Options Against Appraisal Criteria

Appraisal Criteria		Red Corridor Option	Yellow Corridor Option	Green Corridor Option	
Planning Objectives	Objective 1 – Reduce the **impact on journey times** by reducing the frequency and duration of road closures caused by landslides	Additional landslide mitigation measures would significantly reduce the frequency of landslide debris reaching the A83 Trunk Road causing a full road closure and the subsequent economic impact	Following construction of a viaduct the likelihood of landslide debris reaching the A83 Trunk Road would be negligible since it would instead pass below the road. This would significantly reduce the impact on journey times caused by landslides over this section of route and the subsequent economic impact	A new 4.0km alignment on the south-west side of Glen Croe would be engineered in such a way to significantly reduce the likelihood of landslide debris reaching the road. This would significantly reduce the impact on journey times caused by landslides and the subsequent economic impact	
	Objective 2 – Reduce the **economic impact to the A83 study area** by reducing the frequency and duration of road closures caused by landslides				
Environment		Neutral	Minor impact Potential effect on local landscape and views	Moderate impact Potential effect on landscape and visual receptors and ecological effects (as a result of woodland loss) such as habitat loss, fragmentation and disturbance.	
Safety		Minor benefit Reduced risk of landslide debris causing road accidents	Moderate benefit Road alignment and cross section improvements as well as reduced risk of landslide debris causing road accidents	Minor benefit Road alignment and cross section improvements as well as reduced risk of landslide debris causing road accidents	
Economy	Present Value of Benefits (PVB) (£m)	2.54	2.67	2.47	2.67
	Present Value of Costs (PVC) (£m)	5.86	69.67	21.37	66.47
	Net Present Value (NPV) (£m)	-3.32	-67.00	-18.90	-63.80
	Benefit/Cost Ratio (BCR)	0.43	0.04	0.12	0.04
Integration		No impact	No impact	No impact	
Accessibility and Social Inclusion		Minor Benefit Improved accessibility due to reduction in road closures	Minor Benefit Improved accessibility due to reduction in road closures	Minor Benefit Improved accessibility due to reduction in road closures	

Conclusions

At the A83 Rest and Be Thankful, since publication of the Scottish Road Network Landslide Study (2005), appropriate physical hazard reduction measures have been introduced at locations considered to present the greatest hazard. Following the appraisal of the range of permanent options considered in this report, it is concluded that the Red Option offers the best performance against the assessment criteria.

The Red option comprises an additional 440m of debris flow barriers, representing a significant step-change in the landslide hazard reduction for the A83 Rest and Be Thankful. In addition, this option includes measures to improve the hillside drainage adjacent to and under the road. The planting of vegetation may also help contribute to this strategy though the beneficial effects of vegetation would be realised during a period around 15 to 35 years after planting. The cost of these measures is estimated to be in the range £9m-10m (excluding VAT). This represents a cost-effective way of reducing the impact on journey times and the subsequent economic impact as a result of road closures due to landslides at Rest and Be Thankful. The Emergency Diversion Route being brought into use by Transport Scotland would be required until the proposed measures had provided sufficient protection to the A83.

Actions are also recommended to address the ground related hazards at other locations on the A83 Trunk Road, in particular at Glen Kinglas, Cairndow and Loch Shira to give a comparable level of landslide protection to that proposed at the Rest and Be Thankful.

JACOBS

Contents

1 INTRODUCTION

1.1 Study Background

The A83 Trunk Road Route Study recognises the significant challenges that exist along the length of this vital road. It will identify potential options to minimise the effects of road closures on the local communities and road users in the area and potential options to address identified problems along the route.

Following a landslide at Rest and Be Thankful on 1 August 2012, the A83 Rest and Be Thankful Taskforce was established to provide leadership and direction and ensure the delivery of the A83 Rest and Be Thankful emergency diversion route and the wider study into the permanent solution to landslides at this area. This taskforce is chaired by Keith Brown MSP, Minister for Transport and Veterans, and comprises members representing a wide range of local interests.

This Part A report examines the landslide problem at Rest and Be Thankful and considers options to minimise the effects of road closures on the local communities and road users in the area. It also addresses other sections of the A83 trunk road where a high risk of landslides has been identified.

The Part B report examines the remainder of the A83 Trunk Road from Tarbet to Kennacraig and considers measures to address other issues along the route.

1.2 Description of A83 Ardgartan to Rest and Be Thankful

The A83 Trunk Road runs from the A82 at Tarbet on Loch Lomond in a generally south west direction for 108 km to the Islay Ferry port at Kennacraig in Kintyre. The A83 continues south from Kennacraig to Campbeltown but this final section is not part of the trunk road network. The principal towns on the A83 Trunk Road are Inveraray, Lochgilphead and Tarbert and the road also serves Dunoon and Cowal, Campbeltown and Kintyre, and the islands of Islay, Jura and Gigha.

The A83 is of variable width single carriageway two lane construction throughout its length with the exception of three localised short single lane narrowings at Aray Bridge, Minard and Ardrishaig. The Strategic Transport Projects Review (STPR) identified the A83 as a route that would be maintained and safely operated within the general remit of Transport Scotland. No specific interventions were indicated within STPR.

Ardgartan to Rest and Be Thankful is a seven kilometre section of the A83 at the north of the trunk road in Argyll Forest Park through Glen Croe. Ardgartan village is on the shore of Loch Long at the mouth of Croe Water. Travelling west from Ardgartan, the A83 follows Croe Water at the bottom of Glen Croe for just over three kilometres. At this point the original road alignment, known as the Old Military Road, continues along a lower section of the valley floor while the current A83 Trunk Road follows the alignment completed in 1941[2] and rises steadily at a gradient of around 5% (1 in 20) for 3.5km along the lower slopes of The Cobbler and Beinn Luibhean to a high point at the junction with the B828 and the view point at Rest and Be Thankful.

[2] Arrochar, Tarbet and Ardlui Heritage Website: http://www.arrocharheritage.com/HistoryOfRABT.htm

A plan of the A83 from Ardgartan to Rest and Be Thankful is shown in Figure 1-1 and two aerial photographs showing the Glen Croe valley at Beinn Luibhean are shown in Figure 1-2 and Figure 1-3.

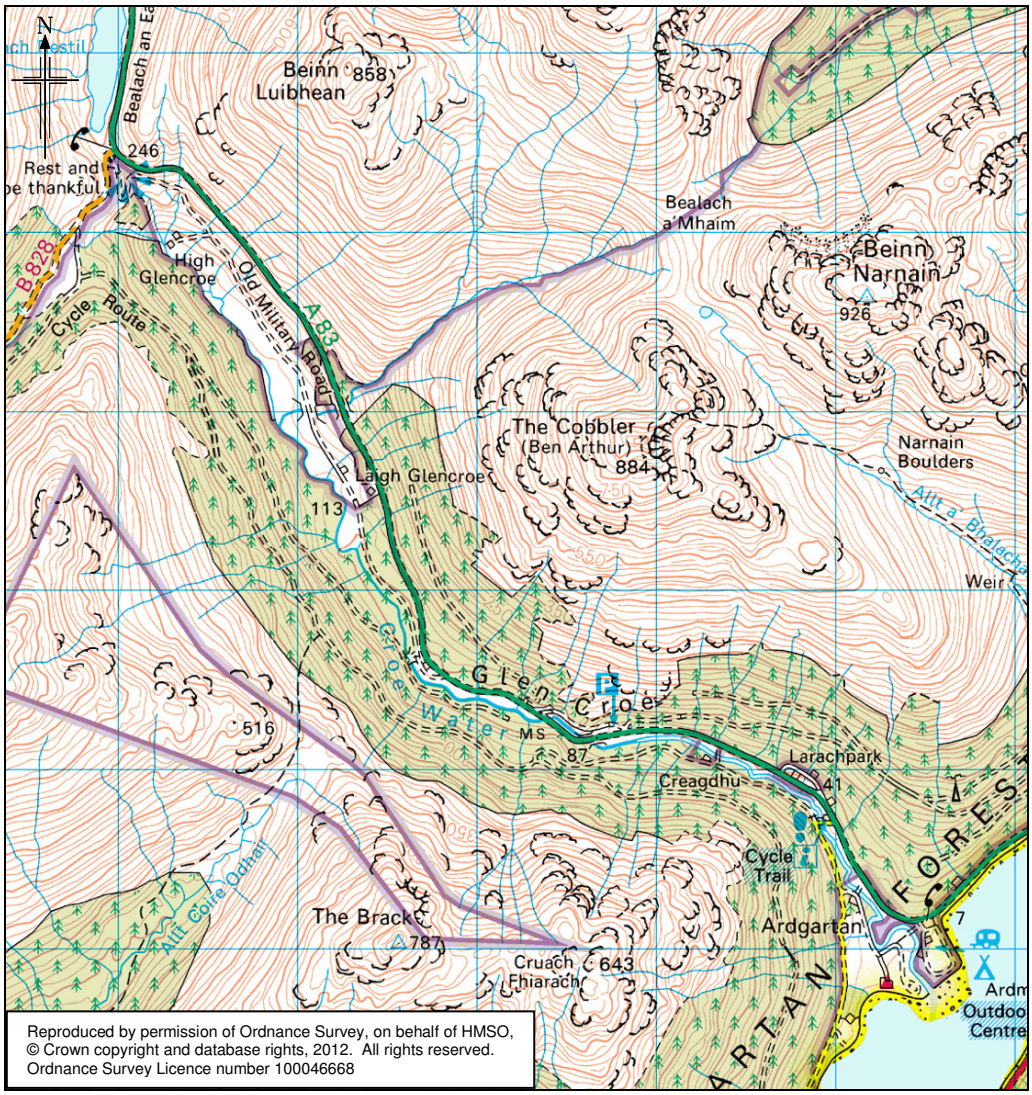


Figure 1-1: Plan of A83 Ardgartan to Rest and Be Thankful

For the purpose of this report, 'Rest and Be Thankful' shall be used to describe the section of the A83 from bridge over Coire Croe Burn (NN 224000 706000) to the first sharp bend in the road near the top of the hill, before the car park (NN 223700 707000). 'The Rest and Be Thankful car park' shall be used to describe the car park and viewpoint.

The area affected by closures of the A83 at Rest and Be Thankful includes Cowal, Mid Argyll, Kintyre, Islay, Jura and Colonsay. For the purpose of this report, this is referred to as the A83 study area.

Figure 1-2: Glen Croe looking south-east down the valley with the Rest and Be Thankful car park in the foreground. Photo © Aerial Photography Solutions.

Figure 1-3: Beinn Luibhean and Glen Croe with the Rest and Be Thankful car park and Loch Restil visible on the left. Photo © Aerial Photography Solutions.

2 ANALYSIS OF PROBLEMS AND OPPORTUNITIES

2.1 Introduction

The purpose of this section is to document existing patterns and characteristics of the A83 between Ardgartan and the Rest and Be Thankful car park. It then identifies evidence-based transport problems in this area and the evidence to support these problems.

2.2 Methodology

The methodology agreed for this study combines the process set out in the Design Manual for Roads and Bridges (DMRB) and transport appraisal in line with Scottish Transport Appraisal Guidance (STAG). This methodology adopts a staged approach to scheme development, involving:

- Preparation of a Stage 1 Scheme Assessment Report in accordance with the DMRB, together with preparation of an appraisal in line with Scottish Transport Appraisal Guidance. At this stage the options have been considered as broad corridor options, enabling the general effects of each option to be identified. Consultation with local stakeholders will be undertaken following completion of this report. Options have been generated and assessed against the transport planning objectives. Only those options which meet the transport planning objectives were carried forward to scheme assessment and appraisal.

- Further work on developing any option(s) emerging from this study is subject to decision by the Minister for Transport and Veterans.

2.3 Existing Traffic and Safety Characteristics

2.3.1 Traffic Data

Traffic volumes are measured as Annual Average Daily Traffic (AADT). This is the total number of vehicles using the route in both directions per day when averaged over the year, to account for peaks such as summer traffic. On this section of the A83 the AADT is approximately 4,000 vehicles.

The variation in monthly traffic flows is shown in Figure 2-1. As tourism is a key sector in the study area daily traffic flow is around 3,000 vehicles or less in December and January, but rises to a spring peak of 5000 in May and a summer peak of 5000 to 6000 vehicles in August.

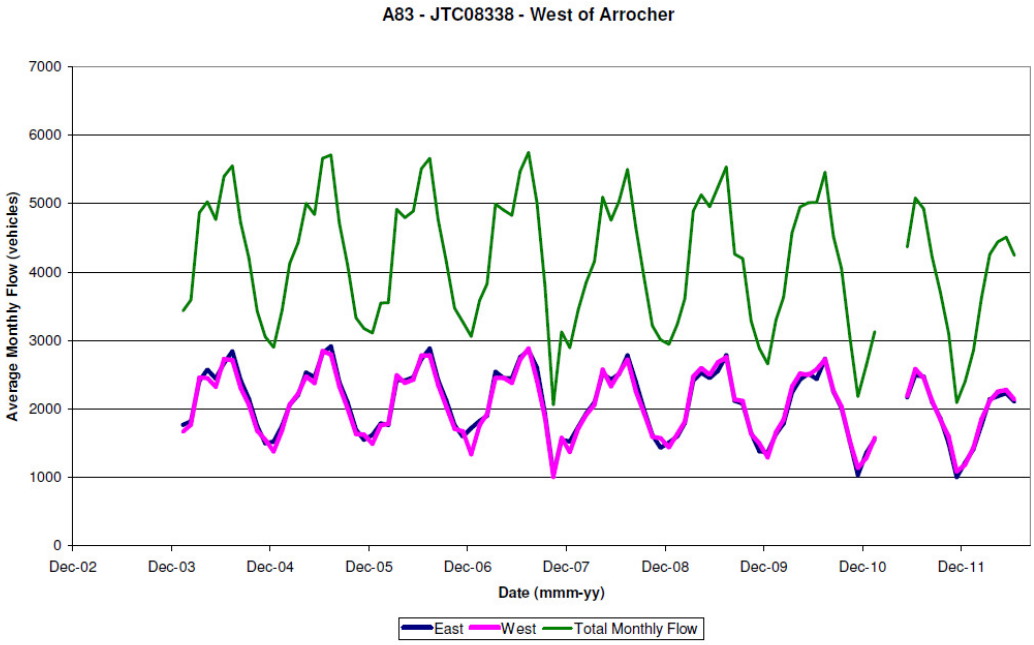


Figure 2-1: Historic traffic flow trends 2003-2012

Figure 2-1 above shows the historic trends in traffic flows on the A83. As can be seen these have been steadily reducing over the last decade. The recent reductions are in line with the national trends, impacted by the economic recession but the longer term pattern could be partly due to the impact of the closures on the route.

2.3.2 Accident Data

In 2010 and 2011, the A83 between Ardgartan and Rest and Be Thankful has been closed a total of eight times due to road traffic accidents. These closures ranged from 20 minutes to over 12 hours, with six being over two hours. At least four of the eight accidents involved HGVs and two of those involved HGVs overturning.

Between 2007 and 2011 inclusive there have been a total of 22 accidents. Of these, 16 resulted in slight injuries, 5 resulted in serious injuries, and 1 resulted in a fatality.

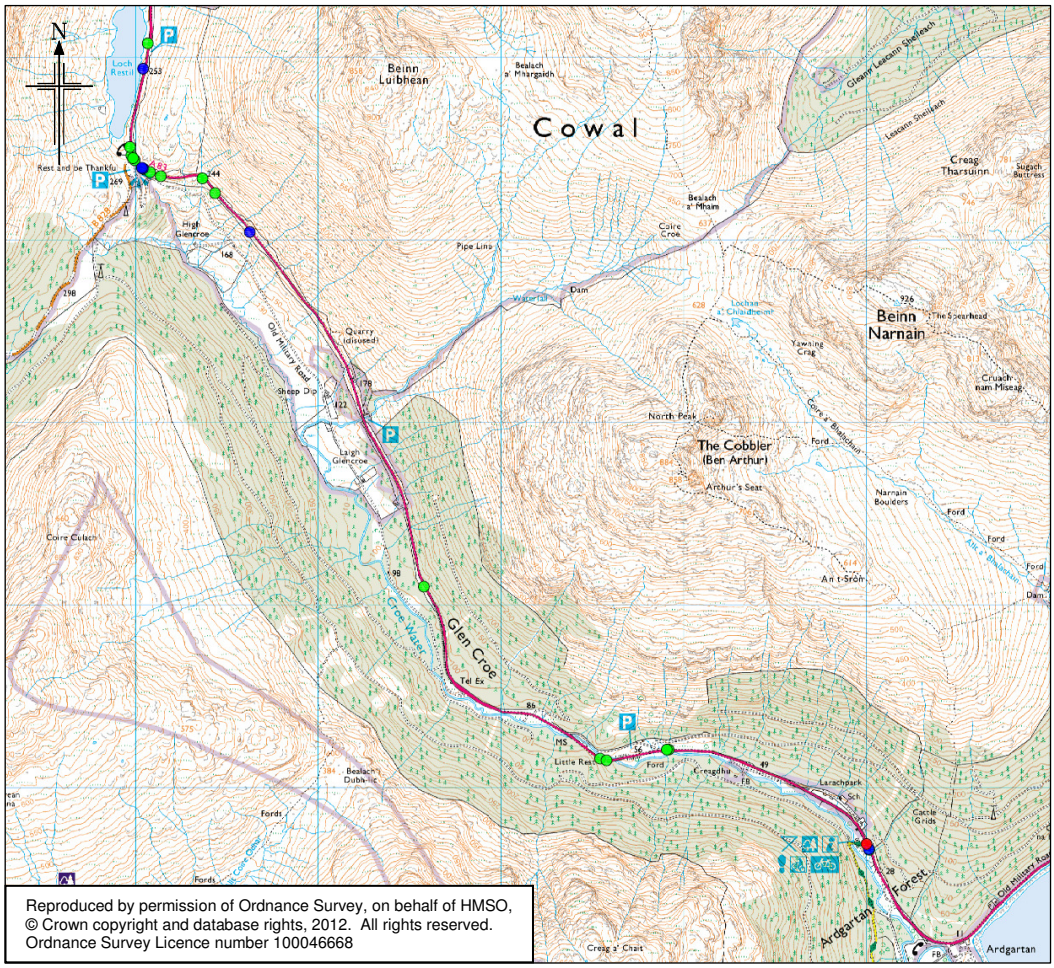


Figure 2-2: Accident Locations in the Part A Study Area

As shown in Figure 2-2 the majority of accidents that occurred within this section happened at the bend at the Rest and Be Thankful car park. The fatal accident occurred at the junction west of Ardgartan in May of 2010.

2.4 Social and Economic Context

A report on the socio-economic impacts of road closures due to landslides at Rest and Be Thankful is included as Appendix F. A summary social and economic context is given below.

2.4.1 Social Context

The area affected by closures of the A83 at Rest and Be Thankful includes Cowal, Mid Argyll, Kintyre, Islay and Jura. This is referred to as the A83 study area. The population of the study area was 37,300 in 2011 which accounts for almost 42% of the total population of Argyll and Bute. However, the population of the A83 study area has declined by 2.5% between 2008 and 2011 compared to a decline of 1% across Argyll and Bute as a whole. Over the same period, the population of Scotland has grown by 1.7%[3].

[3] Source: Scottish Neighbourhood Statistics

The study area is characterised by a lower proportion of people of working age and a higher proportion of people of pensionable age compared to Argyll and Bute as a whole and Scotland.

Between 2010 and 2035, the population of Scotland is forecast to increase by over 10% from 5.22 million to 5.76 million[4]. However, growth is not forecast across all local authorities and Argyll and Bute is one of only ten local authorities forecast to experience population decline over the period to 2035. Population projections are not available for sub-local authority areas, but it is expected that the study area would also lose population over the forecast period. The age profile within Argyll and Bute is also forecast to continue towards a more elderly population with the proportion of people of working age declining while the population of pensionable age increases.

2.4.2 Economic Context

Gross value added (GVA) is a measure of economic output, defined by the OECD[5] as the value of output less the value of intermediate consumption. It can be estimated by subtracting from turnover the cost of bought in materials, components and services. It is a measure of the contribution to GDP made by an individual producer, industry or sector. GVA generated in Argyll and Bute was £756 million[6] in 2010 which is equivalent to GVA per employee of £33,346. GVA per employee is a measure of productivity and the data for Argyll and Bute are low in comparison to GVA per employee in Scotland in 2010 which was £59,934.

Employment in the A83 study area in 2011 was 15,300 which is just under 42% of employment in Argyll and Bute. Employment has remained relatively stable in the A83 study area and Argyll and Bute since 2008 while Scottish employment has declined by 1.8%[7].

The service sector accounted for 84% of employment in the A83 study area in 2011 i.e. over 12,900 jobs. The largest component of service sector employment in this A83 study area is the public sector including public administration and defence, education and health. The public sector accounts for over 50% of all service sector employment.

Comparison of the employment structure of the A83 study area to Scotland as a whole shows that the following industries are over-represented in the area, that is, these activities account for a higher proportion of employment in the study area than across Scotland as a whole:

- Agriculture, forestry and fishing;
- Transport and storage;
- Accommodation and food services; and
- Public administration.

Almost all employment in the agriculture, forestry and fishing sector is in forestry and fishing/aquaculture. Forestry is a particularly important industry in the A83 study area with Argyll and Bute production some 1 million cubic metres per annum which is approximately one sixth of Scottish production. Production in Argyll and Bute is

[4] Source: 2010 Based Population Projections, General Register for Scotland
[5] Source: OECD Glossary of Statistical Terms (http://stats.oecd.org/glossary/detail.asp?ID=1184)
[6] Source: Annual Business Survey, but excludes part of agriculture, finance and the public sector
[7] Source: Business Register and Employment Survey

likely to rise to 1.5 to 2 million cubic metres over the next ten to 20 years as forest blocks mature and are harvested. Most of the trees grown for timber, pulp, board and pallets are processed outside Argyll and Bute reflecting the difficult geography of the area and the recent trend for large scale timber processing plants to be situated close to the main markets. The forestry industry therefore gives rise to a need for the transport of timber out of the area.

Although there is relatively little manufacturing, almost all goods landed/produced and consumed in the area have to be brought into/taken out of the area with road being the main mode of transport (see also food and drink below). Hence, the transport sector plays a key role in the economy both in generating jobs and facilitating other types of economic activity. In recent years the key issue facing this sector is increased costs, particularly related to fuel.

The accommodation and food services sector accounts for over 11% of employment in the A83 study area compared to 7% of employment in Scotland. This sector forms an important part of the tourism economy and reflects the importance of tourism to the study area. Key destinations include Inveraray and wider Loch Fyne, Kintyre, Portavadie Marina, Drimsynie Resort and the islands of Islay and Jura. Significant investments have been made in the tourist infrastructure in recent times, and road equivalent tariff (RET) fares have been introduced by Transport Scotland on the ferry routes to Islay/Jura and Gigha, in part to encourage tourist visits to these islands. The A83 study area is part of the Argyll, Loch Lomond, Stirling and Forth Valley tourist area which in 2011, had 1.747 million visitors who spent £363 million[8]. Between 2009 and 2011, visitors to this tourist area were down 6.1% and expenditure was down by almost 16% in real terms compared to growth in visitors of 4.7% and growth in expenditure of over 4% (in real terms) across Scotland as a whole.

Data are not available for the A83 study area or Argyll and Bute in terms of visitor numbers and expenditure, but survey evidence and visitor attraction data show the following:

- 44% of visitors[9] to Argyll and the Isles are visiting as part of a wider visit to Scotland e.g. touring Scotland;
- 11% of visitors to Argyll and the Isles make no bookings before travelling[9]; and
- visitor attractions in Argyll and Bute recorded a reduction in visitors of over 7% between January and August 2010 and January and August 2011[10]. This compares to an increase at attractions across Scotland of 2.6%.

Hence, the tourism sector in the A83 study area is important, but the performance of the wider tourist area of which the A83 study area is a part has been weak in recent years compared to Scotland as a whole. Tourists have a choice of destinations and competition between destinations is considerable.

The food and drink sector has an important presence in the area. In particular, whisky production is significant, with numerous distilleries on Islay and Jura and in Campbeltown. It is heavily reliant on road connections; most, if not all, of this commercial traffic uses the A83 to access the Scottish Central Belt.

[8] Source: Tourism in Western Scotland 2009 and 2011, VisitScotland
[9] Source: Scotland Visitor Survey 2011: Regional Results – Argyll and the Isles, VisitScotland
[10] Source: Scotland Visitor Attraction Barometer Report, August 2010/11, Moffat Centre

Also noteworthy are developments in the energy sector. The Wind Towers Ltd plant at Machrihanish currently has around 100 employees and has wider strategic significance in the supply chain for wind turbine towers. It is hoped that the development of offshore wind sites west of Kintyre and Islay will see a significant increase in energy sector activity in the area in future years, including increased activity at Machrihanish.

A general point which is relevant across sectors is that part of the rationale behind the designation of the A83 as a trunk road is the link it provides to ferry services, in particular the ferry connection to Islay, which connects, in turn, to Jura. Latest available figures[11] show that crossings by both commercial vehicles and buses (10,900) and cars (56,000) are at historically high levels.

The unemployment rate in the A83 study area in August 2012 was 3.6% compared to the Scottish rate of 4.3%. Although both the Scottish rate and A83 study area rate have both increased since 2008, the A83 rate has been below the Scottish rate since 2009[12].

[11] Source: Scottish Transport Statistics 2012, table 9.15 (http://www.transportscotland.gov.uk/news/Scottish-Transport-Statistics-2012)
[12] Source: Claimant Count, Crown Copyright

2.5 Landslide Hazard

2.5.1 History

The section of the A83 between Ardgartan and the Rest and Be Thankful car park has a history of hillside instability both above and below the road, in particular the slopes above Rest and Be Thankful. This has led to road closures on a number of occasions with an apparent increase in frequency since December 2011.

The 1km Rest and Be Thankful section referred to above has experienced road closures on six separate occasions between 1 January 2007 and 31 October 2012 as shown in Table 2-1. These closures have been due to actual landslide events or where there was a high risk of a potential event, resulting in the road being closed for a total period of 34 days. Within the 2007-2012 period, four of these events have occurred in the last two years. Whilst there is no complete record of all such events going further back in time, the oldest recorded event identified during the study was in the early 1980s when a failure occurred below the road (approx NN 223600 707000). This was subsequently remediated under the direction of Strathclyde Regional Council, Department of Roads. With the exception of the latter failure, all of the recent failures appear to have originated above the road, although in some instances debris or water originating above the road has led to erosion of the slopes directly below the road.

	Date & Time Closed	Date & Time Re-opened	Duration of Closure	Comments
1	28/10/07	13/11/07	17 days	
2	08/09/09 12:30	10/09/09 15:00	2 days 2½ hours	
3	01/12/11 07:00 03/12/11-13/12/11 16:00	03/12/11 08:30 04/12/11-14/12/11 08:30	2 days 1½ hours 11 x 16½ hours	 A83 open from 08:30 to 16:00 only from 03/12/11. This restriction was lifted from 14/12/11
4	22/02/12 13:00	24/02/12 10:30	2 days 22½ hours	
5	22/06/12 20:45	23/06/12 15:00	18¼ hours	Closure due to high risk of landslide
6	01/08/12 16:00	03/08/12 18:00	2 days 2 hours	
Total Duration			**34 days**	

Table 2-1: Date and duration of A83 Rest and Be Thankful Road Closures due to landslide events for period from 1 January 2007 to 31 October 2012[13]

The fact that Rest and Be Thankful has been subject to a number of landslides, increasingly so in recent times, is attributed to a number of factors including: the alignment of the road, which follows sidelong ground along the steep slopes of Beinn Luibhean; climatic factors, in particular the significant rainfall experienced in the west of Scotland; and poor natural drainage conditions on the hillside and the nature of the soils covering the hillside.

2.5.2 Geological Description

The superficial deposits present on the hillside comprise mainly glacial till deposits, locally in the form of morainic deposits near the base of the slopes. In many areas these deposits have been reworked and redeposited on the lower slopes as colluvium, as a result of downslope movements due to gravity through a variety of

[13] Source: Scotland TranServ and Transport Scotland

geological processes, including landslides and soil creep. There is extensive evidence of these processes on the hill slopes represented by a number of geomorphological features including terracettes, failure backscarps, lobes of deposited materials, deeply incised stream channels, all characteristics of a steep hillside topography undergoing change. The geological processes of erosion and deposition are currently active on the hillside creating a dynamic environment of constant change. Alluvial deposits are likely to be present on the valley floor beneath the floodplain of the River Croe.

The bedrock geology comprises a sequence of metamorphic rocks belonging to the Beinn Bheula Schist which is made up of mainly cleaved greywackes, green siltstones and schists. The geological structure has been complicated by folding and faulting, with two approximately North-South trending faults indicated to occur in the vicinity of the Rest and Be Thankful car park. Igneous intrusions, principally in the form of dykes, are also indicated to occur in this area. The bedrock is exposed locally on the hillside, particularly on the higher ground, well above the road. Soil cover appears generally to increase in thickness in a downslope direction towards the road. Below the road, the soil slopes generally appear to be less steep and the thickness of superficial deposits is likely to increase in this area and towards the base of the valley. These lower slopes also contain run-out fans of layered and mounded soils from previous debris flows and landslides.

2.5.3 Scottish Road Network Landslides Study

In August 2004 Scotland experienced rainfall substantially in excess of the norm. The rainfall was both intense and long lasting and as a result, a large number of landslides in the form of debris flows were experienced in the hills of Scotland. A small number of these intersected the strategic trunk road network including the A83. On this occasion, Rest and Be Thankful was not directly affected but landslides occurred at several locations between Glen Kinglas and Cairndow, the most significant being at Cairndow. The severity of the landslides prompted Transport Scotland to undertake the Scottish Road Network Landslides Study (SRNLS)[14], alongside a study on climate change[15]. The initial landslides study collated and presented the background information and developed the plan for the second part. The second (implementation) part of the landslides study[16] presents a detailed debris flow hazard assessment and ranking of sites on the trunk road network and sets out the proposed strategy for the management and mitigation of such events.

As part of the Implementation study a hazard assessment and ranking was undertaken for debris flow. In summary the system used raw data from a variety of sources including the extended digital data set underlying British Geological Survey (BGS) maps (DiGMap), high resolution elevation data (NEXTMap) and CEH (Centre of Ecology and Hydrology) land use data maps. The system used five variables (availability of debris material, water conditions, vegetation, and land use, stream channels, and slope angle) obtained from the above datasets to provide a GIS based susceptibility assessment for most of the land area of Scotland. The results of the susceptibility assessment were subject to detailed interpretation using further digital datasets to determine the hazards relevant to the trunk road network. This

[14] Winter, M.G., Macgregor, F. and Shackman, L. (Eds). 2005. Scottish Road Network Landslides Study. The Scottish Executive, Edinburgh.
[15] Galbraith, R.M.,Price, D.J. and Shackman, L. (Eds) 2005 Scottish Road Network Climate Change Study. The Scottish Executive, Edinburgh.
[16] Winter, M.G., Macgregor, F. and Shackman, L. (Eds) 2009. Scottish Road Network Landslides Study: Implementation. Transport Scotland, Edinburgh.

desk/computer-based work was verified by means of site-specific assessments involving field-based inspections. Finally, the hazards were ranked by combining the hazard assessment with the exposure scores based on traffic volumes (Average Annual daily Flows, AADF) and the length and difficulty/viability of diversion route (in some cases there is no diversion). Full details of the methodology are contained within the Scottish Road Network Landslide Study Implementation Report[16]. The risk values reflect the likelihood of the hazard and the consequences of its occurrence, taking into account the factors described above.

With regard to the section of the A83 containing the Rest and Be Thankful (SRNLS Location Ref. A83-02 Ardgartan to Rest and Be Thankful) the most recent Hazard Ranking (2009) indicates a score of 200, placing it high on the list within the High/Very High category (score >100). The score has increased from that determined in 2007[16] (when the score was 180) for the reason that a site-specific inspection of this section was not undertaken until 2009 at which point high resolution aerial photography became available. By way of comparison, the highest hazard ranking score for the trunk road network is 250 and applies to locations where the available diversion route is considered 'more significant' (i.e. longer and more difficult).

Other sections of the A83 included within this study also score highly, namely Glen Kinglas (190) and Clachan to Strone Point (170). Table 2-2 below indicates the top group of locations in Scotland in terms of Hazard Ranking and Table 2-3 lists A83 locations with High/Very High rankings. Further consideration of these locations is given in section 6.4 as part of the landslide hazard reduction for the whole A83 Trunk Road.

Route Code	Hazard Ranking (Risk) Score	Locality
A82-17	250	A82 Loch Lochy
A9-12	250	A9 South of Helmsdale
A85-09	250	A85 Glen Dochart
A82-08	225	A82 North of Invermoriston
A9-35b	225	A9 North of Glen Garry
A82-37	213	A82 Inverbeg
A82-36	213	A82 South of Tarbet
A82-09	200	A82 Invermoriston
A82-34	200	A82 North of Loch Lomond
A83-02	200	A83 Ardgartan to Rest and Be Thankful

Table 2-2: Top group of sites in Scotland in terms of Hazard Ranking (Risk) Score[17]

Route Code	Hazard Ranking (Risk) Score	Locality
A83-02	200	A83 Ardgartan to Rest and Be Thankful
A83-04	190	A83 Glen Kinglas
A83-06	170	A83 Clachan to Strone Point
A83-05	150	A83 Cairndow
A83-10	140	A83 East of Auchindrain Folk Museum
A83-18	125	A83 South of Inverneill
A83-12	120	A83 West of Furnace

[17] Transport Scotland 2009. Scottish Road Network Landslide Hazard Ranking

Route Code	Hazard Ranking (Risk) Score	Locality
A83-20	113	A83 North of Tarbet
A83-01	110	A83 West of Succoth
A83-07	100	A83 East of Loch Shira

Table 2-3: Locations on A83 with Hazard Ranking (Risk) scores of 100 or more[17]

The scores set out in Table 2-2 and Table 2-3 are not intended to provide an exact quantitative risk assessment in respect of debris flow hazards. A regional study, commencing with almost the entire land area of Scotland, simply does not lend itself to that type of approach. Its function is to provide a categorisation, or ranking, of the hazards that affect the trunk road network into groups that can be used by those experienced and expert in this area to prioritise management and mitigation actions. It thus guides an experienced hand in determining the highest ranked groups of hazards and the sites most likely to require further action. Thus it is clear to those who work in this area in Scotland that the A83-02 is amongst the most highly ranked debris flow hazard sites in Scotland.

2.5.4 Management and Mitigation

In order to manage the landslide hazard, active monitoring and inspection of the slopes above and below the A83 at Rest and Be Thankful has been undertaken by the Operating Companies appointed by Transport Scotland (BEAR and Scotland TranServ) since 2001, following a landslide at the south end of Rest and Be Thankful where the A83 crosses the River Croe. This forms an essential part of the management strategy proposed as part of the Scottish Road Network Landslides Study (Implementation) in terms of exposure reduction. Since 2001, annual slope inspections have been undertaken to identify potential failure areas and where appropriate monitoring instrumentation or other remote monitoring techniques have been adopted in an attempt to monitor areas of particular risk and potentially provide advance warning of imminent failures. The successful implementation of such a monitoring system allows the road to be closed where there is considered to be an imminent threat to the road, avoiding the risk to the road users. An assessment of potentially unstable boulders on the hillside is also included within the inspection regime.

Early monitoring of the hillside included survey monitoring pegs within critical areas, which were monitored regularly for movement. In more recent years these have been replaced with more sophisticated techniques such as the use of piezometers, inclinometers and a weather station with continuous data monitoring and transmittal of data via a modem to the internet for processing and assessment. The data from the inclinometers is processed and analysed in near real-time to assess the conditions within potential slip areas. Using this system, notifications can be made to key personnel within the Operating Company once the defined threshold levels are reached, prompting closer inspection of the area of concern or ultimately to a decision to request the road be closed. Recent monitoring has also included annual laser scan mapping of the hillside from the opposite side of the valley, allowing comparison with previous surveys to identify areas of recent movement on the slopes. There are also movement sensors installed on the debris flow barriers (discussed below) in places. A further measure adopted has been the use of variable message signs (VMS) and Wig-Wag signs providing motorists with advance warning of a higher possibility of landslides on this part of the road network, based on rainfall data.

Two additional rain gauges have recently been installed in the vicinity of the Rest and be Thankful in collaboration with SEPA. These meet national standards and now form part of the national weather monitoring network. The results from these gauges are being actively monitored and, together with other on-going work, used to develop an improved understanding of the rainfall triggers for debris flow at this location. This will ultimately lead to a system whereby periods of higher debris flow probability are able to be forecast, but this is a longer term aim as a significant timeline of data is needed to produce reliable results.

2.5.5 Hazard Reduction

In terms of hazard reduction as set out in the Scottish Road Network Landslides Study (Implementation) and remedial works undertaken in response to failures, this has included the use of rockfill, particularly where failure has occurred below the road with the potential to undermine it due to erosion, repairs to culverts and removal of failed materials from the road. Preventative measures in response to either previous failures or as part of a proactive management approach implemented as part of the hazard reduction approach, have included upgrading culverts, the construction of a new cascade and culvert, and more recently the installation of a number of debris fences.

Scotland TranServ has installed approximately 168m of debris flow barrier as part of their Phase 1 (2010) and Phase 2 (2012) works, in addition to a single in-channel barrier (VX barrier). A further two phases (Phase 3 & Phase 4) of debris flow barrier and other measures are currently being considered to address further areas of particular concern including the location of the August 2012 failure (Phase 3).

Figure 2-3 and Figure 2-4 show the locations of recent slope failure events and the location of the installed debris flow barriers. The locations identified by Scotland TranServ for further protection measures are also indicated. The locations are also marked on drawing B1557610/WP08/002 included in Appendix A.

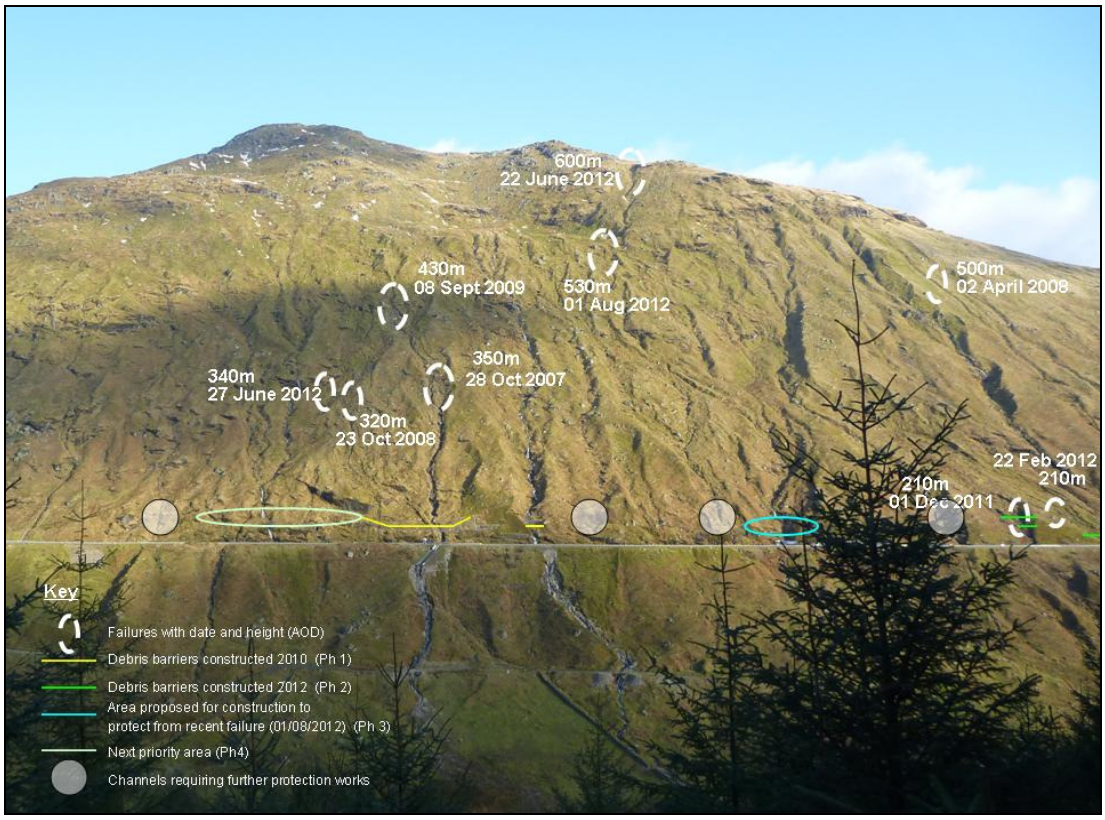


Figure 2-3 : ***Image showing recent slope failure locations and location of existing and proposed debris barriers. Image courtesy of Scotland TranServ***

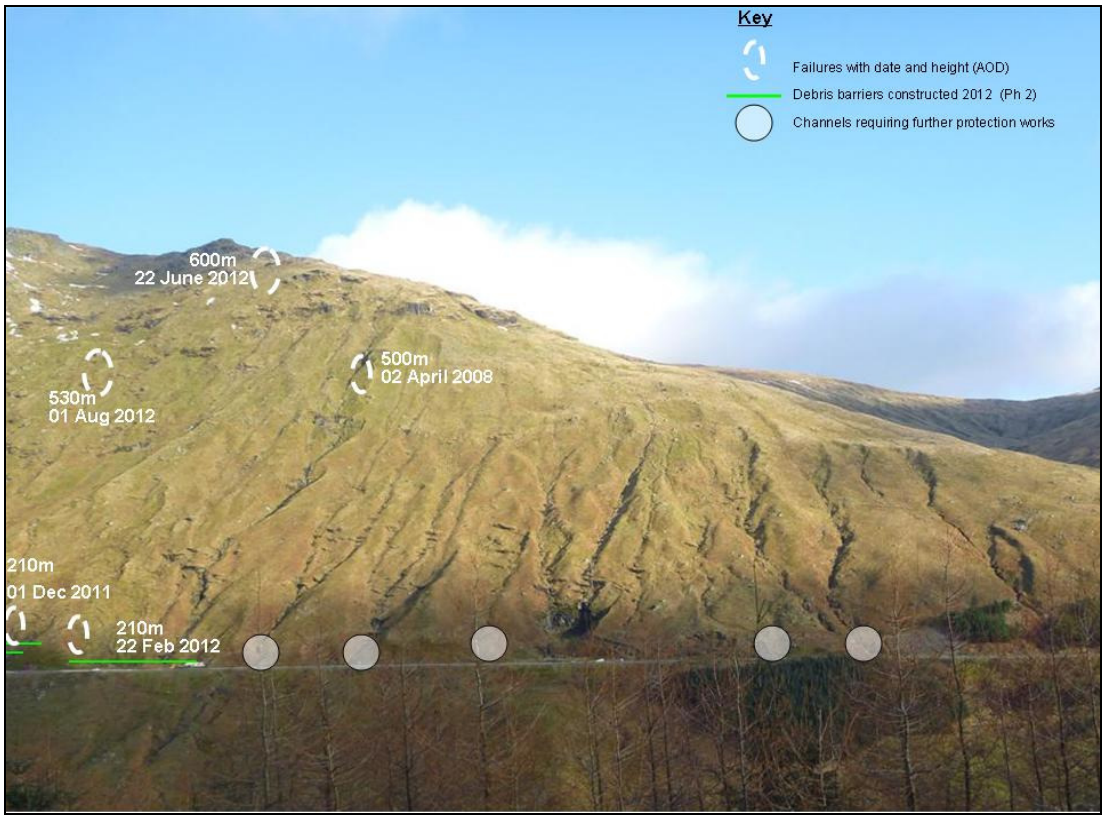


Figure 2-4: ***Image showing recent slope failure locations and location of existing and proposed debris barriers. Image courtesy of Scotland TranServ***

2.6 Stakeholder Consultation

A stakeholder consultation workshop for the study was held at the Loch Fyne Hotel, Inveraray, on 22 August 2012. It was attended by various parties including local elected members, officials from Argyll and Bute Council, community council representatives, transport operators, local business groups, Transport Scotland, Scotland TranServ and Jacobs. Further written feedback was also received from stakeholders through the project email address.

A further (technical) workshop was held on 29 August 2012 with a focus on operational management issues This workshop was held in Jacobs offices in Glasgow and was attended by representatives of Transport Scotland, Scotland TranServ, the Transport Research Laboratory and Jacobs.

The transport issues raised by stakeholders have been considered in the identification of transport problems and constraints, which is the first stage of a Transport Appraisal.

Following the stakeholder workshops the issues raised have been examined alongside previous reports and studies for the route and accident records for the route in order to build up the evidence of the identified problems.

In addition, a site visit has been undertaken along the length of the route.

The issues discussed at the Inveraray Stakeholder event are detailed in the Stakeholder Consultation Workshop – Summary of Discussion [18], which was published on the Transport Scotland website following the events and which is included as Appendix C.

2.7 Analysis of Problems and Constraints

The issues which have come forward about the closure of the A83 at the Rest and Be Thankful due to landslides or the risk of landslides are as follows:

Transport

- The A82/A85/A819 diversion route results in significantly increased journey times. Journey times between Tarbet and Inveraray increase by approximately 45 minutes, while journey times between Tarbet and the Cowal increase by approximately 70 minutes.
- Public bus services are affected by the diversion route and require the operators to implement an alternative timetable. Closure of the road and the use of the diversion add to operating costs and the time taken for the journey – an additional 45 minutes. The additional time takes the driver to his legal limit (in driving hours) and the need for a 45 minute break. Rather than add 1.5 hours to the travel time of a single journey, the company sends a relief driver to meet the service to ensure that the original driver can get his break and the additional time for the journey is kept to a minimum of 45 minutes.
- Reduced passenger numbers have been recorded on the Campbeltown to Glasgow bus service 926 during closure periods. The bus operator advised

[18] A83 Trunk Road Route Study – Stakeholder Consultation Workshop: Summary of Discussion. Produced by Jacobs for Transport Scotland. August 2012. http://www.transportscotland.gov.uk/road/maintenance/landslides/A83-rest-and-be-thankful

that passenger numbers have been noted to drop from 40 to 20 per trip during closure periods.

- Stakeholders have advised that there is an increased risk of accidents due to the use of an unfamiliar diversion route and significantly longer driving times result in additional time pressures.
- Increased journey times can result in ferry connections to Islay and Gigha being missed with a resultant knock on effect to businesses on the islands. In the peak seasons, ferry sailings can be fully booked, so vehicles may not be able to cross on the next sailing.
- Some school pupils travel to school through the landslide area. When the route is closed, travel to school via the diversion route is not considered viable.
- Access to and from the study area for personal and social reasons is reduced, e.g. shopping and hospital appointments.

Forestry & Haulage

- As there is no processing of forest products in Argyll and Bute, all timber production must be moved from the area. While some forest products move by sea, the majority move by road to processors in the Central Belt, Ayrshire and Fort William. Approximately 40 loads per day move via the A83 and Rest and Be Thankful.
- Depending on origin/destination of timber, most hauliers expect to make two return trips per day. When Rest and Be Thankful is closed, the time taken to travel the diversion route prevents two return trips being made. This adds to costs and ability to make deliveries as scheduled.
- The effect of “missed” deliveries is felt further down the processing chain with sawmills/other processors often depending on a continuous supply of timber.
- The “unreliability” of supply could result in a longer term effect on future sales from the A83 area as sawmills/other processors source some timber from other areas to ensure that they have continuity of supply.
- The points made regarding two return trips per day apply to other hauliers delivering some non-timber products.
- There can be additional pressure on hauliers delivering specific products to certain destinations (e.g. ports, supermarkets etc) where the haulier is given a specific delivery slot and the goods will not be accepted after this time.
- Businesses experience additional costs from additional fuel, staff time and other running costs; the costs vary depending on the nature and size of the business, however some businesses report daily additional costs in excess of £3,000.

Tourism

- There is concern that tourist trips are lost as closure of the A83 at Rest and Be Thankful makes it more difficult to access the region. This will include people who are touring Scotland and intend to visit the area but decide, due to the closure, to visit another part of Scotland. While there may be no effect on tourism numbers in Scotland as a whole, there is an adverse effect on the local A83 area.
- Coach tours are planned with specific itineraries, distances and travel times to meet the needs of the driver and passengers. The A83 diversion route can pose problems for this part of the market in terms of meeting the itineraries and if the problem persists, there is a concern that tours will be put off travelling to the A83 area.

- The cruise market is an important part of the Scottish tourism sector. Many of the passengers arriving at Scottish ports take organised trips to nearby attractions. Passengers arriving at Greenock often visit Inveraray but this is only possible when the A83 at Rest and Be Thankful is open. Given that there is a time constraint for these passengers on their trips, closure of the A83 and the diversion route would result in these trips visiting another part of Scotland.
- There is also concern about the loss of future trips as a result of perceptions that the A83 study area is difficult to access/does not have reliable access. The A83 study area is competing with other areas in Scotland that may be perceived to have better, more reliable access. If people perceive that the A83 area is difficult to access, there could be a long term adverse effect on visitor numbers.
- Discussions suggest a reduction in tourism expenditure of between 20% and 36% per day when the A83 is closed at Rest and Be Thankful.
- Some businesses along the A83 between Tarbet and Inveraray can experience a particularly severe loss of turnover when the Rest and Be Thankful is closed since very few (if any) visitors travel this section of the road.

Public Sector

- Argyll and Bute covers a large area and there is often a need for public sector employees to move between offices. When the diversion route is in place this adds to costs and the time taken for staff to get to meetings.
- Fire cover in the area is provided through a combination of full-time, retained and volunteer stations with the majority of stations being in the volunteer category. This means that there can be a need to provide additional resources from other stations in the event of an incident which incurs additional time and costs if the diversion route has to be used. The additional amount of time taken to get to the incident can have consequences regarding the severity of the incident.
- Using the diversion route results in logistical problems for the fire and rescue service, but it also reduces the resilience of fire cover in the areas which have sent vehicles/resources onto the diversion route.
- The police and ambulance services experience increased attendance times due to travel via the diversion route.

Other Potential Effects

- Closure of the road and the diversion route give the impression that the A83 study area is difficult to access and access is not reliable. Given the declining population of the area, there is a need to attract population, but perception problems surrounding access will make this more difficult, particularly given the links between the A83 study area and Glasgow for access to certain services e.g. hospitals.
- There has also been substantial investment in the parts of the A83 study area in recent years (e.g. the wind turbine manufacturing site at Machrihanish and the Machrihanish Dunes golf and hotel complex) and it is important that further investment is not hampered by perceptions that the A83 is not a guaranteed link into the area.

Additional issues were raised relating to existing operational matters. These matters do not form part of this study but are being considered by Transport Scotland's Operating Company:

- Stakeholders highlighted a risk of material on lower slopes, below current road level, on Rest and Be Thankful slipping. TranServ have confirmed that there is one part of the route through the Rest and Be Thankful where there are historical issues below the route itself.
- The hazard warning system flashes when there is an increased risk of landslide but drivers are unsure how to react when the warning is activated.
- The closures and the risk of closure due to landslides/landslide risk are discouraging visitors from using the A83 and therefore accessing the communities along the A83. This is being made worse by the higher risk message that is being portrayed. Intensive monitoring and warning are making the situation worse.
- The length of time to re-open the road following closure is perceived as being excessive.
- Traffic Scotland information is slow to load on mobile devices and is not specific to the area.
- Traffic is queuing back onto the adjacent road from the ferry terminals at McInroy's Point and Hunter's Quay due to increased use of the ferry service to access the A83 via the A814 during closure periods and to limited available storage space at the terminals.

The identified problems are listed below. The views shared by stakeholders has informed the process of identification of the problems.

- The A82/A85/A819 diversion route increases journey times by 45 to 70 minutes.
- The increased journey times of this diversion route reduces access to and from the study area.
- This diversion route increases times of public bus services, requires a relief driver and can reduce passenger numbers by up to half.
- The increased journey times of this diversion route can result in missed ferries to Islay and Gigha.
- Businesses in Argyll experience additional costs from additional fuel, drivers wages and other running costs.
- Unreliability of supply is created by longer journey times can result in missed deliveries and missed delivery slots, which in turn can affect repeat business.
- Increased journey times may result in lost tourist trips to the study area.
- Perception of unreliable access may result in lost tourist trips to the study area.
- The public sector in Argyll experience additional costs from additional fuel, wages and other running costs and lost productive time.
- Emergency services may take longer to respond to an incident.

2.8 Economic Impact of Road Closures at A83 Rest and Be Thankful

A study has been undertaken in parallel to this study on the socio-economic impact of road closures due to landslides at the Rest and Be Thankful. The 'parallel' study report is included as Appendix F. The outcomes from the parallel study provide evidence in addition to, and not in place of, the standard economic appraisal reported in Chapter 9.

Rather than using standard transport appraisal methodology, the parallel study report draws on information from some key economic stakeholders. The parallel study aims to provide an estimate of the socio-economic impacts associated with past landslides at the Rest and Be Thankful site in order to build on the evidence base of the problems faced at the site.. A summary of the results of this work is given below.

As shown in Table 2-1, between 1st January 2007 and 31st October 2012, the A83 at Rest and Be Thankful has been closed five times as a result of a landslide and closed once due to the high risk of a landslide. In total, these closures amounted to 34 days. The 2007 closure was extreme and lasted 17 days and the 2011 closure included 11 overnight closures. The other closures lasted 1 to 3 days. For the purpose of the economic appraisal the average duration of these road closures is taken to be 5½ days (calculated by averaging the six events with the overnight closures being counted as 11 half-days based on the change in traffic flows).

From information gathered during the consultations, it has been possible to estimate the additional costs to the transport and tourism sectors of the A83 study area from closure of the A83 at Rest and Be Thankful and the use of the pre-planned diversion route via the A82/A85/A819.

The approach to the calculations is:

- calculate the additional costs that are incurred per day from closure of the road by sector
- gross up the daily costs to reflect the central scenario which assumes that on average the road is closed for 5½ days a year.
- convert costs into 2010 prices
- assume that the additional costs would result in reduced income to the study area and calculate the number of jobs that could be supported by the reduced income using Gross Value Added per employee
- test the sensitivity of the results to the assumptions regarding length of closure through two sensitivity tests – low and high:
    - low – the average duration of road closures since 2009 which is 2.5 days;
    - high – the number of days the road has been closed over the last 12 months due to landslides which is 13 days.

The additional annual costs to the A83 economy from landslides at the Rest and Be Thankful is estimated to be £286,300 (in 2010 prices) under the central scenario.

If these additional costs, identified above, are assumed to be a direct loss of income to the local area, the number of jobs which would be supported by this “lost” income is calculated using GVA per employee. Under the central scenario, the lost income would support almost 12 jobs in the A83 study area.

The sensitivity analysis shows that the additional annual costs to the A83 economy from landslide events at the Rest and Be Thankful are in the range £130,200 to £676,800.

These economic impacts should not be added to the results of the core economic appraisal of options presented in section 9 because this would involve the double

counting of impacts. It should also be noted that these costs are calculated on the basis of no availability of the Old Military Road, while the core economic appraisal undertaken in section 9 takes this new diversion route into account. Note that the results are based on the experience of the stakeholders in a selection of key sectors and other potential impacts identified above have not been capable of quantification at this point in time.

There is some anecdotal evidence of wider impacts, including tourist businesses reporting a loss of business in the days following a closure, but it has not been possible to establish this. Data on traffic flows provide a possible indication of this for the long closure in 2007, i.e. flows did not immediately recover, but since then, closures show a reasonably quick bounce back subsequent to reopening (typically within hours).

3 TRANSPORT PLANNING OBJECTIVES

3.1 Introduction

This section provides a summary of transport planning objectives and sets out the project objectives that align to the national and regional objectives.

3.2 National and Regional Objectives

3.2.1 Strategic Transport Projects Review (STPR)

The following specific objectives were established by the STPR with respect to the Glasgow to Oban/Fort William and the Western Isles Option (Option 7), which includes the A83:

- To provide improved road standards and overtaking opportunities; and
- To reduce accident severity to the national average.

The A83 was identified, under Intervention 5, as one of a number of routes which performed well and therefore did not need specific interventions to address option specific issues in order to meet the established objectives.

However, the STPR recognised that there is a need to maintain and safely operate the options listed under Intervention 5 in the context of a route management strategy. The STPR also highlighted that this may be achieved through localised improvements targeted to bring the physical condition and safety standards of these options to a level which will support the expected levels of traffic during the period of the review.

3.2.2 National Transport Strategy

The Scottish Government's Purpose is to focus government and public services on creating a more successful country, with opportunities for all of Scotland to flourish, through increasing sustainable economic growth. This is translated to five strategic objectives for a safer and stronger; smarter; wealthier and fairer; greener; and healthier Scotland.

Scotland's National Transport Strategy (NTS) uses the following Key Strategic Outcomes (KSOs) as the basis for delivering improvement to transport in Scotland in response to the Scottish Government's purpose and strategic objectives:

- Improve journey times and connections between our cities and towns and our global markets to tackle congestion and provide access to key markets - wealthier and fairer, safer and stronger;
- Reduce emissions to tackle climate change - safer and stronger, wealthier and fairer; and
- Improve quality, accessibility and affordability of transport, to give people the choice of public transport and real alternatives to the car. - greener, healthier, smarter.
- The STPR adopted the National Transport Strategy KSOs and used them as a basis to develop national and specific objectives for various urban networks, strategic nodes and transport options.

- In developing and appraising transport interventions, the STPR used a tiered approach to investment, based around the priorities of:
- Maintaining and safely operating existing assets;
- Promoting a range of measures, including innovative solutions, that make better use of existing capacity; and
- Promoting targeted infrastructure improvements where these are necessary, affordable and practicable.

3.2.3 Adopted Argyll and Bute Local Plan

Several projects were taken forward by the Council and its partners for the period of the Local Plan including;

- To continue to address public transport and community transport issues such as the HITRANS contract to deliver improved transport infrastructure throughout the Highlands and Islands.
- To work with SUSTRANS and Scotex to provide long distance cycle paths including the West Argyll Route.
- To work with HITRANS and the Strathcylde Partnership for Transport to address transport policy issues on a regional and national level by means of a Regional Transport Strategy.

The Local Plan supported seven strategic issues that were recognised by the Structure Plan including *''encouraging the further regeneration of the West of Argyll and the islands given their ''fragile'' status and the need for further investment to counter economic and geographic disadvantages''*.

An Action Plan was produced in conjunction with the Local Plan to provide a priority framework for delivering key elements of the plan including Allocations; Areas For Action; Potential Development Areas; Development Road Actions and Traffic Management Actions.

3.2.4 Emerging Argyll and Bute Development Plan Main Issues Report

''Improving our Connectivity and Infrastructure Together'' is one of the key themes within the Main Issues report for the emerging Argyll and Bute Development Plan, which is currently being developed. It concerns such issues as the need to integrate new developments with existing infrastructure and making the necessary improvements to the transport network to make public transport and other modes of private and freight transport more attractive as a means of travel.

Some of the key transport issues which are considered within the LDP include:

- To ensure integration with Regional and Local Transport Strategies covering Argyll and Bute.
- To focus investment on our road network where it can achieve the best impact;
- Improving accessibility to key services and facilities through better integration of land use and transport and the path network;
- Continue to advocate improvement of our strategic links; life line ferry and air services; trunk roads A82, A85, A83; bus and rail services;
- Ensuring significant new development contributes to improving our transport infrastructure;

- Climate Change; reduce emissions and safeguard transportation routes from impacts of climate change (e.g. flooding of coastal routes, increased landslide risk):

''The mitigation of impacts such as flooding and landslip, particularly on strategic routes and links to our remote communities' is considered as the main transport issue within the LDP.

3.2.5 HITRANS Regional Transport Strategy

The vision of HITRANS Regional Transport Strategy (2008) for the Highlands and Islands is: ''enhancing the area's viability – enhancing its place competitiveness and thereby attracting and retaining people in the area and making it a more attractive place in which to live, to work, to conduct business and to visit.''

The HITRANS strategy states that to accomplish this, a suitable multi-modal transport system is required.

Ten horizontal themes were developed to concentrate action and investment to work towards their vision during the next fifteen years. Those relevant to the A83 route are:

- Active travel – promoting the long term development of walking and cycling across the region to reduce the use of cars for short journeys and to contribute towards good health.
- Freight transport – assisting freight transport to shift mode from road to less environmentally damaging rail and sea.
- Locally significant network and maintenance of the area's roads - developing a programme of investment to improve and maintain the locally significant rural road network which has suffered from under-investment in the past.
- Mainstream passenger transport. – preparing a strategy for investment in the region's bus services.
- Ports, ferries and waterway transport – preparing a strategy for investment in ports and ferries.
- Cost of transport and travel – developing initiatives for reducing the cost of transport and travel.
- Environmental impacts – develop ways to reduce and mitigate the climate change impact of travelling in, to and from the region.

The principle objective of HITRANS is to generate sustainable economic growth across the region by improving the interconnectivity across the area to destinations and strategic services. This is undertaken through the support of Local Authorities, Scottish Government and other important public and private sector partners to create an enhanced transport network across the Highlands and Islands.

HITRANS aim to *"improve journey reliability connecting Argyll and Bute to Glasgow via the trunk roads and the West Highland Line"* in addition to *''improving mainland road connections and sea crossings to the Western Isles"*. They have also identified priorities for improving the regionally significant network, such as upgrading the connections to the Argyll islands from the mainland.

They also aim to improve and create more integrated transport services to increase the tourist and business usage of public transport. Subsequently they want to provide high quality public and freight transport services and be considered as one of the leading regions in reference to intelligent transport systems.

3.2.6 Argyll and Bute Local Transport Strategy

The vision for the current Argyll and Bute Local Transport Strategy is to enable a vibrant Argyll and Bute. To achieve this, the LTS has adopted the following objectives:

- Encourage a growing and sustainable economy in Argyll and Bute;
- Improve people's transport experience;
- Manage the effect of transport on Argyll and Bute's rich natural environment;
- Improve accessibility for all our communities;
- Improve journey safety and personal security for everyone in Argyll and Bute.

3.3 Project Objectives

Draft transport planning objectives were presented to the stakeholder workshop at Inveraray on 22 August 2012. These objectives align to the National and Regional Objectives outlined in the previous sections of the report and are:

1. Provide a long term solution to address landslide impacts at the Rest and Be Thankful;
2. Improve journey time reliability by reducing the frequency and impact of road closures;
3. Improve operating conditions on the A83;
4. Reduce accident rates and severity on the A83;
5. Improve pedestrian and cycling amenities in the settlements on the A83; and
6. Deliver environmental benefits where possible, and minimise necessary environmental impacts to an acceptable level.

The first of these objectives is the overarching strategic objective for the A83 at Rest and Be Thankful. Specific objectives have then been developed to address the problems identified in Section 2.

Strategic Objective:

Provide a long term solution to address landslide impacts at Rest and Be Thankful**.**

Objective 1:
Reduce the **impact on journey times** by reducing the frequency and duration of road closures caused by landslides

Objective 2:
Reduce the **economic impact to the A83 study area** by reducing the frequency and duration of road closures caused by landslides

Strategic Objectives 2-5 have been incorporated into the appraisal of the whole A83 Trunk Route from Tarbet to Kennacraig, considered in Part B of the A83 Trunk Road Route Study[19]. Strategic Objective 6 is facilitated through the appraisal process within the 'environment' STAG criteria and has therefore been removed.

[19] A83 Trunk Road Route Study – Part B Tarbet-Lochgilphead-Kennacraig, Produced by Jacobs for Transport Scotland, December 2012

Table 3-1 below identifies how the transport planning objectives detailed above relate to the problems, impacts and consequences that were identified in Section 2.

Identified Problem, Impact or Consequence	Objective 1	Objective 2
The A82/A85/A819 diversion route increases journey times by 45 to 70 minutes.	✓	✓
The increased journey times of this diversion route reduces access to and from the study area.	✓	-
This diversion route increases times of public bus services, requires a relief driver and can reduce passenger numbers by up to half.	✓	✓
The increased journey times of this diversion route can result in missed ferries to Islay and Gigha.	✓	✓
Businesses in Argyll experience additional costs from additional fuel, drivers wages and other running costs.	✓	✓
Unreliability of supply is created by longer journey times can result in missed deliveries and missed delivery slots, which in turn can affect repeat business.	✓	✓
Increased journey times may result in lost tourist trips to the study area.	✓	-
Perception of unreliable access may result in lost tourist trips to the study area.	✓	✓
The public sector in Argyll experience additional costs from additional fuel, wages and other running costs and lost productive time.	✓	-
Emergency services may take longer to respond to an incident.	✓	✓

Table 3-1: Identified Problems and Transport Planning Objectives

4 OPTION GENERATION

4.1 Overview

The potential options assessed in this study have been generated following the stakeholder workshop event and discussions with Transport Scotland about a broad range of alternative options.

- Do Minimum scenario
- Glen Croe on-line improvement corridor options
- Glen Croe off-line improvement corridor options
- Alternative route corridors providing access to mid-Argyll

Further details in respect of each of these options are provided below. In considering these alternatives it is important to note that each should be considered as a conceptual proposal at this time and is considered on a corridor basis and not on the basis of a specific route alignment. Indicative proposals have been developed for the purposes of the assessment documented in this report only. These proposals are subject to significant refinement at later stages of the design development process. The options as described at this time should therefore not be taken to be definitive route proposals for the corridor concerned.

Some suggestions made during the Stakeholder Consultation Workshop have been discounted at an early stage of the assessment process. These are discussed in Section 4.5.6 Other Options.

Approximate preliminary cost estimates at 2012 prices have been developed for each of the options described below. The costs outlined have been generated as an approximate cost of an indicative alignment within each respective corridor for the purpose of comparing options on an equitable basis. Costs will be subject to change depending on further development of the options that progress in the next stage.

4.2 Do Minimum Scenario

The Do Minimum Scenario comprises the existing A83 alignment including the 168m of debris flow barriers that have been installed by October 2012. This scenario also includes the works being undertaken to bring into use the Old Military Road as an Emergency Diversion Route during road closures due to debris flow events on the A83. This is intended as a short-term measure until a longer term solution is implemented. The Emergency Diversion Route is 4km long from the Rest and Be Thankful car park to part-way down Glen Croe at the point where the Old Military road rejoins the route of the current A83.

In this scenario, the effect of road closures on the existing A83, due to debris flow events is partly mitigated through the use of the Emergency Diversion Route. Transport Scotland and the Operating Company will review the operation of the Emergency Diversion Route in order to minimise delays.

4.3 Glen Croe On-Line Improvement Options

4.3.1 Red Corridor

The Red Option is an on-line scenario following the route of the existing A83 with the extents shown in Figure 4-1. This scenario involves substantial hazard reduction measures along the line of the existing road to reduce the occurrence of landslides and/or the frequency and duration that landslides cause road closures. These measures represent a significant step-change in the provision of landslide hazard reduction and the level of capital investment at this location.

This follows the landslide management strategy recommended in the Scottish Road Network Landslides Study (SRNLS) and includes the following range of measures as part of that management strategy:

- installation of a further 440m of debris flow barriers, including phases 3 and 4 being constructed in early 2013, refer to drawing B1557610/ WP08/002 in Appendix A;
- slope vegetation. The vegetation aspect is covered in a separate report by Transport Scotland and Transport Research Laboratory (Winter and Corby, 2012)[20]; and,
- improved drainage measures to collect and convey surface water run-off from the hillside, including landslide debris, in the form of a slurry, which passes the debris barriers. For example improvements to culverts under the A83 carriageway and longitudinal drainage adjacent to the A83.

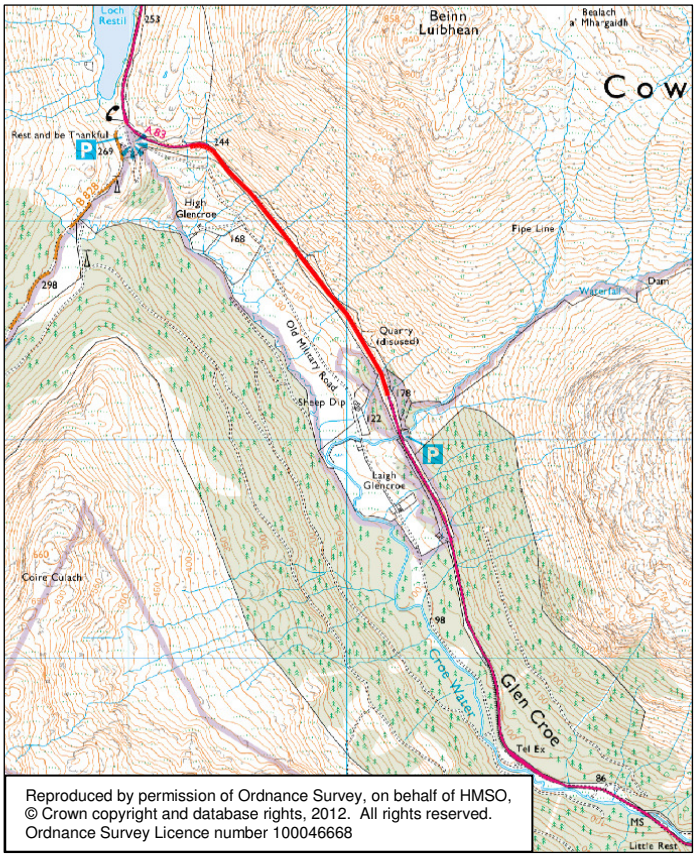


Figure 4–1 : Red Option

The preliminary cost estimate for this option is in the range £9 - 10 million (2012 prices excluding VAT). This excludes operational costs following landslide events.

[20] Winter, M G and Corby, A (2012). A83 Rest and Be Thankful: Ecological and Related Landslide Mitigation Options. Published Project Report PPR 2300. Transport Research Laboratory, Wokingham.

4.3.2 Brown Corridor

The Brown Option is an on-line scenario following the route of the existing A83. This option involves the construction of Debris Flow Shelters to protect traffic and the road in the event of future debris flow events. The length of this option is around 1.5km and covers a similar stretch of the A83 trunk road as the Red Option.

Debris flow shelters, which are of a similar form to the more widely used rockfall or avalanche shelters, are engineered structures that form canopies over a section of road prone to debris flows. These structures are usually constructed from reinforced concrete. They allow future landslides to slide over the top of the structure without disrupting traffic flow. These structures can be built over the existing road and the area between the structure and the existing hillside backfilled, or a new road can be constructed cut into the hillside and covered in-line with the existing ground level, or some combination thereof. Energy is able to be dissipated by placing a depth of granular material on the roof on which the debris flow lands.

The preliminary cost estimate for this corridor option is in the range of £105 - 120 million (2012 prices excluding VAT).

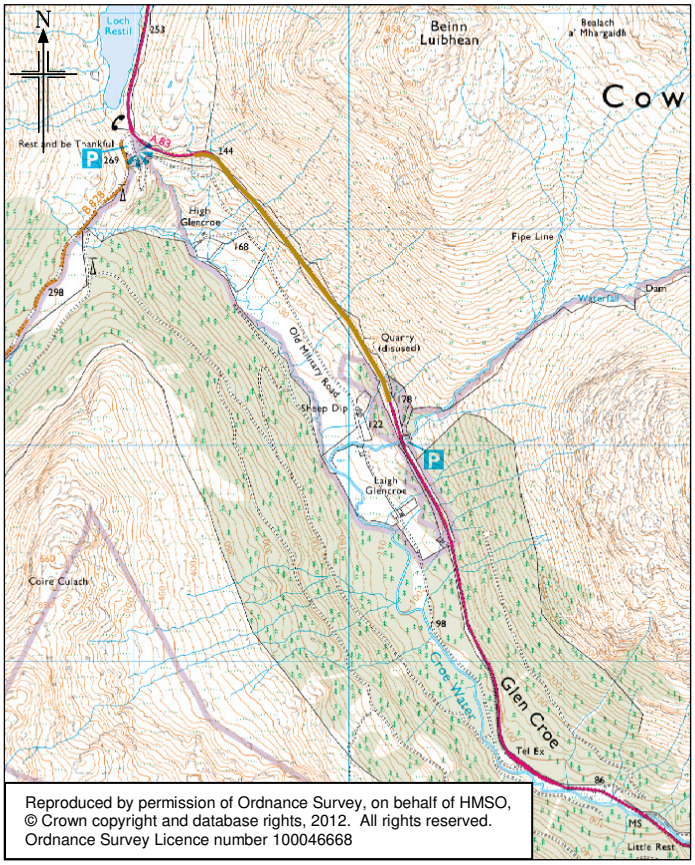


Figure 4-2: Brown Corridor

4.4 Glen Croe Off-Line Improvement Options

4.4.1 Yellow Corridor

The yellow corridor is an off-line corridor starting from the bridge over Coire Croe Burn between the Cobbler and Beinn Luibhean and is shown in Figure 4-3 below. It runs parallel to the existing A83 and rejoins the alignment of the existing A83 before the bend prior to the junction with the B828 and the access to the Rest and Be Thankful car park. This route option would provide a new 1.5km long single carriageway with 1.2km on viaduct. It would generally follow a similar profile to the existing road with an average climbing gradient of 5%. The viaduct structure would be set at a sufficient level to permit debris flow events to pass below the A83. Any existing road culverts would be removed and the natural gullies opened up.

The preliminary cost estimate for this corridor option is in the range of £83 - 95 million (2012 prices excluding VAT). The majority of the cost being attributed to the length of the viaduct structure proposed.

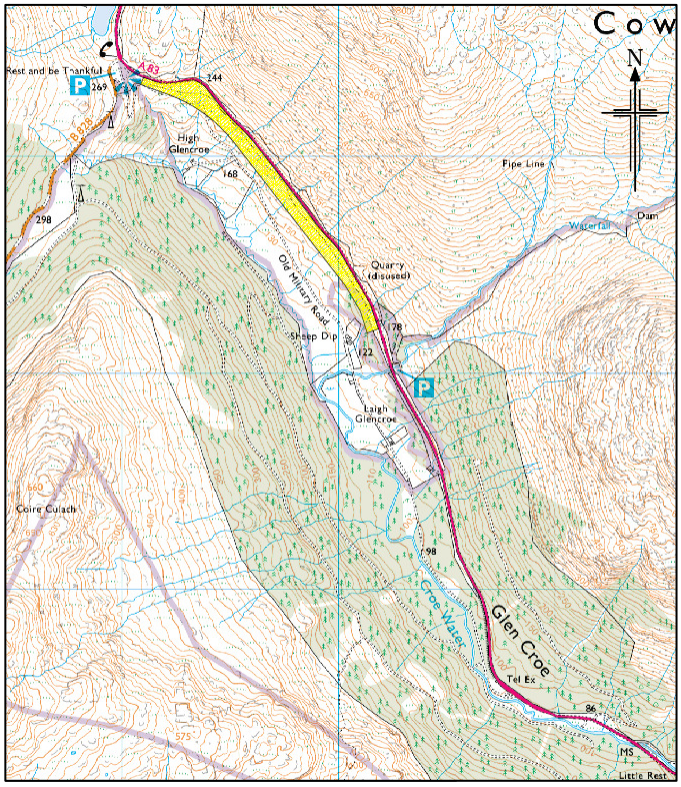


Figure 4-3: Yellow Corridor

4.4.2 Purple Corridor

The purple corridor shown in Figure 4-4 is generally parallel to the Old Military Road through Glen Croe and at the head of the glen enters a tunnel to climb up to rejoin the existing A83 in the vicinity of Loch Restil.

Two route alignments have been considered for the tunnel section. The first is for a shorter single-bore tunnel at 600m long with a maximum gradient of 8%. The relevant UK design standard for road tunnels[21] states that tunnel gradients that exceed 6% are unlikely to be practical due to higher ventilation costs due to increased vehicle emissions. Lower gradients in the range 3 – 4% are preferred. Therefore a second alignment was developed with a maximum gradient of 4% and this resulted in a tunnel 1900m long. At this length a twin bore tunnel arrangement is necessary in order to provide suitable evacuation and emergency escape.

A new junction arrangement to provide the connection to the B828 and access to the Rest and Be Thankful car park would be required north of Loch Restil. If it is not possible to form a simple junction with the existing A83 then a realignment of the B828 to the west of Loch Restil may be required and this has been assumed for the purpose of the assessment presented later in this report.

Preliminary cost estimates have been prepared for each tunnel scenario described above. The cost estimate for the shorter single bore tunnel is in the range £87 – 98 million (2012 prices excluding VAT) and for the longer twin bore tunnel is in the range £460 - 520 million (2012 prices excluding VAT). The full annual operating cost of the tunnel is likely to be in the region of £0.5 million per annum excluding VAT.

The cost range chosen for this corridor option throughout the rest of the appraisal is for the longer twin-bore tunnel at a maximum gradient of 4%.

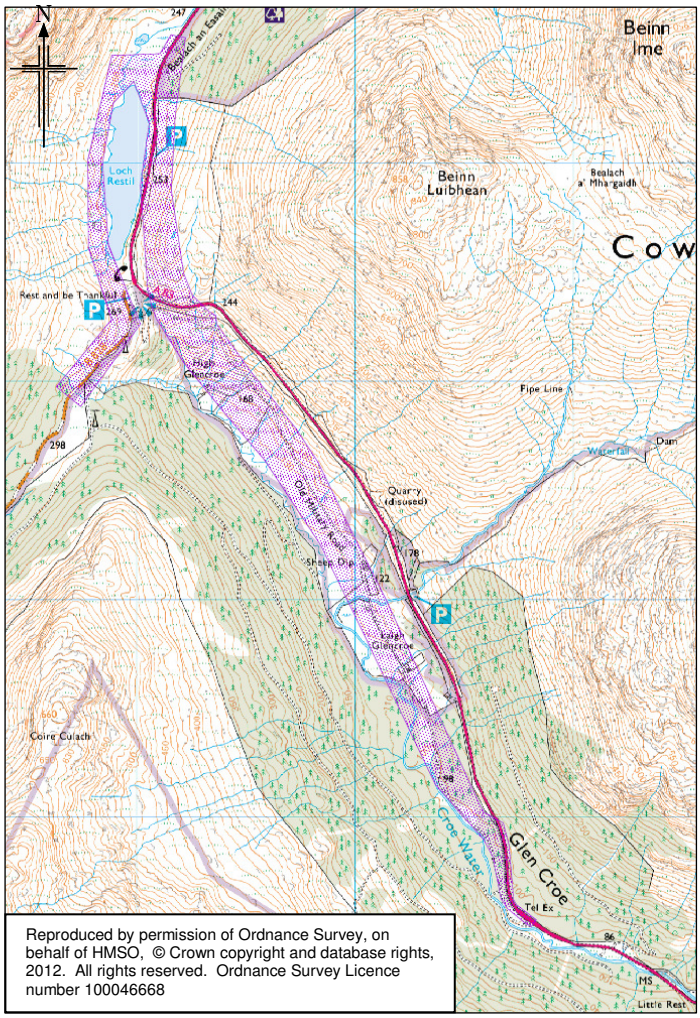


Figure 4-4: Purple Corridor

[21] DMRB BD78/99 Design of Road Tunnels

4.4.3 Blue Corridor

The Blue corridor shown in Figure 4-5 is generally parallel to the Old Military Road through Glen Croe for much of its length. The corridor begins 3.2 km north-west of Ardgartan, in the vicinity of the junction between the existing A83 and the Forestry Commission track that leads to the Old Military Road. It passes to the west of the Rest and Be Thankful car park and rejoins the existing road before Loch Restil.

The northern end of Glen Croe is a half-basin shape, so the major challenge for any route alignment in the blue corridor is to climb from the valley floor at a height of around 150m above ordnance datum to a height of around 250m at the car park at Rest and Be Thankful. This option climbs on the north-east side of the glen, parallel to the Old Military Road, and curves around the half-basin to achieve the required level on the south-west side of the glen on or close to the Forestry Commission Track (Green Option). A sharp bend would be required to reverse the direction, and the route would continue to Rest and Be Thankful. It is anticipated that after the alignment curves round the half-basin it would be at such a level that it shall have to be supported upon a viaduct structure of around 800m long until it lands on higher ground, part way through the hairpin bend, where the road approximately meets the Forestry Track.

The preliminary cost estimate for this corridor option is in the range of £66 - 75 million (2012 prices excluding VAT) with approximately half of the cost being attributed to the length of the viaduct structure.

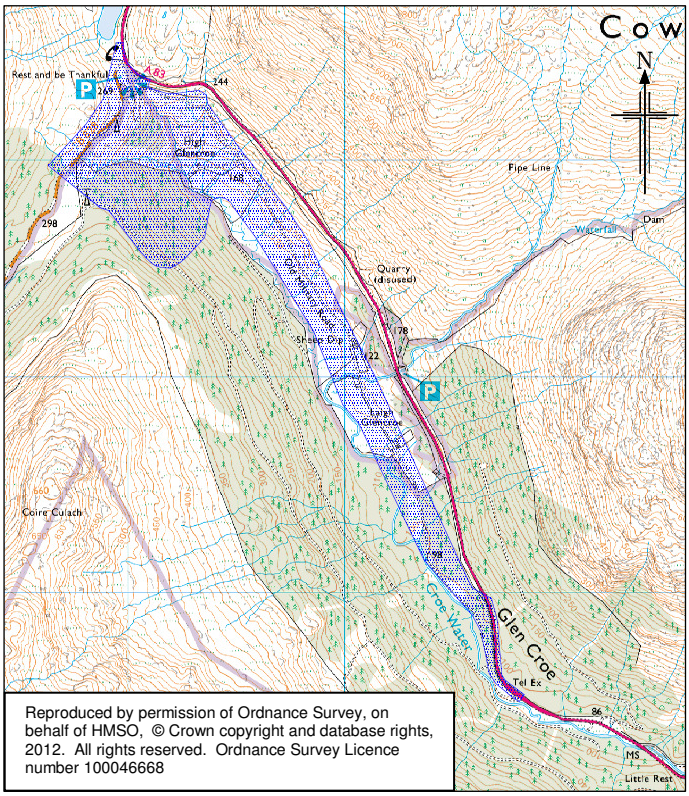


Figure 4-5: Blue Corridor

4.4.4 Green Corridor

The Green option is off-line within Glen Croe in the area of forestry on the south-west side of the valley. Options in this corridor tie-in with the south-east end of the existing A83 approximately 3.2 km north-west of Ardgartan, in the vicinity of the A83/Forestry Commission Track & the Old Military Road junction. On the northwest end of the scheme the route options tie-in to the north side of the Rest and Be Thankful car park. Potential route options in this corridor would provide a new 4.0km single carriageway from the start of the Emergency Diversion Route to the A83/B828 junction north of the car park at Rest and Be Thankful. The alignment follows the Forestry Track alignment in places and road structures and ground engineering measures would be required to fit the new road in the topography of this side of Glen Croe. To minimise the risk of land slide events on this side of the valley affecting the carriageway, the route would be built on viaduct over the high risk sections.

The vertical alignment would broadly follow the existing forestry track resulting in sections with gradient of up to 8% and the provision of a climbing lane and vehicle arrester beds may be necessary.

Since there are landslide hazards associated with the south-west side of Glen Croe, cost estimates for two alternative schemes have been developed. A lower cost scheme in the range of £27 – 30 million (2012 prices excluding VAT) would have a residual risk of road closures due to landslides considered to be similar to the red option. A higher cost scheme in the range £81 – 91 million (2012 prices excluding VAT) would have a negligible risk of closure due to landslides considered similar to the yellow option. The higher cost range is considered to be more likely.

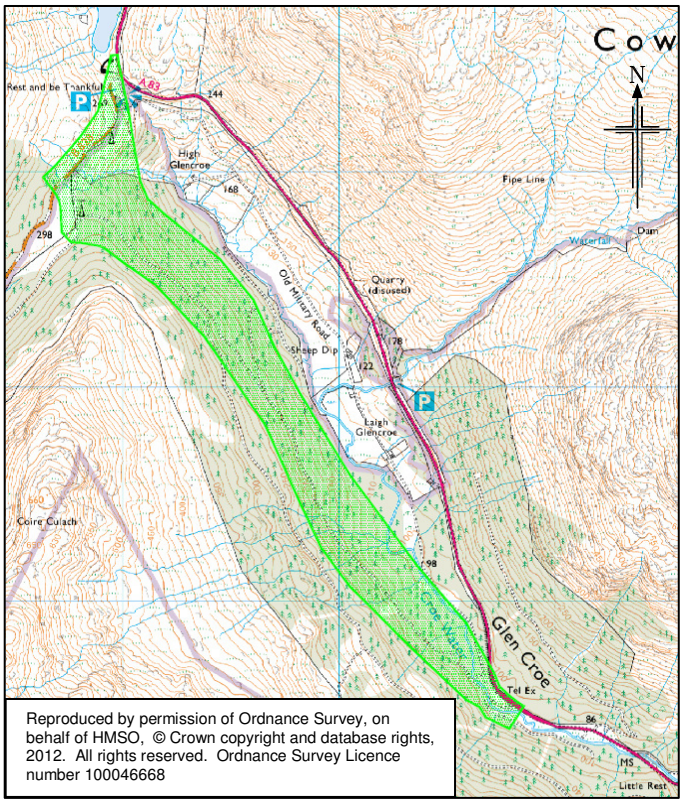


Figure 4-6: Green Corridor

4.5 Alternative Route Corridors Providing Access to Mid-Argyll

4.5.1 Glen Kinglas Corridor

The Glen Kinglas corridor option is off-line within Glen Kinglas and follows the wider valley floor heading north-east towards Loch Sloy. An existing access track following the valley floor contours could be utilised in places over the first 6km of the route but road structures and ground engineering measures would be required to fit the new road in the topography of the valley. This section of the route rises gently from the existing A83 at Butterbridge which is 180m above ordnance datum to the highest point on the route at 320m above datum to the north of Loch Sloy. The route reaches this elevation over 5.5km providing a shallow climb for the route to this point. A mixed woodland plantation is present on the south side of Glen Kinglas at Abyssinia but the existing access track skirts the northern boundary of the plantation. A further coniferous plantation skirts the northern end of Loch Sloy and extends along the northern edge of the option to the A82. The route to the north of Loch Sloy from the highest point at 320m above ordnance datum gently descends along the valley floor towards the A82. It reaches a point 0.5km to the north of Stob an Fhithich where the existing topography descends steeply from 250m above ordnance datum to the existing A82 at a height of 15m above ordnance datum.

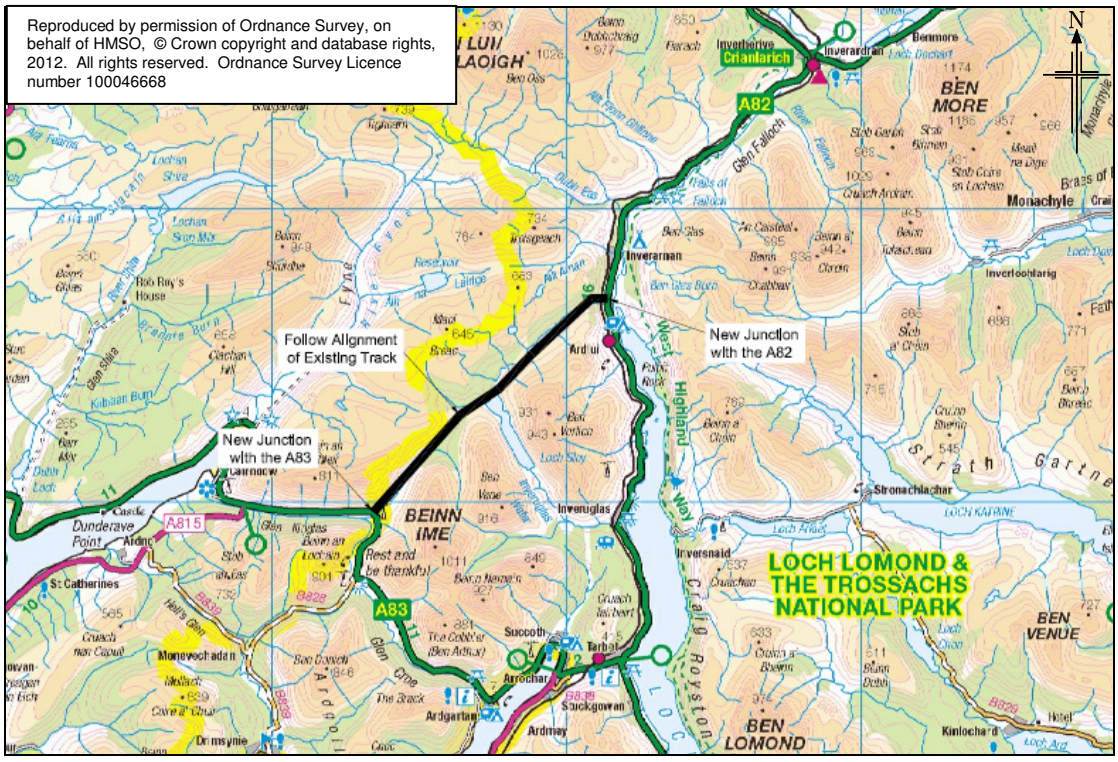


Figure 4-7: Glen Kinglas Corridor

Other engineering challenges along the route include electricity transmission lines which cross the option at Ch 4400m and Ch 6500m. The crossing at Ch 6500m turns sharply to the east and skirts the northern slope of the valley to the end of the option. It is envisaged that these services would require to be altered to allow the safe passage of the new road alignment.

Two tributaries flow out of the northern end of Loch Sloy with one meandering to the southwest through Kinglas and one to the northeast towards the A82. A significant

number of secondary tributaries connect to the tributaries from the side slopes of the valleys and engineering measures would be required to negotiate the watercourses in both the northeast and southwest sections of the route.

The overall length of the new single carriageway route is 14km.

The route passes through similar terrain to that of the Rest and Be Thankful and therefore the landslide Hazard Ranking is likely to be at least High for parts of the route.

A preliminary cost estimate in the range of £64 - £92 million was developed for this option. The cost for this option was developed from previous cost estimates of similar length schemes.

4.5.2 Glen Fyne Corridor

The Glen Fyne corridor option is off-line within Glen Fyne and follows the wide valley floor to the northeast to the existing A82 at Inveranan. The existing A83 north of Cairndow is 20m above ordnance datum and skirts the northeast corner of Loch Fyne. The valley floor is wide at this section of the route with the valley sides becoming steeper towards the edge of the valley floor. The River Fyne meanders along the valley floor, flowing in a southwesterly direction towards Loch Fyne. An existing access track follows the route of the river along the north bank which could be utilised as part of the new route but road structures and ground engineering measures would be required upgrade the track to an appropriate standard.

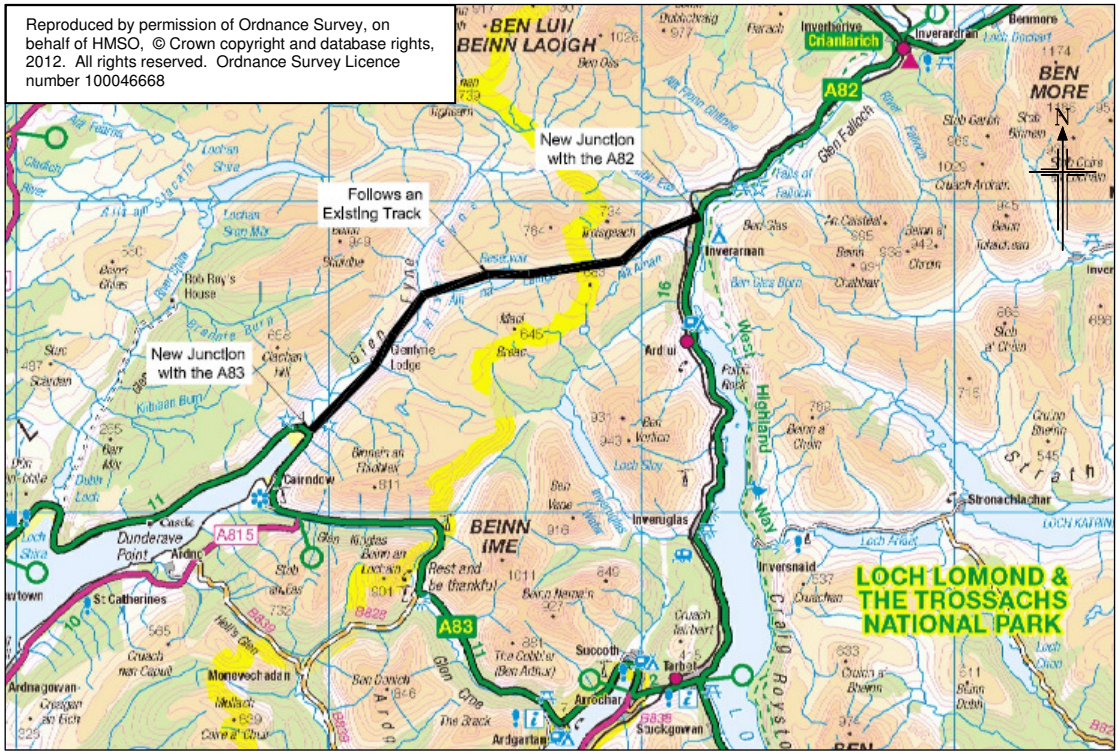


Figure 4-8: Glen Fyne Corridor

The route climbs from the existing A83 at a height of 20m above ordnance datum to 50m above ordnance datum where a tributary from the Allt na Lairige Reservoir flows into the River Fyne. The route follows this tributary, climbing over the next

2kms towards the reservoir dam where the access track to the south west corner of the dam ends at a height of 300m above ordnance datum.

The reservoir creates a pinch point at this location as the valley floor is flooded leaving only the steep side slopes of the valley for the proposed route. Significant engineering works would be required to traverse the edge of the reservoir on this section of the route as it continues up the valley.

Following the pinch point at the reservoir the valley floor to the northeast widens providing reasonable terrain to construct the route. However, as the route approaches its highest point of 380m above ordnance datum to the north of Beinn Damhain summit, the valley floor narrows and the side slopes become very steep.

The route from this point falls at a steady grade until it reaches a point north of Garabel Hill where it enters a woodland area. The edge of the woodland area at this point is 250m above ordnance datum. As the route progresses through the woodland area it descends at a steep gradient over a distance of 5km towards the existing A82 which is 20m above ordnance datum. This would require steep gradients over extended lengths and climbing lanes and arrester beds would need to be considered.

Other engineering challenges along the route include electricity transmission lines which cross the corridor at Ch 2000 m and Ch 12800m. It is envisaged that these services would require to be altered to allow the safe passage of the new road alignment.

A significant number of secondary tributaries connect to the tributaries from the side slopes of the valleys and engineering measures would be required to negotiate the watercourses in both the northeast and southwest sections of the route.

The overall length of the new single carriageway route is 17km.

The route passes through similar terrain to that of the Rest and Be Thankful and therefore the landslide Hazard Ranking is likely to be at least High for parts of the route. An added benefit would be that the route would bypass the sections at Glen Kinglas and Cairndow which have suffered from landslides in the recent past (Section 6.4).

A preliminary cost estimate in the range of £78 - £112 million was developed for this option. The cost for this option was developed from previous cost estimates of similar length schemes.

4.5.3 A82/A85/A819 Upgrading

Another possible alternative is to de-trunk the A83 between Tarbet and Inveraray and focus central government capital investment on the A82 and A85 trunk roads and to adopt as a trunk road the A819 between Dalmally and Inveraray.

After de-trunking, the A83 between Tarbet and Inveraray would be maintained by Argyll and Bute Council. The A83 through Glen Croe could then be permanently closed so the remaining sections from Tarbet to the south end of Glen Croe and from Inveraray to the north end of Glen Croe become for local access only.

4.5.3.1 A82

The current standard of the A82 remains variable and some sections are narrower than that which would be considered desirable for a Trunk Road. A number of schemes are underway to improve the current standards on the A82 particularly where the road narrows and traffic is limited to one-way operation such as Pulpit Rock.

The current cross-section of the A82 at Pulpit Rock is reduced to single lane running with traffic lights which have been in operation for over thirty years. A new 180m viaduct running in parallel with Loch Lomond is being promoted to remove the need for the traffic signals.

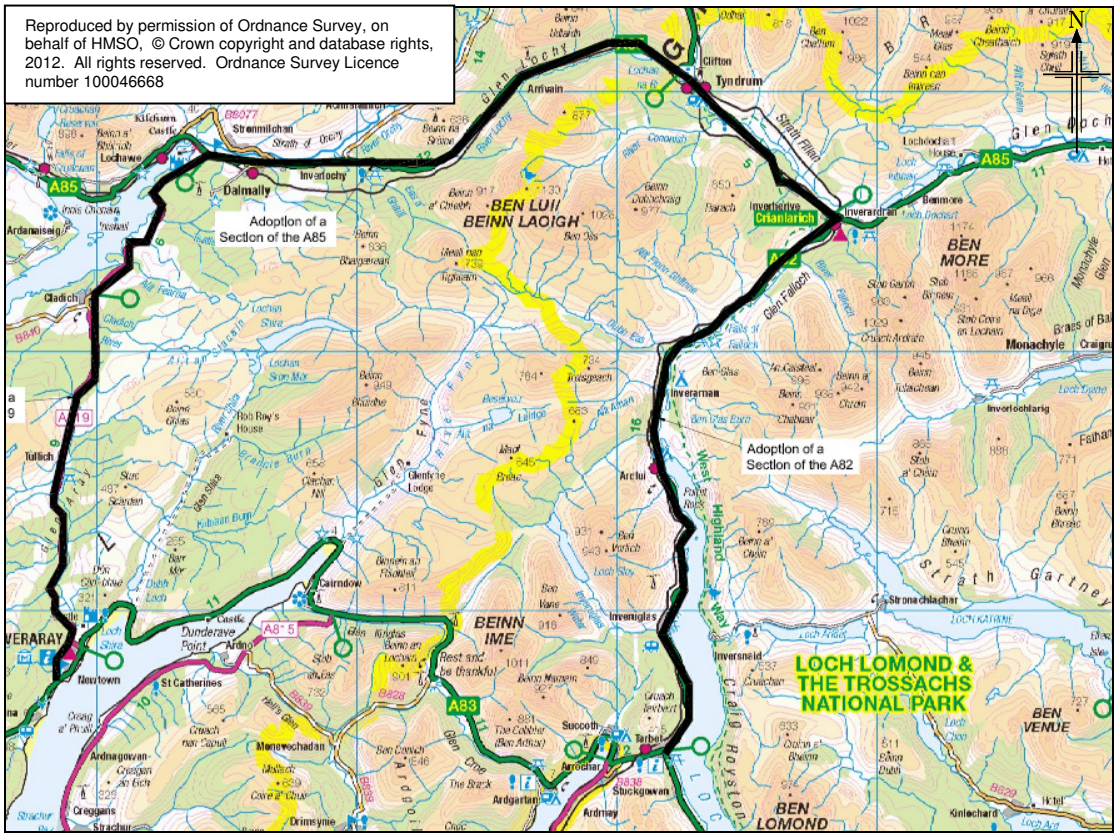


Figure 4-9: A82/A85/A819 Upgrading

Further planned improvements to the route include the construction of the Crianlarich Bypass to link the A82 and A85. The trunk roads currently meet in Crianlarich and cause significant delays in the village during the peak tourist season. The construction of this scheme is expected to start in 2013.

The design of road improvements for the A82 between Tarbet and Inverarnan will begin in 2013 and aims to improve some of the existing issues on the route. The upgrade to this part of the route is expected to be around £200 million pounds.

4.5.3.2 A85

The A85 trunk road would be utilised as part of this proposed route and this route has an AADT of approximately 2300. As the current traffic flow on the A83 through Glen Croe has an AADT of approximately 4000, traffic flows on the A85 would increase significantly if the Rest and Be Thankful was closed and all traffic diverted

via this route, and so engineering measures may be required to improve the standards of the route. A study should be undertaken to identify current issues and accident hotspots in order to address these as part of this proposed route. It is envisaged that localised improvement would be required in order to improve the route.

4.5.3.3 A819

The A819 which runs between the A85 at Dalmally and the A83 at Inveraray would also be utilised as part of the proposed route. It would need to be part of the trunk road network and as such be adopted by Transport Scotland. The existing A819 cross-section is of a generally acceptable standard to be upgraded to Trunk road status, but as with the A85, a study should be undertaken to identify current issues and accident hotspots.

Further localised realignments and improvements may be required due to an increase in traffic volumes. As the A819 approaches the junction with the A83 in Inveraray the route narrows to a single lane and passes under an archway from the Argyll House Hotel which would be less desirable. Therefore a new alignment bypassing the village centre may be required. The realignment could skirt the west of Inveraray and link back onto the A83 north of The Old Rectory.

The existing route from Tarbet to Inveraray is 38km, however the proposed route de-trunking the existing A83 between Tarbet and Inveraray and utilising the A82, A85 and the trunking of the A819 is 79km in length.

4.5.4 Loch Long Crossing

This option involves a connection from Whistlefield (near Garelochhead) on the A814 across Loch Long onto the Cowal with a new line found for a road through the Cowal. The A814 from Dumbarton to Whistlefield, or from Arrochar to Whistlefield, or both, would need to be upgraded to trunk road standards and be adopted as part of the trunk road network. The route would run south-west along the shore before connecting into a new bridge spanning Loch Long. The route corridor is indicated on Figure 4-10.

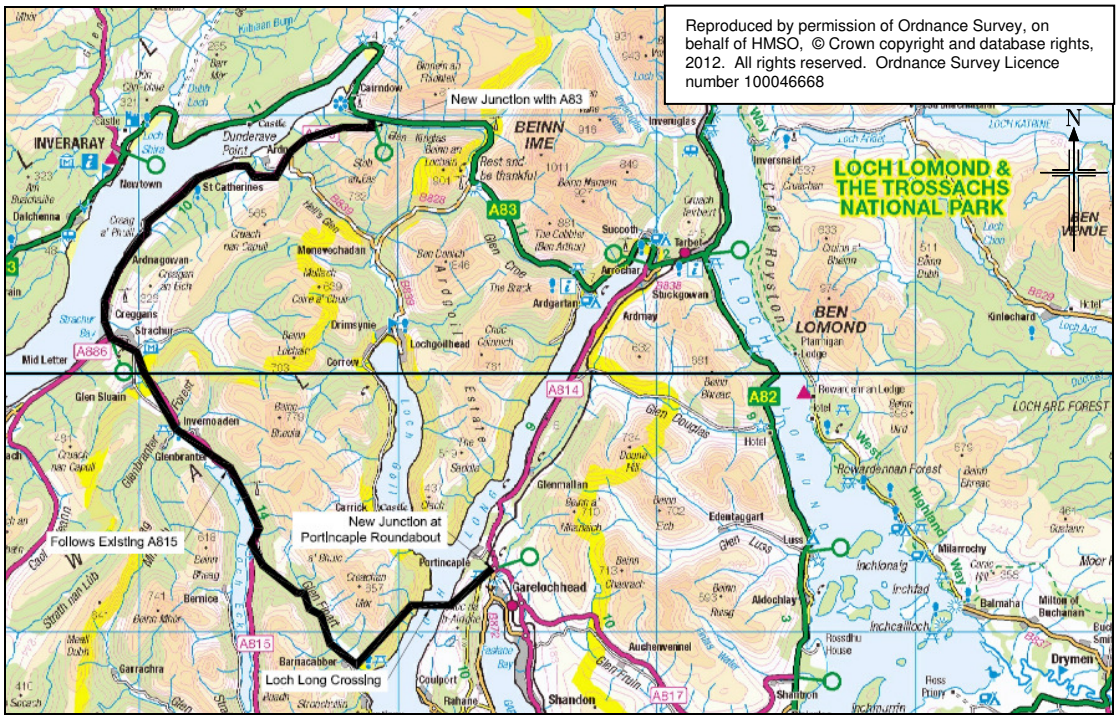


Figure 4-10: Loch Long crossing and road connection to the A83

A bridge with a span of around 1000m would be required to cross Loch Long in a single span. This is equivalent to the span of the current Forth Road Bridge. It would be possible to span Loch Long with a single span however significant engineering works and costs are associated with this option. The deep water channel of Loch Long is used by Royal Navy vessels and so a major single span bridge is considered to be the only suitable solution.

Following the bridge crossing from the east to the west coast of Loch Long the route would turn south through a woodland area and follow the edge of the loch to the next valley.

The route would then turn and head northwest following the route of an existing single track road until it meets the A815. Significant engineering works would be required to upgrade the single track road and A815 to single carriageway Trunk Road standards along with localised areas of realignment. The A817 south of Garelochhead would also require to be added to the Trunk Road network.

The overall length of the new single carriageway route is 15km.

A preliminary cost estimate in excess of £250 million is considered realistic for this option.

4.5.5 Ferry Options

Consultation with the Ferries unit of Transport Scotland was undertaken as part of this study. The Draft Ferries Plan published in December 2011 for consultation mainly recommends maintaining existing levels of service with some potential enhancements.

Given the inaccessibility of the Kintyre peninsula via road, the ferries review looked at the potential for a new ferry route between Campbeltown and the Scottish

mainland. This would be subject to two smaller vessels being introduced on the Arran route with a service operating between Kintyre, via Arran to Ardrossan (or Troon). The service would operate one or two days per week and allow for a meaningful day return trip to the Scottish mainland.

If such a service was to be introduced it could offer the potential to increase the frequency of sailings in emergency situations such as a road closure due to a landslide at Rest and Be Thankful, however for many road users this would not offer any meaningful benefit over the normal diversion route.

A commercial operator provides a vehicle and passenger service, sailing between Hunter's Quay (Dunoon) to McInroy's Point (Gourock). This service provides a twenty minute crossing with four services per hour at peak periods. The service operates from very early morning to late evening. During road closures at the Rest and Be Thankful some road users do divert to this service however there are capacity issues at the terminals which can result in traffic queuing on the approach roads to the terminals.

4.5.6 Other Options

Following on from the stakeholder workshops[22] and subsequent comments submitted, several option suggestions were collated and examined further in relation to the scheme.

4.5.6.1 Split Dual Carriageway using the Forestry Commission Track and the existing A83

One of the suggestions proposed that a long-term solution could be the construction of a new two-lane carriageway on the Forestry Commission Track to the west side of the valley, creating 2 two-lane roads, including the existing A83, running along either side of Glen Croe. It was envisaged that the new carriageway on the west side of the valley would be utilised for northbound traffic while the existing A83 carriageway would accommodate southbound traffic. This provides potential to divert both directions of traffic onto either side if one carriageway was to close for any reason, including landslides.

As landslides are weather dependent, they may on occasion affect both sides of the valley at the same time. For example, in December 2011, when a debris flow event resulted in the closure of the existing A83, the Forestry Commission track was also closed due to another landslide on that side of the valley.

The engineering standards of the existing A83, and the Forestry Commission Track, are considered too poor to be safely used as a dual carriageway. Dual carriageways encourage higher speeds, especially in the off-side lane as drivers attempt to overtake. The existing A83 has sub-Standard horizontal alignment and visibility, particularly on the series of bends just south of the Rest and Be Thankful car park. Furthermore, the existing cross-section would be sub-Standard for dual carriageways which should have hardstrips on both sides to give overrun facility for driver error or evasive action.

[22] A83 Trunk Road Route Study – Stakeholder Consultation Workshop: Summary of Discussion. Produced by Jacobs for Transport Scotland. August 2012.

4.5.6.2 Two single lane carriageways on the South-West side of Glen Croe

Similarly, one option submitted detailed two single-lane roads to be constructed benched into the south-west slope of Glen Croe. It is envisaged that the northbound carriageway would follow the Forestry Track for the majority of its length while the southbound carriageway would run adjacent to this alignment benched further down the slope into the valley.

Single-lane carriageways must have hard-shoulders to allow traffic to pass a broken-down vehicle and for emergency service vehicles. Therefore, the cross-section would not be significantly different from a two-lane single-carriageway.

An option following a similar alignment to this, tracing the line of the Forestry Commission Track, has been considered and a two-lane single-carriageway has been developed as part of the Green Corridor Option, details of which are provided in Section 4.4.4.

4.5.6.3 Old Military Road

Another suggestion was to follow a section of the Old Military Road from the junction of the A83 with the Forestry Track & Old Military Road, in the south-east of the valley, and then split from this alignment part way along the valley, while continuing to run adjacent to the OMR. On reaching the half basin to the north-west of the valley the alignment would climb the level difference from the valley floor to the level west of the Rest and Be Thankful car park with a double-hairpin arrangement. This suggestion contributed towards the development of the Blue Corridor Option which is described in detail in Section 4.4.3.

4.5.6.4 Vegetation

In the longer term the planting of vegetation may form part of a broader strategy, including other land management issues and engineering measures, to address instability issues. However, the beneficial effects of vegetation would be realised during a period around 15 to 35 years after planting. The vegetation aspect is being dealt with in a separate report by Transport Scotland and Transport Research Laboratory (Winter and Corby, 2012)[23].

4.5.6.5 Heavy Goods Vehicles only on the Emergency Diversion Route

This proposal was that once construction of the Emergency Diversion Route (EDR) was complete, if there was a closure on the existing A83 then during the operation of the EDR all car traffic should be diverted to use the ferry while only Heavy Goods Vehicles (HGV's) would be allowed to use the EDR. This would not be legally enforceable as there are only laws in place for maximum height and weight of vehicles; there a no laws relating to minimum height and weights or class of vehicle that can be imposed. .

4.5.6.6 Lay-by on the Emergency Diversion Route

It was suggested that long lay-by should be included as part of the Old Military Road improvement measures for adoption as an Emergency Diversion Route (EDR). This

[23] Winter, M G and Corby, A (2012). A83 Rest and be Thankful: Ecological and Related Landslide Mitigation Options. Published Project Report PPR 2300. Transport Research Laboratory, Wokingham.

would give the potential for the two convoys to operate simultaneously, utilising the lay-by as a passing place, thus reducing the delays on the road as a result of a closure.

Proposals such as this to improve the operation of the Emergency Diversion Route may be considered by Transport Scotland as part of the Do Minimum scenario, however these would be subject to agreement with the private landowners. As the Emergency Diversion Route is intended to offer only a short-term solution no further measures such as these have been considered as part of this study.

5 OPTION SIFTING

5.1 Description

The options identified were sifted against the transport planning objectives presented in section 3.3:

- Reduce the **impact on journey times** by reducing the frequency and duration of road closures caused by landslides (Objective 1); and
- Reduce the **economic impact to the A83 study area** by reducing the frequency and duration of road closures caused by landslides (Objective 2).

For an option to progress to appraisal it is required to fulfil both these objectives, otherwise it is sifted out. The sifting assessment is detailed in Table 5-1: below.

Option	Option Description	Sifting Criteria		Further Comments
		Objective 1	Objective 2	
Red	The Red Option maintains the existing alignment of the A83 and includes a range of landslide mitigation measures such as – • Substantial lengths of additional debris flow barriers • Improved carriageway drainage • Introduction of vegetation and planting on the slope	✓	✓	This option meets both objectives. The additional mitigation measures are expected to significantly reduce the frequency of occurrence of landslide debris reaching the A83 Trunk Road. This option is progressed to the appraisal stage.
Brown	The Brown Option maintains the existing alignment of the A83 and involves the construction of debris flow shelters over a length of up to 1km.	✓	✓	This option meets both objectives. The construction of a debris flow shelter over the road should reduce to negligible risk the occurrence of landslide debris reaching the A83 Trunk Road causing a full road closure for the length of road protected by the shelter. However, during construction of the debris flow shelters, construction traffic management is likely to result in potentially significant journey time delays. This option is progressed to the appraisal stage.
Yellow	The yellow corridor option provides a new 1.2km long single carriageway on viaduct offset from the existing A83 set at a sufficient level to permit debris flow events to pass below the viaduct.	✓	✓	This option meets both objectives. The construction of a viaduct would reduce to negligible risk the occurrence of landslide debris reaching the A83 Trunk Road since it would instead pass below the road This option is progressed to the appraisal stage.
Purple	The Purple Corridor Option follows the Glen Croe valley floor parallel to the line of the Old Military Road. It enters a tunnel close to the Rest and Be Thankful car park and emerges from tunnel to rejoin the existing road at the north end of Loch Restil.	✓	✓	This option meets both objectives. This proposal provides a new alignment for the A83 along the valley floor and then in tunnel, rejoining the existing road at the north end of Loch Restil. It would be engineered in such a way to prevent or reduce to negligible risk landslide debris reaching the road. This would significantly reduce the impact on journey times caused by landslides over this section of route. This option is progressed to the appraisal stage.

Option	Option Description	Sifting Criteria		Further Comments
		Objective 1	Objective 2	
Blue	The Blue Corridor Option follows the Glen Croe valley floor parallel to the line of the Old Military Road and then climbing through two sweeping bends to rejoin the existing A83 beyond Rest and Be Thankful	✓	✓	This option meets both objectives. This proposal provides a new alignment for the A83 and would be engineered in such a way to prevent or reduce to negligible risk landslide debris reaching the road. This would significantly reduce the impact on journey times caused by landslides over this section of route. This option is progressed to the appraisal stage.
Green	The Green Corridor Option follows the south-west side of the Glen Croe valley in a corridor generally following the route of existing forestry tracks. This route provides a new 4.0km single carriageway from the Old Military Road junction to the to the B828 junction.	✓	✓	This option meets both objectives. This proposal provides a new alignment for the A83 and would be engineered in such a way to prevent or significantly reduce landslide debris reaching the road. This would significantly reduce the impact on journey times caused by landslides over this section of route. This option is progressed to the appraisal stage.
Glen Kinglas	New route between Butterbridge and the A82 north of Ardlui through Glen Kinglas	×	×	As a replacement trunk road route between the A82 and the A83 at Butterbridge, this route option does not meet the objectives. By inspection of the route plan in section 4.5.1 it is clear that this route is at least twice as long as the direct route via Rest and Be Thankful and diverts A83 traffic to use the A82 north of Tarbet. This would lead to longer journey times between the Scottish Central Belt and mid-Argyll, Cowal, Kintyre and the Isles. The existing A83 would no longer offer a suitable alternative route for the A82 between Tarbet and Crianlarich during closures, thereby reducing resilience of the Trunk Road network. This route poses significant engineering challenges and the anticipated cost and potential environmental impacts of such a route would be disproportionate to the identified problems on the existing A83. This option has not progressed to the appraisal stage.

Option	Option Description	Sifting Criteria		Further Comments
		Objective 1	Objective 2	
Glen Fyne	New link between the A83 north of Cairndow and the A82 at Inverarnan through Glen Fyne	×	×	As a replacement trunk road route between the A82 and the A83 north of Cairndow, this route options does not meet the objectives. By inspection of the route plan in section 4.5.2 it is clear that this route is at least twice as long as the direct route via Rest and Be Thankful and diverts A83 traffic to use the A82 north of Tarbet. This would lead to longer journey times between the Scottish Central Belt and mid-Argyll, Cowal, Kintyre and the Isles. The existing A83 would no longer offer a suitable alternative route for the A82 between Tarbet and Crianlarich during closures, thereby reducing resilience of the Trunk Road network. This route poses significant engineering challenges and the anticipated cost and potential environmental impacts of such a route would be disproportionate to the identified problems on the existing A83. This option has not progressed to the appraisal stage.
A82-A85-A819	Development of the A82/A85/A819 and de-Trunking/stopping up the A83	×	×	This option does not meet the transport planning objectives as utilisation of the A82/A85/A819 as the main route to/from Argyll would result in significantly higher journey distances/times than at present for all journeys. In addition, the existing A83 would no longer offer a suitable alternative route for the A82 between Tarbet and Crianlarich during closures, thereby reducing resilience of the Trunk Road network. This option has not progressed to the appraisal stage.

Option	Option Description	Sifting Criteria		Further Comments
		Objective 1	Objective 2	
Loch Long Crossing	New bridge across Loch Long between Whistlefield and the Cowal Peninsula	×	×	As this option is considered as a replacement trunk road route between the A82 and the A83 at north of Cairndow then it does not meet the objectives. By inspection of the route plan in section 4.5.2 it is clear that this route is at least twice as long as the direct route via Rest and Be Thankful and diverts A83 traffic to use the A82 north of Tarbet. This would lead to longer journey times between the Scottish Central Belt and mid-Argyll, Cowal, Kintyre and the Isles. This route poses significant engineering challenges and the anticipated cost and potential environmental impacts of such a route would be disproportionate to the identified problems on the existing A83. This option has not progressed to the appraisal stage.
Ferries	Additional ferry provision	×	×	Although this option does not reduce the impact on journey times due to delays and diversions caused by landslide incidents, it provides additional routes into Argyll that could reduce the economic impact to Argyll due to any delays or road closures in the future. This option is therefore not suitable as a stand-alone measure but could support some of the other options where there is still a risk, albeit reduced, of road closures due to landslides. No further detail of this option has been developed as part of this study since it does not meet the objectives.

Table 5-1: Option Sifting Table

5.2 Option Sifting Summary

From Table 5-1:, six potential options have been progressed to the appraisal stage:

- Red Option: Substantial lengths of additional landslide mitigation measures on the existing A83 Rest and Be Thankful;
- Brown Option: Construction of debris flow shelters over a length of up to 1.2km on the existing A83 Rest and Be Thankful;
- Yellow Corridor Option: Construction of a new 1.2km long single carriageway on viaduct offset from the existing A83 and set at a sufficient level to permit debris flow events to pass below the viaduct;
- Purple Corridor Option: New 5.3km single carriageway following the Glen Croe valley floor parallel to the line of the Old Military Road. It enters a tunnel close to the Rest and Be Thankful car park and emerges from tunnel to rejoin the existing road at the north end of Loch Restil;
- Blue Corridor Option: New single carriageway following the Glen Croe valley floor parallel to the line of the Old Military Road and then climbing through two sweeping bends to rejoin the existing A83 beyond Rest and Be Thankful. This route provides a new 5.5km single carriageway from the Old Military Road junction to the B828 junction;
- Green Corridor Option: New single carriageway following the south-west side of the Glen Croe valley in a corridor generally following the route of existing forestry tracks. This route provides a new 4.0km single carriageway from the Old Military Road junction to the to the B828 junction.

6 ENGINEERING ASSESSMENT

6.1 Condition of Existing Road Pavement and Structures

The existing condition of the route has been assessed using Transport Scotland's SERIS database. The Scottish Executive Roads Information System (SERIS) is a database maintained by Transport Scotland to log and predict the current condition of the trunk road network in Scotland.

The SERIS database contains information on surface profile, skidding resistance, rutting and deflectograph results. From this information, the system can predict the residual life of each part of the network. It is also used to log any maintenance that has been undertaken on the trunk road network.

The existing road is generally 6.8m wide. Recent data from SERIS indicates the pavement on this section of the route has a variable residual life, with many sections with a low life. The pavement SCRIM, a measure of how much skid resistance the pavement offers to a breaking vehicle, is also low in many parts. Structural maintenance works are planned in the study area to address these deficiencies. The pavement is a fully flexible pavement with an average bituminous depth of 300mm and a gravel based sub-base of 150mm. This is typical of a pavement section with this level of traffic.

.

The section of the A83 between the junction with the Old Military Road and the Rest and Be Thankful summit car park has 13 structures. These consist of 10 culverts, 2 retaining walls and a bridge.

No information on the existing condition of the culverts or retaining walls is available from SERIS. A recent bridge inspection survey indicates that the bridge structure has some minor faults including low reinforcement cover which is causing longitudinal cracking. This was present at the previous survey last year and is being monitored. The parapet end protection is sub-Standard and is envisaged to cost around £5,000 to rectify but the survey also indicates that this is to be monitored.

6.2 Engineering Design Standards

Trunk roads in Scotland are designed to the requirements set out in the Design Manual for Roads and Bridges (DMRB). This is a fifteen-volume collection of documents which comprises Standards and Advice Notes. While Advice Notes contain only advice and guidance, Standards include advice and guidance as well as requirements. These requirements include desirable minimum requirements, and unqualified requirements. Designs can be below the desirable minimum requirements at the discretion of the designer; this is known as a Relaxation. If a design fails to meet the unqualified requirements, a Departure from Standard is required and this must be approved by the Overseeing Organisation, in this case Transport Scotland.

6.2.1 Road Cross-Section

Road cross-sections are to be designed to Volume 6, Section 1, Part 2 of the DMRB: TD27/05 Cross-sections and Headrooms.

The DMRB compliant cross-section for rural all-purpose single carriageways is a 7.3m wide carriageway, with 1.0m hardstrips and 2.5m wide verges.

A 6.0m wide carriageway is permitted in Scotland if the two-way design year flow is 5,000 AADT or less (TD27/05 4.2.1 i). The existing flow on this section is 2000 to 5000 vehicles per day. This flow has remained relatively steady between 2007 and 2010, with a slight decrease each year.

However, adequate carriageway width is vital for maintenance. A 6.0m carriageway does not allow maintenance work to be safely carried out if a defect develops on or near the centre, and a road closure would be required. Therefore, a carriageway width of 7.3m is adopted for all sections of new carriageway construction in the design options.

There are no hardstrips on most of the existing A83 and, for route consistency, hardstrips have not been adopted in the design options however this should be reviewed during any further work developing any option(s) that emerge from this study.

The verges adjacent to the carriageway are an essential part of the cross-section and provide space for safety barriers, drainage systems and public utilities. If safety barriers are placed too close to the carriageway, drivers tend to drift towards, and even over, the centre of the carriageway reducing safety. In addition, safety barriers are designed to deflect when struck, making sufficient space behind them an important part of their design. Therefore, the verge width must allow for the 'set-back' between the carriageway and the barrier and the 'working width' behind the barrier.

To preserve the trunk road carriageway surface and minimise delays due to maintenance works, public utilities are ideally placed in verges in rural areas. To provide sufficient space for these, a drainage system, and safety barrier foundations below ground, and the set-back and working width above ground, the minimum verge width of 2.5m has been adopted in the design options.

6.2.2 Horizontal Alignment

The horizontal alignment of road is how it would appear on a plan or a map; that is, the curves and straight sections. Road horizontal alignments are to be designed to Volume 6, Section 1, Part 1 of the DMRB: TD9/93 Highway Link Design.

The road alignment shall be designed to ensure that standards of curvature, visibility, superelevation, etc. are provided for a 'design speed' which shall be consistent with the anticipated vehicle speeds on the road. For the A83 through the study area, a design speed of 100kph (62mph) has been calculated.

For a 100kph design speed the desirable minimum horizontal curvature is a radius of 720m. This can be reduced to a 180m radius curve as a relaxation at the discretion of the designer, provided the visibility and vertical alignment meet the desirable minimum standard. Any reduction below this is a Departure from Standards and requires the approval of Transport Scotland Standards Branch.

6.2.3 Vertical Alignment

The vertical alignment of a road is the crests (or hills), sags (or dips) and gradient. Road vertical alignments are also to be designed to Volume 6, Section 1, Part 1 of the DMRB: TD9/93 Highway Link Design.

For a 100kph design speed, the desirable minimum radius for a vertical crest curve is 10,000m. This can be reduced to a 3,000m radius curve as a relaxation provided the visibility and horizontal alignment meet the desirable minimum standard. The absolute minimum for a sag curve is a 2,600m radius curve.

The desirable maximum gradient for an all-purpose single-carriageway road is 6%, but this can be increased to 8% as a relaxation.

On single carriageways climbing lanes can be considered on hills with gradients over 2% and longer than 500m. A detailed assessment should be carried out based on safety, environment, economy, accessibility, and transport integration. It should be noted that climbing lanes are unlikely to provide economic benefits in the study area as the traffic volumes are low.

Arrester beds are designed to stop, without serious injury or serious damage to vehicles or to adjacent property or other road users, heavy goods vehicles whose brakes fail on long downhill gradients. DMRB Volume 6, Section 3, Chapter 6, TA 57/78 Roadside Features recommends:

> *On new construction, where long steep gradients are unavoidable, and where the probability of damage caused by runaway vehicles is greater than normal, the provision of arrester beds should be considered as an integral part of the scheme design. As a guide for provision, where gradients are over 5%, an arrester bed should be considered if the gradient value (in percent) squared, multiplied by the approach length from the crest in kilometres, is over 60, i.e. if (gradient %)^2 x (length km) > 60.*

The DMRB goes on to say that on long, straight stretches of road where there is a sufficiently steep or long up-grade before any bend is met, arrester beds are not used.

Options within this study include gradients of up to 8%, for 1km or longer, giving a value of over 64. Therefore, arrester beds should be considered on these options.

6.2.4 Tunnel Standards

A road tunnel is a subsurface structure enclosed for a length of 150m, or more. The following standards set out the current requirements for all road tunnels in the UK:

- Volume 2, Section 2, Part 9 of the DMRB, BD 78/99 - Design of Road Tunnels
- Volume 6, Section 1, Part 2 of the DMRB, TD 27/05 – Cross-Sections and Headrooms
- European Union Directive 2004/54/EC Road Tunnel Safety
- The UK Road Tunnel Safety Regulations 2007

Following a number of serious fires in road tunnels, notably the Mont Blanc Tunnel fire disaster in 1999, the European Union funded a number of tunnel safety projects. Although there was an emphasis on fire safety, the work covered many aspects of design, operation and emergency response for road tunnels. This work culminated in 2004 in the EU Tunnel Safety Directive (Directive 2004/54/EC), transposed into UK law under the Road Tunnel Safety Regulations 2007.

The EU Directive provides limited prescriptive detail on how a tunnel should be designed or operated and instead promotes a risk-based approach which ensures that the final tunnel solution is matched to its operational demands, including aspects such as traffic type, speeds, emergency escape and emergency intervention.

6.3 Engineering Assessment of Options

6.3.1 Red Option – Substantial Landslide Mitigation Measures

6.3.1.1 Alignment

The red option maintains the existing alignment of the A83. This is relatively straight through most of Glen Croe, with frequent, but short curves. However, at the northern end of Glen Croe there are two significant curves, to follow the existing topography, of 90m and 250m radius. These are six steps and three steps below standard, respectively.

The vertical alignment is a moderately constant 5% gradient as the road climbs from the Glen Croe floor at the southern end to the Rest and Be Thankful car park at the northern end.

6.3.1.2 Junctions and Side Roads

A single priority (give way) junction serves both the Rest and Be Thankful car park and the B828 at the northern end of the Red Option. This would be unaffected by the on-line Red Option.

6.3.1.3 Structures

All the existing structures described in Section 6.1 would be retained and would require continued maintenance under this option.

6.3.1.4 Impact during Construction

Works in the Red Option would be constructed using single-lane closures. These would be short in length and in duration, offering minimal disruption to the travelling public.

It is expected that the construction would last one and a half to two years.

6.3.1.5 Topography and Land Use

The existing A83 trunk road is on steep side-long ground through Glen Croe and sheep and cattle graze on the hillside.

In this option the carriageway remains within the existing trunk road boundary, so no land acquisition is required for realignment. For Phases 1 and 2 of the debris flow

barriers, the netting was placed outside the trunk road boundary, by agreement with the land-owner. It is envisaged that the remaining phases would also be carried out by agreement, without land acquisition.

6.3.1.6 Geology, Geomorphology and Ground Conditions

(a) Existing Geology

The superficial deposits occupying the west side of the Glen Croe valley are indicated on the published BGS geological maps[24] to comprise glacial till deposits, locally in the form of moraines near the base of the hillside. The valley floor below the proposed route is underlain by deposits of alluvium (silt, clay and sands and gravels). Near surface deposits of colluvium are also anticipated to occur across the hillside.

The underlying bedrock geology[25] is indicated to comprise a mixed sequence of Dalradian metamorphic rocks (Precambrian - Cambrian age) consisting generally of cleaved greywackes, green siltstones, slates and schists assigned to the Beinn Bheula Schist Formation. The geological structure has been complicated by folding and faulting with two approximately North -South trending faults indicated to occur in the vicinity of the Rest and Be Thankful car park. Igneous intrusions, principally in the form of dykes, are also indicated to occur in this area.

The existing A83 has been formed in sidelong ground along the steep southwest facing slopes of Beinn Luibhean which are mantled with a cover of colluvium and glacial till deposits of variable thickness. The slopes are generally steeper above the road, reducing in gradient below the road towards the valley floor. Vegetation cover comprises grass, bracken, ferns and locally reeds in areas of poor drainage. There is no tree cover north of the River Croe crossing, except for a small plantation above and below the road over a length of up to 400m from the bridge. The existing A83 is affected by slope failures, both above and below the road, following periods of heavy rainfall, the failures generally taking the form of debris flows following the course of existing drainage channels above the road on the hillside. Occasionally water directed across the road, as a result of an upslope failure, has caused erosion below the road, potentially undermining the carriageway.

The hillside is inspected annually to identify any significant changes in slope conditions and is also monitored in real-time using instrumentation linked to data recorders and connected to the internet. To address the potential landslide hazard, debris flow barriers have been installed at a number of locations, including previous failures. Some culvert improvements have also been undertaken.

(b) Discussion

This option includes the extension of the existing debris flow barriers or other measures (such as debris basins or sumps) to cover the main channels draining the hillside above the road over the 1km section of concern, as these provide the main pathways/conduits for channelised debris flows. Barriers would also be considered to prevent landslide material reaching the road in other high risk areas. Figure 6-1: shows debris flow barrier installed on the A83.

[24] BGS Scotland Sheet 37 Drift
[25] BGS Scotland Sheets 37 and 38W Solid

It is estimated that of the order of 440m of additional barriers or other measures would be required, in addition to the Phase 1 (80m plus VX barrier) and the Phase 2 debris fence works (88m plus VX and VU barriers) which were completed in mid October 2012. Figure 2-3 and Figure 2-4 in section 2 show the extents of existing and proposed debris flow barriers. The actual extents would require to be confirmed by means of a detailed site inspection and assessment. It is anticipated that the above works would substantially reduce the landslide hazard and hence disruption to road users. Where a landslide does occur, some debris, predominantly in the form of a slurry, might reach the road as the debris fences do not provide a complete containment system, but the quantity of material and risk to road users would be substantially reduced. Also, as the debris fences have a finite capacity in terms of material retention, it is possible that on occasion the design capacity might be exceeded resulting in greater volumes of coarser material reaching the road. Additionally, in the event of a landslide occurring there may be a requirement to remove the debris trapped in the netting and replace damaged netting components, both of which are likely to need traffic management with associated disruption to road users. Provided the components are replaced, there would be no reduction in the barrier's integrity and design life which should be of the order of 80 to 100 years. The long-term operational costs of clearing and replacing parts of the netting following a landslide, would depend on the number and magnitude of events, which could be of the order of £3 – £5 million over a 100 year period.

Figure 6-1: Phase 2 debris-flow barriers installed on the A83 at Rest and Be Thankful

The use of debris flow barriers is well established in the containment of failed material from debris flows or landslides in mountainous terrain, with many examples of their installation and performance. Details relating to the design of the barriers, together with case histories provided by suppliers are included in Appendix G.

The results of research and testing carried out on debris flow barriers, supported by the case history examples, demonstrates their effectiveness in containing failed materials provided the barriers are properly designed and installed. There will inevitably be some uncertainty as to the volume of materials potentially involved in a possible failure and realistic and conservative assumptions must be made in this respect.

With regard to debris flows, where the failed material is essentially supported by a fluid medium, it is likely that some debris in the form of a slurry may pass through the barrier, at least initially until the debris has built up sufficiently behind the barrier. This material however is unlikely to cause any major disruption to the road due to the relatively small volumes involved which could be accommodated by the open ditch drainage system with under road culverts, provided these are upgraded adequately as part of the debris barrier solution.

In the longer term the planting of vegetation may form part of a broader strategy, including other land management issues and engineering measures, to address instability issues. However, the beneficial effects of vegetation would be realised during a period around 15 to 35 years after planting. The vegetation aspect is being dealt with in a separate report by Transport Scotland and Transport Research Laboratory (Winter and Corby, 2012)[26];

In summary, this option provides a significant reduction in risk to the existing A83 as a result of hazard reduction, through the installation of debris fences, drainage and culvert improvements. It does not, however, completely eliminate the hazard and some traffic disruption, albeit much reduced, would still be anticipated in the future.

6.3.1.7 Hydrology, Hydrogeology and Drainage

In order to mitigate water and finer debris affecting the road, it is recommended that a number of the existing culverts are replaced with those of a substantially higher capacity, so that they can accommodate greater runoff volumes and also reduce their susceptibility to blockages by providing larger cross sectional areas. This would be combined with improvements/extensions to the interceptor ditch on the upslope side of the road and the provision of new culverts where required. These measures would also help to address erosion of the lower slope due to uncontrolled discharges which cross the road.

Implementation of the above measures should also reduce the potential for erosion of the lower slopes below the road. However, it is important to limit surface water feeding into the slope below the road as this could result in instability and restrictions on the road use. Improvements to existing roads drainage, including the culverts, are recommended to further reduce the potential for this to occur.

6.3.1.8 Public Utilities

Public utilities affected by this and other corridor options shall be considered during further development of any option(s) emerging from this study.

[26] Winter, M G and Corby, A (2012). A83 Rest and be Thankful: Ecological and Related Landslide Mitigation Options. Published Project Report PPR 2300. Transport Research Laboratory, Wokingham.

6.3.2 Brown Option – Debris Flow Shelters

6.3.2.1 Alignment

The brown option maintains a similar alignment to the existing but is sufficiently offset to allow some of the proposed scheme to be constructed without full closures of the existing road, but full closures would be required for certain operations and these may be required for a significant duration. Being partially off-line offers the opportunity to improve the alignment and cross-section of the route.

The existing vertical alignment would be maintained at a relatively constant 5% gradient.

6.3.2.2 Junctions and Side Roads

The priority junction of the Rest and Be Thankful car park and the B828 would be unaffected by the Brown Option.

6.3.2.3 Structures

(a) Introduction

The most likely form of construction of the debris flow structure would involve cutting into the existing hillside upslope of the road; the structure effectively forming an upslope retaining wall in these areas. A comprehensive ground investigation would be required to allow detailed design of the shelters, in particular to determine: the most suitable founding horizon; the nature of the ground to be excavated within the cuts; and slope stability for temporary works and the final design.

The general form of the structure would comprise a reinforced concrete box running the full length of the area of concern (approx 1.2km). Consideration has been given to providing more limited coverage, locating shelters at the highest risk locations. There are however numerous channels running down the hillside, each of which has the potential to direct debris onto the A83 during a landslide event. These channels vary in width across the hillside. There is also potential for landslides to occur between channels, although these would appear to be less common based on recent experience. To provide an effective solution therefore, this option provides a continuous shelter covering the full 1km length. At detailed design stage it may be possible to reduce the length of shelter construction based on a detailed assessment of the hillside. However, a solution involving many individual sections of shelter with gaps in-between is unlikely to be acceptable due to the adverse driver experience cause by frequent changes in lighting conditions when going in and out of the shelters.

The downslope side of the concrete box would be an ‘open’ structure, thus providing light and assisting with ventilation, whilst also reducing the impact on the views experienced by the road user. By providing a structure that is ‘open’, the special requirements which would normally be required for a tunnel would not apply, i.e. ventilation, fire suppression systems, etc. The structure would be cut into the hillside above the A83 and would include a profiled roof (a chute) to allow landslide debris to flow freely across the structure. For sections of shelter located opposite existing drainage channels on the hillside, provision would be included in the design for directing existing drainage into new culverts beneath the A83. The conceptual design of this option is shown on Figure 6-2 and on drawing B1557610/WP08/001 in Appendix A.

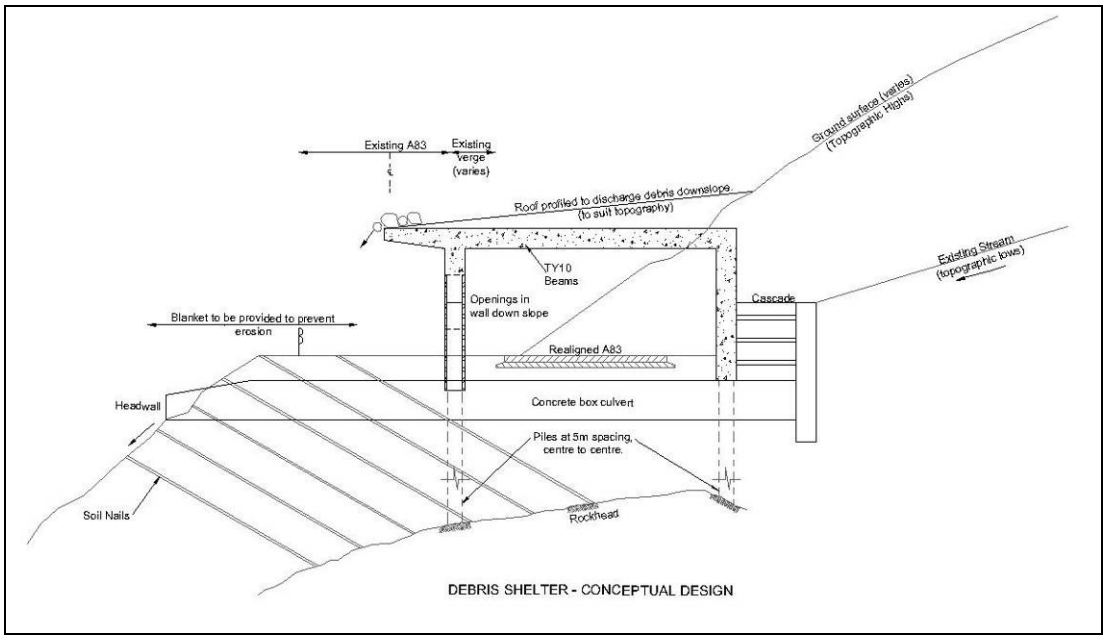


Figure 6-2: Debris Flow Shelter – Conceptual Design

(b) Buildability

Construction of the shelters would require cutting into the hillside to allow part of the existing A83 carriageway to be maintained for traffic during construction, though full road closures may be required for a significant duration. This presents a number of potential problems, in particular, the width of the structure would require extensive cutting into the hillside in places due to the sidelong nature of the A83 alignment. This could be reduced however, if the requirement for 2.5m verges on either side of the carriageway within the shelters was reduced, as a departure to current design standards. Provided construction is undertaken in short sections then it is likely to be feasible to form relatively steep temporary slopes in the anticipated soil deposits. Locally, however where there are existing steep lower slopes and where there is limited existing verge width, relatively deep cuts may be required (up to 10m), potentially requiring temporary slope stabilisation measures such as soil nailing, to allow the cut to be formed safely. A detailed assessment of the existing alignment together with the ground conditions, as revealed by a comprehensive ground investigation, would be required.

Although the extent of cutting into the existing hill slope could be reduced by widening the existing road on the downslope side, this is not recommended due to the potential impact on the stability of the lower slopes.

It has been assumed at this stage that construction of the shelter would require a piled foundation with the piles bearing on rock with additional soil nails installed locally into the downslope in front of the shelter. This recognises the potentially high loading on the slope from the shelter and temporary loads imposed by landslide materials. Following detailed ground investigation and design, it may be possible to demonstrate that piles are not required everywhere and it is sufficient for the structure to bear directly onto the in situ soils/rock.

Some construction work would be required on the lower slopes to provide erosion protection from any debris directed across the shelter into this area, including the remaining section of the existing A83. This may include the use of gabion mattresses or other revetment works.

(c) Aesthetics

The debris shelter would be visually intrusive within the rural setting of Glen Croe, although mitigation measures such as vegetation cover (e.g. Grassblock) over the top of the shelter would help to reduce the impact. Localised reinstatement of the vegetation would be required in the event of a landslide at that particular location. An example of a similar structure, although built to protect a road against rockfall rather than debris flow material, is shown in Figure 6-3.

Driver experience would be impacted with a reduction in the open and picturesque panoramic views currently enjoyed by travellers along this section of the A83.

Reproduced from Geological Society Engineering Geology Special Publication No. 24 "Slope Engineering for Mountain Roads"

Figure 6-3: Example of debris shelter to protect road from rockfall

(d) Operation/Maintenance/Inspection

There are no specific operational requirements for the shelter structure. Routine maintenance and inspection would be required as for any structure, with specific requirements relating to drainage, lighting and road surface issues. Occasional maintenance to remove debris from the roof of the shelter and within the downslope areas would be required. With regard to the former it is envisaged that an access ramp onto the shelter structure would be provided at both the upstream and downstream ends of the structure to allow access for small plant to remove debris.

(e) Risks

The principal technical risk relating to this option is considered to be the stability of the slopes affected by the construction works. This includes the risk of slope failures during construction due to disturbance of the ground, not only localised small scale failures on temporary slopes, but also major debris slides following prolonged periods of heavy rainfall. However, it is considered that these risks affecting both construction and use of the road could be adequately managed.

With regard to the design, a clear understanding of the ground conditions is critical to the successful implementation of this option to ensure that the structure is capable of resisting any ground forces due to upslope failures and soil creep, and that construction of the shelters with dead and temporary loads does not adversely impact on the stability of the road itself resulting in a major downslope failure.

6.3.2.4 Impact during Construction

It is envisaged that construction of the structure would be undertaken in a number of sections to reduce the length of road under single lane traffic management (temporary traffic lights) at any given time. Full road closures are also likely to be required for certain construction operations.

The duration of the works is likely to be two to three years.

It is considered that the traffic management delays during construction would be the most significant of all the corridor options being considered and would out-weigh any longer term benefits.

6.3.2.5 Topography and Land Use

This option requires additional land outside the current road boundaries both upslope and downslope of the existing A83. The extent of additional land acquisition would vary according to topography and would be required for both the permanent works and the temporary works to construct the shelter with the formation of temporary slopes, working areas etc.

6.3.2.6 Geology, Geomorphology and Ground Conditions

The geology and ground conditions described in Section 6.3.1.6 are applicable to this option, supplemented as follows.

It is anticipated that the debris flow shelters would be founded on variable ground conditions, generally consisting of a mixture of glacial till deposits and colluvium overlying bedrock. From previous ground investigations, the thickness of superficial deposits is also likely to be variable with thicknesses of up to 15m having been encountered. Locally rock may also be encountered at formation level and within the excavations to form the shelters.

6.3.2.7 Hydrology, Hydrogeology and Drainage

New culverts would be built to replace each existing culvert. These are expected to be larger than the existing, to be more resilient to blockages from landslide debris. However, maintenance and inspection culverts below the debris flow shelters may result in significant ongoing maintenance costs.

Appropriate measures for treating water from the carriageway would be implemented prior to allowing the water to join the existing watercourses.

6.3.3 Yellow Option - Viaduct

6.3.3.1 Alignment

The yellow corridor is a 1.5km, off-line section beginning at the Bridge over Coire Croe Burn between the Cobbler and Beinn Luibhean. This option bypasses the main areas of landslide risk on viaduct parallel to the existing A83 and connects back in before or at the sharp bends close to the Rest and Be Thankful car park.

The horizontal alignment shall be offset from the existing A83 alignment providing separation between the slope and the carriageway, to protect to the road from landslides.

The vertical alignment is expected to broadly follow that of the existing A83 with sections of the alignment resting on viaducts to allow passage of debris flows under the road.

6.3.3.2 Junctions and Side Roads

A single priority (give way) junction serves both the Rest and Be Thankful car park and the B828 at the northern end of the Yellow Option. This would be unaffected by the off-line Yellow Option as it ties-in with the existing road network before this junction location.

6.3.3.3 Structures

The Yellow Option is predominantly supported on a viaduct structure for approximately 1.2km of its length. This structure would be built on side-long ground, which is prone to landslides, presenting engineering challenges for both design and construction. However, examples of viaducts on side long ground are available and therefore it is conceivable that such an option could be adopted. The A9 Killiecrankie viaduct is one example in Scotland and other examples are available in the Rhine Valley (Krahnenberg Bridge) and the Brenner Autobahn (Lueg Bridge) shown in Figure 6-4.

Figure 6-4: ***Example of viaducts on side-long ground – A9 Killiecrankie (top left and top right); Rhine Valley Krahnenberg Bridge (bottom left), and; Brenner Autobahn Lueg Bridge (bottom right)***

For this section of the A83 the piers of the viaduct would be susceptible to the impacts of future landslides. For this reason, it would be logical to minimise the number of piers by maximising the spans of the viaduct, commensurate with considered aesthetics. Additional measures of designing the piers to be reasonably wide and thick and hence robust can be introduced as well as deflector walls locally around the piers at ground level.

The superstructure would be required to be a reasonable minimum height above the existing slope and would be highly visible in the valley. It is common practice for this situation to adopt a constant deck thickness. In order to minimise the number of piers and maximise the span, spans of 50 to 70 metres are likely to be most appropriate. This would require spine beam construction, with a post-tensioned concrete box girder likely to offer the best long term maintenance benefits.

(a) Buildability

(a).1 Method

Along this section of the A83 it is anticipated that rock could be up to 15m below ground level, depending on the alignment, and which is likely to require piled foundations to bear onto sound rock. This would require access to all pier locations to form a platform which would be used to construct the individual foundations. Reinforced concrete piers would then be constructed from the pile caps by either precast segmental construction or in situ construction with a climbing formwork system.

Assuming a post-tensioned concrete box is adopted for the superstructure, this could be built by balanced cantilever or span-by-span utilising a temporary truss or gantry system.

(a).2 Access

Access for construction is one of the most challenging aspects of this option. For a viaduct of 1.2km in length with spans of 50-70m, this would require access to around 20 individual pier locations. It is unlikely that the viaduct would be close to the Old Military Road therefore the Old Military Road is unlikely to offer a means of access. Accessing the pier locations directly from the A83 may be appropriate depending on the proposed alignment.

Alternatively, temporary 'linear' road may be a suitable means of access to the piers, which would be formed by a combination of benching into the existing sloping ground on one side and providing retained support to the other.

Access for the superstructure construction could either be via this access road or along the superstructure if span-by-span techniques were adopted.

(a).3 Disruption

As this is an off-line option it is likely to have limited disruption to the A83. As noted above, this is dependent on the access arrangements for construction; however, utilising a temporary access road would be the least disruptive.

(a).4 Existing Slope Drainage Regime

The existing slope drainage regime would remain largely unaltered by the construction of this option. Local alterations to existing drainage channels would be required, but this is not considered to be of great significance. If the significance of diverting any particular drainage channels is considered to be high, the bridge pier locations could be altered to avoid them - within certain limits.

(b) Aesthetics

The viaduct would be a highly visible feature in the scenic Glen Croe. Significant architectural input would be required to ensure that an elegant design is produced that is fitting for this area. Items that are likely to affect this are the consideration of:

- span to height ratios
- deck thickness and cross-section
- pier heights, widths and cross-sections
- materials and finishes

This would also require early consultation with Architecture and Design Scotland and the Loch Lomond and Trossachs National Park.

(c) Operation/Maintenance/Inspection

The operation, maintenance and inspection requirements of the viaduct are not considered to be any different to any other structure of this size and type. It would be important in the design phase to incorporate as many durable features as possible e.g. minimising the number of expansion joints, or making provision for bearing replacement etc. Routine maintenance and inspection would be carried out from the carriageway above and would utilise the likes of underbridge units and roped access inspections etc. Right of access to and around the piers would be required for future bearing replacement.

(d) Risks

The main risk associated with the viaduct option is the lack of information available at this early stage of the study. The information required to assess these risks are:

- ground investigation
- detailed topographical survey
- land searches

If these items provide sufficient information to confirm the feasibility of the viaduct, the only remaining risk is considered to be health and safety during construction. This would need to be considered in great detail, making use of the information listed above.

6.3.3.4 Impacts during Construction

The preferred alignment of a viaduct within the yellow corridor has not been determined at this stage. Access would be required to the pier foundations for construction so a new haul road may be built along the proposed alignment. However, if the alignment is sufficiently close to the existing A83, the trunk road may be used during construction. This would require single-lane closures for much of the construction period, and may require full-road closures for short durations. These would be limited to night-time closures where possible

The construction period is likely to be two to two and a half years.

6.3.3.5 Topography and Land Use

This option requires additional land outside the current road boundaries which may be both upslope and downslope of the existing A83. The width of additional landtake upslope would vary according to topography and the alignment, and would be required for both the permanent works and temporary works.

The landowner currently uses the land for non-commercial sheep and cattle grazing.

6.3.3.6 Geology, Geomorphology and Ground Conditions

The geology and ground conditions described in Section 6.3.1.6 are applicable to this option, supplemented as follows.

The ground conditions beneath the majority of the viaduct are anticipated to comprise a relatively thick cover of superficial deposits made up of colluvium overlying glacial till deposits, resting on bedrock. Towards the northern end of the proposed alignment rock would appear to be shallower based on the frequent occurrence of rock outcrops. From previous ground investigations carried out near existing road level the superficial deposits were found to be up to 15m in thickness. Similar thicknesses, although potentially greater, might occur below the road where the thickest deposits would be anticipated to occur.

6.3.3.7 Hydrology, Hydrogeology and Drainage

Additional road drainage systems would be included for the section of the alignment offset from the existing A83 in this option. Appropriate measures for treating water from the carriageway would be implemented prior to allowing the water to join the existing watercourses.

The existing culverts may be removed to allow the existing watercourses running down the hillside to pass under the A83 with as minimal impact as possible.

6.3.4 Purple Option – Tunnel

6.3.4.1 Alignment

The purple corridor covers an off-line section on the valley floor from a point on the A83 3.2 km north-west of Ardgartan, in the vicinity of the A83/Forestry Commission Track & the Old Military Road junction extending to Loch Restil, after tunnelling from the Glen Croe.

The horizontal alignment would broadly follow the corridor of the existing Old Military Road until it reaches the north side of the valley where it is anticipated that it shall tunnel under the existing A83 before the Rest and Be Thankful car park then follow adjacent to the existing alignment until reconnecting with the existing A83 at Loch Restil.

The vertical alignment is expected to be higher than the valley floor to minimise the likelihood of future landslides from impacting on the trunk road. The major challenge for alignment options in this corridor is to climb from the valley floor (approx. level 150m) to the height north of the Rest and Be Thankful car park (approx. level 250m).

A steep gradient in the tunnel would result in a tunnel length of approximately 600m. A tunnel of this length could be constructed as a single bore tunnel. At this gradient, a climbing lane within the tunnel should be considered. Arrester beds are unlikely to be feasible due to the straight horizontal alignment.

Steep gradients in tunnels lead to increased ventilation costs due to increased vehicle emissions. Also traffic speed within the tunnel may be reduced unacceptably, particularly HGV traffic, as overtaking cannot be permitted. Trunk road tunnels with gradients exceeding 6% are generally not desirable, and a maximum of 4% is considered preferable.

Should a tunnel with a maximum gradient of, say, 4% be used then the tunnel length would increase to around 1900m and reach ground level in the vicinity of Loch Restil. In this case, a twin bore tunnel with cross passages at regular intervals would be required. The capital and operating costs of this option would be considerably greater than the single bore, steep gradient option.

If the tunnel option is taken forward, then further work would need to be carried out into optimising the layout and vertical alignment of the tunnel.

Other Relaxations and Departures from a 100kph design standard are anticipated due to the topographical constraints of the corridor.

6.3.4.2 Junctions and Side Roads

As the A83 trunk road would be in a tunnel past the Rest and Be Thankful car park and junction with the B828, an alternative means of accessing these must be provided. Options considered at this stage include realigning the B828 down the south-west side of Glen Croe to connect to the A83 in the valley floor, or to extend the B828 around the west side of Loch Restil to connect to the existing A83 north of

the proposed tunnel. The Rest and Be Thankful car park can then be accessed via the B828.

6.3.4.3 Structures

The tunnel entrance would be above the level of the valley floor and so significant earthworks or a structure would be required to lift the road from the valley floor to the level of the tunnel entrance.

6.3.4.4 Basis of Tunnel Design

(a) Evacuation and Emergency Escape

The consequences of an accident on a road can be far greater in a tunnel than the same accident occurring on the open road. If an accident occurs in a tunnel, it is essential that personnel can escape quickly to a place of safety and that emergency services can reach the incident to tackle it and help those that may be injured.

The greatest single risk in a road tunnel is from a fire and this risk must be mitigated by provision of rapid detection and response systems as well as robust ventilation and escape facilities. The regulations require emergency escape points at least every 500m.

In longer tunnels, a twin bore tunnel configuration is used with the escape routes to the adjacent tunnel bore e.g. the recently completed A3 Hindhead Tunnel in Hampshire has this configuration, which is 1,830 metres (1.14 miles; 6,000 feet) in length. The non-incident bore provides safe and smoke free access for the emergency services.

1.0m wide walkways would be provided on each side of the tunnel in accordance with BD 78/99. Emergency points with emergency telephones, fire hose reels and fire hydrants would be provided at 50m intervals in accordance with the requirements of BD78/99.

(b) Ventilation

Longitudinal ventilation in road tunnels is generally provided by jet fans mounted in the tunnel crown. In twin bore tunnels ventilation is normally in the traffic direction to take advantage of the piston effect of traffic. In a bi-directional tunnel, the jet fans need to be reversible to ensure the fans operate in the predominant traffic direction. This may change twice or more during a day.

In the event of a fire incident, the fans need to have the capability of directing smoke to either portal under all prevailing wind conditions.

A mid-tunnel ventilation shaft is likely to be required for the Rest and Be Thankful Tunnel at the current proposed gradient and length.

(c) Tunnel Lighting and Drainage

The entire length of the tunnel, including the tunnel portals, would be provided with a high standard of lighting, with lighting transition zones at portals to allow driver's eyes to adapt from/to exterior conditions to/from lighting levels within the tunnel. Provision of tunnel lighting is a significant proportion of the operating cost of a road tunnel.

The drainage system within the tunnel is likely to consist of longitudinal slot drains feeding to sumps which are discharged to the storm water drainage system. Oil and petrol interceptors would be provided. The tunnel storm water drainage system would outfall to local watercourses via SUDS ponds.

Sumps would be located close to the uphill portal to intercept rainwater flowing down the tunnel approach ramps. With the possibility of flammable liquid flowing into the drainage system, a combustible gas detection system and fire suppression (foam) system must be provided in the sumps.

(d) Breakdowns and Accidents

Risks that may arise from incidents such as a broken down or over-height vehicle entering the tunnel need to be managed. If a car breaks down, vehicles must be able to pass safely without interfering with oncoming traffic and without causing stationary traffic within the tunnel. Recovery vehicles must also be able to reach a stranded vehicle quickly without the need to turn traffic around inside the tunnel.

For these reasons, a hard shoulder is considered essential within the tunnel. Even so, it must be recognised that overtaking within the tunnel would not be possible over the full length of the tunnel. To further reduce the risks of accidents within the tunnel, a speed limit of 30 mph may be necessary.

(e) Traffic Control and Monitoring Systems

The tunnel would be provided with a range of systems for lighting, ventilation, drainage, fire detection, automatic incident detection system, air quality monitoring, CCTV, emergency telephones, and other equipment. All these systems must be maintained and monitored to ensure the safe and reliable operation of the tunnel.

A continuously manned Tunnel Control Centre would be required to provide an immediate response to any incident, setting traffic and ventilation controls as well as evaluating any incident before arrival of the emergency services. This Control Centre does not need to be located adjacent to the tunnel but could be part of the Regional Traffic Control facility.

An on-site Tunnel Operations Facility would also be required. As a minimum, this facility would provide full tunnel system control for emergency services during an incident as well as facilities for visiting tunnel maintenance staff.

(f) Transport of Dangerous Goods

Under the 2011 European Agreement on the International Carriage of Dangerous Goods by Road (ADR 2011), road tunnels must be assigned to a particular category from Category A (no restrictions) to Category E (the most restrictive). The categorisation is based on the assumption that explosions, release of toxic gas or volatile liquids, and fires are the three major dangers and therefore the categories are based on the potential of transported goods to result in one or all of these dangers. The movement of explosive, flammable, oxidising, toxic, infectious, radioactive and corrosive solids, liquids and gases are therefore often restricted through road tunnels.

As the A83 is a strategic route the tunnel would need to be Category A to avoid restrictions on the transit of goods. This would have implications on the design of the tunnel layout and equipment provision within the tunnel to minimise the risks of a

dangerous goods incident. E.g. additional ventilation may need to be provided to ensure the rapid dispersal of a toxic gas release.

6.3.4.5 Tunnel Construction Aspects

(a) Tunnelling Method

Modern tunnelling techniques can cater for virtually all ground conditions. However, alignment and techniques must be matched to the prevailing ground conditions with the main intent being to avoid unnecessary changes in ground types and, as far as possible, avoid difficult geological features that may necessitate changes in technique or greater support measures.

As the ground is expected to be entirely hard rock, drill and blast methods are the most likely. The shape of the excavation profile would probably be D- shaped with a flat or slightly dished floor to ensure stability of the excavation. Temporary support of the ground is most likely to be a combination of rock bolts, sprayed concrete and mesh.

A secondary cast in-situ concrete lining would be used to prevent any loose rock or groundwater falling onto the traffic. The secondary lining would also provide a support for the mechanical and electrical plant as well as providing a suitable surface for minimising tunnel lightings costs.

Due to the short length of the tunnel, the use of a full face tunnel boring machine (TBM) is not likely to be cost effective.

(b) Extent & Layout of Tunnel

To ensure the ground above a bored tunnel excavation arches sufficiently, tunnel portals need to be located where there is adequate cover to the tunnel crown (see Figure 6-5). At this stage a 20m vertical height between road level and existing ground level has been assumed.

The tunnel portals would consist of rock cuttings with head walls in rock, all of which would be supported by rock bolts mesh and sprayed concrete.

Figure 6-5: ***Twin bore road tunnel portal during construction – Photo courtesy Hochtief AG***

(c) Geology

Detailed ground investigation information would be required along the length of the tunnel to confirm the ground conditions. At this stage the tunnel is expected to be constructed entirely within schist rock. Superficial deposits at portal locations are likely to be minimal or absent.

6.3.4.6 Impacts during Construction

This is an off-line option, so disruption to road users due to construction would be limited to the tie-ins with the existing A83 at the end of the construction period.

The construction period is expected to be two and a half to three years.

6.3.4.7 Topography and Land Use

The side slopes at this level in the valley are less severe than those experienced on the forestry track or the existing A83. The valley floor is currently used for non-commercial grazing.

The Old Military Road is used by the Friends of the Rest group for heritage car events. Every effort would be made to maintain this road.

Construction of the purple option would require land acquisition.

6.3.4.8 Geology, Geomorphology and Ground Conditions

(a) Description

The geology and ground conditions described in Section 6.3.1.6 are applicable to this option, supplemented as follows.

The lateral extent of the alluvial deposits occupying the floor of the Glen Croe valley is likely to coincide approximately with the line of the old military road (OMR) on the edge of the valley. Glacial deposits are indicated to occur on the valley sides, locally in the form of morainic deposits near the foot of the hillslopes. The glacial deposits are anticipated to be overlain by colluvium particularly below the existing A83.

A ground investigation undertaken in 2009 for proposed works to the A83 included a number of boreholes located on the Old Military Road in the vicinity of High Glencroe cottage. The boreholes encountered rockhead at variable depths ranging between 2.6m and 15.9m. The superficial deposits were found to comprise mainly silty sands and gravels with a variable content of cobbles and boulders, suggesting a glacial origin.

Where the route starts to climb near the head of the valley as it goes into tunnel, rock is generally anticipated to occur at shallow depths on the higher ground. Whilst there are rock outcrops in the vicinity of the proposed south portal, the superficial deposits could still be relatively thick here.

(b) Discussion

The design and construction issues relating to the tunnel itself are discussed in Section 6.3.4.4. With regard to the remainder of the route, no significant geotechnical problems have been identified on account of the route following the valley floor, with relatively minor earthworks required to provide an acceptable horizontal and vertical alignment. Soft alluvial deposits may be present particularly at the southern end where the road lies closest to the Croe Water in the centre of the valley.

The section of the route within the valley floor has similar susceptibility/hazards as for the A83, but to some extent protected by the A83 and lessened by the shallower slopes below the A83. There is the potential for events that affect the A83 to reach the valley floor, but these would typically be slower moving and involve smaller volumes. A recent hazard ranking assessment by TRL has determined a minimum score of 100 for this part of the route.

The landslide risk to the purple corridor would be mitigated by the road being elevated above ground level, generally on embankment, within the valley floor and as it begins to climb towards the head of the valley.

6.3.4.9 Hydrology, Hydrogeology and Drainage

Additional road drainage systems would be included in this option along the full length of the proposed realignment of the A83. Culverts shall be provided for any watercourses running down the hillside.

Drainage within the tunnel is covered in Section 6.3.4.4(c), above.

Appropriate measures for treating water from the carriageway would be implemented prior to allowing the water to join the existing watercourses.

6.3.5 Blue Option – Valley Floor and Longer Horizontal Alignment

6.3.5.1 Alignment

The blue corridor covers an off-line section on the valley floor from a point on the A83 3.2 km north-west of Ardgartan, in the vicinity of the A83/Forestry Commission Track & the Old Military Road junction extending to the north side of the Rest and Be Thankful car park.

The horizontal alignment is expected to broadly follow the purple corridor along the valley floor until it reaches the north-west end of the valley. To allow for the level difference between the valley floor and the level of the A83 in the vicinity of the Rest and Be Thankful car park the alignment would curve around the northern end of the valley changing direction by approximately 180° and getting further from the valley floor as curves. On the south-western side of the valley, a sharp bend would be required to change direction again. The horizontal alignment would then follow the forestry commission track. This horizontal alignment achieves the distance required to steadily increase the level of the road for tie in with the Rest and Be Thankful car park.

The vertical alignment is expected to be higher than the valley floor to minimise the likelihood of future landslides from impacting on the trunk road. After approximately 2.3km, the proposed alignment climbs from the valley floor (approx. level 150m) to the height of the Rest and Be Thankful car park (approx. level 250m) by following the longer horizontal alignment described above. A gradient of up to 8% for over 1km would be required achieve this level difference. Climbing lanes should be considered for up-hill traffic and arrester beds should be considered for down-hill traffic prior to the tight horizontal bends.

The first 180° bend would require a relaxation or a departure, and the second would require a departure. The 8% gradient is a relaxation. Other Relaxations and Departures from a 100kph design standard are anticipated due to the topographical constraints of the corridor.

6.3.5.2 Junctions and Side Roads

The junction between the B828 and the A83 would have to be altered. The most likely option is that the B828 would be redirected offline from a point 0.7km from the Rest and Be Thankful car park heading east to connect with the proposed A83 south of the proposed structure over the gully in the north-west corner of the glen.

6.3.5.3 Structures

It is highly probable that a viaduct structure of around 800m would be required for this route option to allow for the hairpin bend. This is because the proposed alignment cannot closely follow the existing topography, or the gradient on the bend would match the existing hill slope.

Culverts would be sufficient over many of the watercourses in the valley sides, but some watercourses run in wide gullies, and may require bridges.

6.3.5.4 Impacts during Construction

This is an off-line option, so disruption to the travelling public due to construction would be limited to the tie-ins with the existing A83 at the end of the construction period.

The construction period is likely to be two to two and a half years.

6.3.5.5 Topography and Land Use

The side slopes at this level in the valley are less severe than those experienced on the forestry track or the existing A83. The valley floor is currently used for non-commercial grazing.

There is an existing cottage in the valley within the blue corridor, but it is not expected that this would be directly affected by the blue option.

The Old Military Road is used by the Friends of the Rest group for heritage car events. Every effort would be made to maintain this road.

Construction of the blue option would require land acquisition.

6.3.5.6 Geology, Geomorphology and Ground Conditions

The geology and ground conditions described in Section 6.3.4 are applicable to this option.

(a) Discussion

A discussion of the hazard ranking of the main part of the valley floor, common to both the purple and blue options is contained in Section 6.3.4 (h). Where the route starts to curve westwards to cross the valley, generally following the contours at the head of Glen Croe, shallow rock is anticipated to be present over some sections of the route and elsewhere largely glacial deposits and colluvium are anticipated to be present. The route would be formed across relatively steep slopes. There is a zone of debris susceptibility identified on the susceptibility map from the SRNLS, located

immediately below this part of the alignment, indicating the potential for landslide to occur along this section.

The route then doubles back along the west side of the valley before climbing the hillside in a relatively tight hairpin bend. Similar issues therefore apply to this final section with relatively steep slopes and similar ground conditions. Finally the route follows the existing forestry track alignment to reach the B828 and Loch Restil.
In summary, the blue option alignment crosses, or may be affected by one zone of high debris susceptibility, in addition to similar susceptibility/hazard as for the A83 although protected by the A83, and lessened by the shallow slopes below the A83. Engineered protection in the form of embankment in the valley floor and viaduct at the head of the valley would mitigate the impact of debris flows.

6.3.5.7 Hydrology, Hydrogeology and Drainage

Additional road drainage systems would be included in this option along the full length of the proposed realignment of the A83. Appropriate measures for treating water from the carriageway would be implemented prior to allowing the water to join the existing watercourses.

Culverts would be provided for any watercourses running down the hillside.

6.3.6 Green Option – South-East side of Glen Croe

6.3.6.1 Alignment

The green option begins at the existing A83 3.2 km north-west of Ardgartan, in the vicinity of the A83/Forestry Commission Track & the Old Military Road junction. On the north-west end of the scheme the option ties-in to the north side of the Rest and Be Thankful car park. This route option shall be entirely off-line located within Glen Croe in the area of forestry on the south-west side of the valley.

Alternate options within the green corridor have been considered and discussed in Section 4.5.6.

The horizontal alignment of this option shall broadly follow the existing Forestry Commission Track up to a point 800m from the Rest and Be Thankful car park where it would then follow a route to the west of the Rest and Be Thankful car park.

The vertical alignment of this section is expected to broadly follow the existing vertical alignment of the Forestry Track resulting in a gradient of approximately 7 - 8% over an accumulated length of 1.1 km. Climbing lanes and arrester beds should be considered at design stage. Once diverged from the Forestry Track it is likely that a structure would be required to address local topographical constraints to connect with the level of the Rest and Be Thankful car park.

Relaxations and Departures from a 100kph design standard are anticipated due to the topographical constraints of the corridor.

6.3.6.2 Junctions and Side Roads

As with the Blue Option, the junction between the B828 and the A83 would have to be altered. The most likely option is that the B828 would be redirected offline from a point 0.7km from the Rest and Be Thankful car park heading east to connect with the proposed A83 south of the proposed structure described below.

6.3.6.3 Structures

It is likely that a bridge or viaduct structure of around 200m would be required for this route option to span a gully in the valley near the north end. In addition, a 600m viaduct over the section of higher risk of debris flow should be considered.

6.3.6.4 Impacts during Construction

This is an off-line option, so disruption to the road users due to construction would be limited to the tie-ins with the existing A83 at the end of the construction period.

The construction period is expected to be one and a half to two and a half years.

6.3.6.5 Topography and Land Use

As has been discussed in relation to the existing A83 topography, the forestry track is also on a similarly steep side-long ground through the opposite side of Glen Croe. This land contains an evergreen forest which is used for timber.

6.3.6.6 Geology, Geomorphology and Ground Conditions

The geology and ground conditions described in Section 6.3.1 are generally applicable to this option, supplemented as follows.

The superficial deposits occupying the west side of the Glen Croe valley are indicated to comprise glacial till deposits, locally in the form of moraines near the base of the hillside. The valley floor below the proposed route is underlain by deposits of alluvium (silt, clay and sands and gravels). Near surface deposits of colluvium are also anticipated to occur across the hillside. The geological map records an area of historic landslides high up on the hillside (estimated to be above 365m OD contour) below the summit of Coire Culach, occurring above the northern half of the proposed route.

(a) Discussion

The forestry track has been formed in sidelong ground with steep slopes above and below the road. A brief site inspection of the existing track has confirmed that the cuttings on the upslope side have been formed in both soil and rock. Numerous streams flow down the slope above the track and generally discharge directly into an open ditch system, which feeds a number of culverts constructed beneath the track, linking the ditch to the lower slope. The upper and lower slopes have a relatively dense cover of trees making it difficult to assess the general condition of the slopes. Scotland TranServ, in their study into potential emergency diversion routes[27] , refer to slope remedial measures undertaken in December 2011 due to a lower slope failure which affected the track. This event coincided with a debris flow event on the A83, an indication that the track may share the same risk of landslides.

To assess the potential for landslides affecting this route option, reference has been made to the Hazard Ranking System developed as part of the SRNLS, Implementation Report, for comparison with the alternative route options. An assessment of the route was undertaken, combining the debris susceptibility with

[27] Scotland TranServ (2012), Study into Potential Emergency Diversion Routes at the Rest and Be Thankful

the estimated exposure rating to provide a hazard ranking. The results indicate a minimum hazard score of 100, putting it in the High/Very High risk category, although less than for the existing A83.

In general however, the susceptibility above the forestry track appears to be less than that evident above the A83 on the opposite side of the Glen. There is however, one major zone of susceptibility from the assessment that corresponds with three streams centred on NN 2240 7052, at approximate elevations 300m and 650m. It is arguable whether other zones of susceptibility, centred on the sub-peak (516m) to Ben Donich, are most likely to be channelled to the south of the start of the route. The existing forestry is enhancing the stability of the existing slopes with tree root systems helping to hold the soil mass together, and the tree canopies intercepting rainfall, thus reducing direct runoff and infiltration into the ground.

With regard to the construction of a permanent road along the forestry track, significant cut and fill would be required to provide a full carriageway width at acceptable horizontal and vertical alignments. Considerable slope reinforcement works or retention measures would be required on the uphill side whilst a significant amount of filling or structural support would be required on the downhill side due to the steep topography to provide these alignments. These steepening measures would be significantly greater if a climbing lane was included.

There are a number of risks associated with this option including those which may be realised as a result of the construction process as well as the longer term performance of the road. During construction, there may be a higher risk of localised slope failures due to the disturbance and disruption to the ground. This can be managed to a certain extent through good pre-earthworks drainage and careful construction, but some risk would always remain. In the longer term, as discussed above, there would appear to be a similar potential for landslides to occur compared with the existing A83. Consequently, significant lengths, estimated to be at least 600m long, of this route would need to be protected where there is the highest risk of debris flows. The existence of the relatively dense tree cover which enhances the stability of the slopes cannot be relied upon in the long term unless a commercial agreement can be reached to retain the trees. If this was the case then there would be a requirement for forestry management, including re-planting, removal of dead trees etc.

6.3.6.7 Hydrology, Hydrogeology and Drainage

Additional road drainage systems would be included in this option along the full length of the proposed realignment of the A83. Appropriate measures for treating water from the carriageway would be implemented prior to allowing the water to join the existing watercourses.

Culverts would be provided for any watercourses running down the hillside.

6.4 Tarbet - Kennacraig Landslide Hazard

6.4.1 History

This section considers the landslide hazard of the A83 trunk road between Tarbet and Kennacraig, excluding the Rest and Be Thankful which is covered in section 2.4. It is introduced here since investment decisions on long term improvement measures at Rest and Be Thankful should be taken within the wider context of landslide hazard along the whole A83 Trunk Road.

In general, other sections of the A83 have been less affected by landslides over recent years compared with the Rest and Be Thankful section; however, there have been a number of significant events, as summarised below in Table 6-1: including a major rockfall.

Location	Date	Description
Cairndow	9 August 2004	A number of landslides occurred on the northwest facing hillslopes immediately to the north of Cairndow, the largest of which closed the road with a mass of debris estimated to be of the order of 600Te (Reference 1).
Glen Kinglas	9 August 2004	A number of landslides occurred on the south facing slopes of Binnein an Fhidhleir, of which only 2 had a significant impact on the A83 with a mass of debris of the order of 200Te, closing the road at one location with a single lane closure at the other location (Reference 1).
Artilligan nr Erines	1998	Major rockfall (4500Te) which closed the A83. Rock slope was subsequently remediated together with 2 adjacent high risk rock slopes (Reference 2).
Loch Shira	Mid 1970s to 1994	A short section of the A83 on the east side of Loch Shira has experienced a number of slope stability problems since the mid 1970s, the last major occurrence being in 1994 (Reference 3)

Table 6-1: Locations on A83, excluding Rest and Be Thankful, where previous ground movement events impacted the A83

[1]A83 Cairndow & Glen Kinglas Landslip Inspection Report, BEAR Scotland for Scottish Executive, March 2005
[2]Rock Fall remediation In An Area of structurally Complex geology, The Scottish Caledonides, Nettleton et al, GeoEng2000, Melbourne, Australia
[3]A83 Loch Shira Annual Monitoring Report 2011/2012, Scotland TranServ for Transport Scotland

In addition to the above, available records (Road closure data provided by Scotland TranServ) indicate the road was closed at Butterbridge at the east end of Glen Kinglas on 13 September 2010, although this does not appear to have been a major event as the road was closed for a relatively short period (approx 7 hours).
Notwithstanding the relative paucity of events compared with the Rest and Be Thankful, the landslide hazard potential has been assessed as high/very high at a number of locations, as part of the Scottish Road Network Landslides Study discussed in section 2.5.3.

The most recent site specific assessments (2009) provide the highest Hazard Ranking score of 200 for the Rest and Be Thankful (SRNLS Location Ref. A83-02 - Ardgartan to Rest and Be Thankful), closely followed by Glen Kinglas (190). The locations on the A83 with hazard rankings greater than or equal to 100 (High/Very High), excluding location A83-02 at the Rest and Be Thankful, are listed in Table6-2. By way of comparison, the highest hazard ranking score for the trunk road network is 250, and applies to locations where the available diversion route is considered “more significant” (i.e. longer and more difficult). The total length of the A83 High/Very High locations slightly exceeds 31km.

Route Code	Hazard Ranking (Risk) Score	Locality	Road Length (m)
A83-04	190	A83 Glen Kinglas	4,360
A83-06	170	A83 Clachan to Strone Point	9,170
A83-05	150	A83 Cairndow	1,620
A83-10	140	A83 East of Auchindrain Folk Museum	1,910
A83-18	125	A83 South of Inverneill	7,040
A83-12	120	A83 West of Furnace	3,550
A83-20	113	A83 North of Tarbert	690
A83-01	110	A83 West of Succoth	1,760
A83-07	100	A83 East of Loch Shira	1,260

Table 6-2: Locations on the A83, excluding Rest and Be Thankful, with Hazard Ranking (Risk) scores of 100 or more

6.4.2 Geology

A summary of the general geology of the sections of the A83 with hazard ranking scores of 100 and above (excluding the RABT) is provided in Table 6-3: below, which also gives an indication of the typical ground conditions experienced along the full length of the route. Details such as intrusive dykes and a description of the geological structure have been omitted for simplicity. Locations are listed in order, from Tarbet, heading west and south to Kennacraig.

Route Code	Locality	General Description of Drift Geology	Geology Maps
A83-01	West of Succoth	River Terrace deposits (gravel, sand, silt and clay) at the head of Loch Long and directly beneath road along shoreline of Loch Long. Map suggests drift cover on higher ground is thin or absent. Greywacke and siltstones of Beinn Bheula Schist Formation	BGS GeoIndex Sheet 38W Solid
A83-04	Glen Kinglas	Morainic drift present on lower slopes above road, beneath eastern section and 'Undifferentiated drift and Boulder Clay' beneath western section. 'Landslips' area marked at eastern end of section of route opposite Butterbridge and near the western end. Map suggests upper slopes have thin or absent drift cover. Mica schist and undifferentiated schist.	Sheet 37 Drift Sheet 37 Solid
A83-05	Cairndow	'Undifferentiated drift and Boulder Clay' present on lower slopes. Map suggests drift cover is thin or absent on upper slopes. 'Landslips' areas marked above road at northern end of road section. Raised Beach deposits present beneath road immediately adjacent to Loch Fyne. Epidotic and chloritic schistose grits with some mica schist.	Sheet 37 Drift Sheet 37 Solid

Route Code	Locality	General Description of Drift Geology	Geology Maps
A83-06	Clachan to Strone Point	Raised Beach deposits present beneath road immediately adjacent to Loch Fyne along shoreline. Alluvial and present beach deposits occur at head of Loch Fyne. Map suggests drift cover is thin or absent on slopes up to the ridge line above the road. . Slates and phyllites with some quartzite (Ardrishaig Phyllites), and garnetiferous mica schists.	Sheet 37 Drift Sheet 37 Solid
A83-07	East of Loch Shira	Area of 'Landslips' occurs immediately above road along the majority of this section of road, with Raised Beach deposits occurring beneath the northern section of road. Slates and phyllites with some quartzite (Ardrishaig Phyllites)	Sheet 37 Drift Sheet 37 Solid
A83-10	East of Auchindrain Folk museum	Peat indicated to occur directly beneath road with localised areas of morainic drift, and 'Undifferentiated drift and Boulder Clay' at extreme ends of the road section. Morainic deposits also present on higher ground, with drift cover suggested to be thin or absent elsewhere. Slates and phyllites with some quartzite, schists and felsite.	Sheet 37 Drift Sheet 37 Solid
A83-12	West of Furnace	Drift generally thin or absent with Raised Beach deposits present beneath road along shoreline. Felsite, with schists, slates and phyllites at south-west end.	Sheet 37 Drift Sheet 37 Solid
A83-18	South of Inverneill	Localised areas of Raised Marine (sand and gravel) and present marine deposits (gravel sand and silt) inland, but generally present beneath road along shoreline. Drift cover suggested to be thin or absent on higher ground above road. Quartzite (Upper Erines Quartzite Formation)	BGS GeoIndex
A83-20	North of Tarbert	Drift cover suggested to be thin or absent. Metavolcaniclastic and sedimentary rock of Southern Highland Group	BGS GeoIndex

Table 6-3: General Geology at locations on A83 excluding Rest and Be Thankful with Hazard Ranking (Risk) scores of 100 or more.

6.4.3 Slope Setting

The extent of vegetation cover and the orientation of the slopes at these nine locations are summarised in Table 6-4: below, as these factors could influence decisions on the extent of protective measures which could be implemented.

Route Code	Locality	Vegetation	Slope Orientation
A83-01	West of Succoth	Lower slopes part forested, part recently cleared.	South-east
A83-04	Glen Kinglas	Lightly vegetated with 2 small wooded areas close to the road.	South
A83-05	Cairndow	Lightly vegetated, wooded areas over northern end largely deforested.	North-west
A83-06	Clachan to Strone Point	Generally densely wooded, but locally lightly wooded or clear of trees.	South-east
A83-07	East of Loch Shira	Generally wooded.	West
A83-10	East of Auchindrain Folk museum	Lightly vegetated slopes.	South-east and north-west
A83-12	West of Furnace	Lower slopes wooded.	South-east
A83-18	South of Inverneill	Southern half generally wooded; northern half generally includes a thin strip of trees adjacent to the road and upper slopes lightly vegetated.	East
A83-20	North of Tarbert	Lower slopes part densely wooded, part lightly vegetated.	East

Table 6-4: Vegetation and slope orientation at locations on A83, excluding Rest and Be Thankful, with Hazard Ranking (Risk) scores of 100 or more.

6.4.4 Discussion

The A83 includes a number of sections of road with High/Very High Hazard ranking scores (see Table 6-2:), indicating the potential for landslides to occur along the A83, in addition to the Rest and Be Thankful. The ranking system helps to identify areas where problems may occur but it is not a predictive tool.

The recent history of landslides along the A83 highlights the difficulties in predicting where landslides will occur, with some sections of the A83 with relatively high hazard ranking scores, e.g. A83-06 Clachan to Strone Point (170) and East of Auchindrain (140), with no apparent recent history of failures, although some of these may have occurred higher up on the hillside without reaching the road. Glen Kinglas scores highly (190) and is second only to Rest and Be Thankful; however the frequency and magnitude of recent events here is not comparable to Rest and Be Thankful, with landslides on only two occasions over the last 8 years. Similarly only one event has been recorded at Cairndow (150) in this period, and Loch Shira also with the last recorded event occurring 18 years ago. Interestingly, in the areas where landslides have occurred, the geological maps record areas of 'landslips' relatively close to the failure locations, suggesting the historical nature of the problem in these areas.

With regard to the previous failure areas, listed in Table 6-1:, specific recommendations, as presented in previous reports, are detailed below. With regard to potential rockfall events, no specific assessment of rockfall hazard has been carried out as part of this assessment, and it is recommended that a review be undertaken of the TRL hazard ranking system for rock slopes to assess any specific requirements for the A83.

6.4.4.1 Glen Kinglas and Cairndow

The following recommendations are from the A83 Cairndow & Glen Kinglas Landslip Inspection Report, BEAR Scotland for Scottish Executive, March 2005:

- Assessment of all existing culverts along this section of road with upgrading as required, particularly at previous failure locations.
- Monitoring of rainfall, linked to signage and more frequent patrols by Operating Company
- Annual slope inspections
- Consideration of barriers / catch fences
- Consideration of slope drainage measures

6.4.4.2 Loch Shira

The following recommendations are from the A83 Loch Shira Annual Monitoring Report 2011/2012, Scotland TranServ for Transport Scotland

- Installation of new drainage ditches at crest, toe and mid slope to regain control of slope drainage.
- Topographical survey to quantify any slope movements since the 2008 survey.
- Extension to previous topographical survey area to include saturated area at north end of site.
- Installation of survey monuments to facilitate assessment of slope movement

Although the frequency of debris flows at Glen Kinglas and Cairndow is much less than at Rest and Be Thankful, the previous events in 2004 resulted in significant disruption to the A83. It is considered that any mitigation measures should result in a similar level of residual risk along the whole of the A83 trunk road. The following discussion and recommendations are based on achieving a similar level of protection to that of the Red Option for the Rest and Be Thankful, whereby the recent level of impact on the A83 due to debris flows and the like is significantly reduced.

Six of the nine locations identified have not been affected by debris flows in the recent past, the rock fall near Erines in 1998 representing a different form of event. These route locations all run below slopes facing between east and south. It is possible that the likelihood of the type of rainfall events triggering debris flows is less on slopes which do not face the prevailing south westerly wind direction. Most of these slopes are wooded to varying degrees which is also likely to reduce the likelihood of debris flows reaching the A83. Based on these factors and the lack of events to date, it is considered that mitigation measures are not justified at present. However, it is recommended that the programme for deforestation and any replanting by the Forestry Commission and other land owners be determined in order to facilitate future consideration and planning of mitigation measures for these areas.

The section A83-07 east of Loch Shira is considered to represent a slightly different hazard in that the slope immediately above the road has a history of gradual movement. It is recommended that the previously proposed measures are implemented in the short-term.

This leaves two sections of the route comprising a length of 4,360m in Glen Kinglas (A83-04) and 1,620m at Cairndow (A83-05) where there have been debris flows and there is very little forestry plantation. In order to achieve consistency with the Rest and Be Thankful, it is considered that debris flow barriers and improvements to culverts should be implemented. For costing purposes at this stage, it is considered that the barriers should extend over part of the full length of Cairndow (say 60% - 960m) where the watercourses are more closely spaced, and over part of the length of Glen Kinglas (say 30% - 1320m) as there are more appreciable lengths between individual or groups of watercourses. This would result in a total length of barriers of 2280m at an estimated cost of the order of £10M. Detailed inspections of the slopes would likely enable this length of barriers to be reduced.

The following actions are recommended to address the ground related hazards to those parts of the A83 trunk road outwith the Rest and Be Thankful:

- Liaison with Forestry Commission and other forest owners regarding deforestation and replanting programme
- Rockfall and boulder risk assessments (which are not specifically covered by the existing landslides hazard assessment)
- Implement measures at Loch Shira (as listed above)
- Detailed inspection of the slopes at Glen Kinglas and Cairndow to determine the extent of netting and drainage improvement measures
- Implementation based on findings of above inspection

7 ENVIRONMENTAL ASSESSMENT

7.1 Overview

7.1.1 Introduction

This section of the report presents the findings of the Design Manual for Roads and Bridges (DMRB) Stage 1 environmental assessment of the route corridors against environmental parameters specified in the DMRB Volume 11, Section 3.

The following corridors for the A83 through Rest and Be Thankful have been assessed and are presented in this report:

- Red Corridor.
- Brown Corridor.
- Yellow Corridor.
- Purple Corridor.
- Blue Corridor.
- Green Corridor.

The Do Minimum scenario has also been considered for each environmental parameter. As described in Section 4.2 of this report, the Do Minimum scenario includes the work currently underway to bring into use the Old Military Road as an Emergency Diversion Route during temporary road closures on the A83 following debris flow events.

The construction phase for the Do Minimum works will be completed prior to commencement of works on any of the A83 corridor options considered in this Stage 1 report.

The corridors are shown on Drawing B1557610/WP02/002 in Appendix A and descriptions are contained in Section 4.

7.1.2 Scope of Assessment

The parameters considered as part of the Stage 1 environmental assessment are:

- Land Use.
- Geology, Land Contamination and Groundwater.
- Water Environment.
- Ecology and Nature Conservation.
- Landscape Effects.
- Cultural Heritage.
- Air Quality.
- Noise and Vibration.
- Pedestrians, Cyclists, Equestrians and Community Effects.
- Vehicle Travellers (View from the Road).
- Policies and Plans.

These environmental parameters are each addressed in the following sub-sections of this report. These sub-sections provide:

- An introduction to the subject area.
- The approach and methods used for assessment.
- The general baseline conditions for the relevant parameter.
- The potential environmental effects for the relevant parameter for each of the corridors under consideration, in respect of both construction and operational stages.
- The potential mitigation measures that could be adopted for the relevant parameter in response to the potential environmental effects.
- A summary of the assessment and recommendations for further work.
- References.

It should be noted that as this stage of assessment involves comparison of route corridors and a preferred scheme has not yet been identified, detailed mitigation measures have not yet been developed. The extent to which individual environmental effects are capable of being mitigated has therefore not yet been established. Further consideration of mitigation proposals will form part of the DMRB Stage 2 assessment process should this be taken forward following this Study.

7.1.3 Material Resources

Article 3 of Council Directive 85/337/EEC (as amended) requires that effects of a project on material assets be identified and assessed. In 2011 a DMRB Interim Advice Note (IAN) 153/11 was published, titled 'Guidance On The Environmental Assessment Of Material Resources'. The IAN provides a framework for the assessment using the latest and most up to date guidance available, however, it recognises this is a developing area and currently has a number of limitations.

At this stage, detailed information regarding materials and waste is not available as route alignments have not yet been selected. It is therefore appropriate to undertake a scoping exercise to determine the need for further assessment.

The Red, Brown, Yellow, Blue, Purple and Green corridors are each estimated to have project costs greater than £300,000. In line with the IAN scoping guidance this automatically triggers the need for a 'Simple' level of assessment.

7.2 Consultation

7.2.1 Pre-stakeholder Workshop Consultation (August 2012)

In advance of the stakeholder workshop held in August 2012, a number of environmental organisations were contacted to obtain information on key environmental constraints. This informed the development of environmental constraints plans, which were made available at the workshop. The following organisations were contacted and provided datasets:

- Argyll and Bute Council;
- Forestry Commission;
- Historic Scotland;
- Loch Lomond and the Trossachs National Park;
- Scottish Government;
- Scottish Natural Heritage;
- Scotways;
- Sustrans; and
- Royal Commission on the Ancient and Historical Monuments of Scotland (RCAHMS).

7.2.2 DMRB Stage 1 Assessment Consultation (September 2012)

To inform the DMRB baseline gathering exercise, consultation letters and an accompanying constraints plan were issued to the following consultees in September 2012:

- Argyll and Bute Council Environmental Health Officer;
- Association of Salmon Fishery Boards;
- British Trust for Ornithology (BTO);
- Forestry Commission Scotland (FCS);
- Historic Scotland;
- Loch Lomond and the Trossachs National Park;
- Scottish Natural Heritage (SNH);
- Scottish Badgers;
- Scottish Environment Protection Agency (SEPA); and
- Royal Society for the Protection of Birds (RSPB).

Consultees were asked to verify the constraints plan and provide any additional environmental information where available. Reference to the information received is provided where relevant under each sub-section.

7.3 Land Use

7.3.1 Introduction

This section describes the assessment of the potential effects of the six corridors on land use. Land uses which have been considered include residential, commercial (agricultural and forestry), community and development land.

7.3.2 Approach and Methods

This assessment has been undertaken following DMRB Volume 11, Section 3, Part 6.

Baseline conditions were determined through a review of the following:

- Loch Lomond and the Trossachs National Park Adopted Local Plan (2011);
- Jacobs Geographic Information System (GIS) database;
- Land Capability for Agriculture Map Sheet 4 (The Macaulay Institute for Soil Research (MLURI)); and
- Ordnance Survey (OS) Explorer Map 364.

Baseline conditions are described to provide an overview of land use that falls within the corridor boundaries, which define the study area for this assessment.

The significance of effects on community land and agricultural land is assessed taking into account receptor sensitivity and impact magnitude.

The assessment of residential and commercial land qualitatively assesses the direct adverse effects caused by changes in access or land-take as a result of the corridors.

The assessment of development land identifies the development constraints associated with the corridors.

Effects on land use would be predominantly associated with permanent land-take and associated effects e.g. severance. At this stage the exact areas required for construction and the extent of permanent land-take cannot be quantified. For the purposes of comparing potential effects of the different route corridors at Stage 1, the areas required for construction and operation are assumed to be generally the same (i.e. land disturbed during construction would be permanent land-take during operation).

7.3.3 Baseline Conditions

7.3.3.1 Residential

The study area is rural with no notable residential areas such as hamlets, villages or towns. One residential property named High Glencoe is located within approximately 300m of the A83 to the south of the Rest and Be Thankful car park. Another farmstead property to the south of Laigh Glencroe (referred to as Laigh Glencroe) is located approximately 26m from the A83. It comprises one partially - roofed, T-shaped building, an enclosure and a sheepfold (RCAHMS, 2012).

7.3.3.2 Commercial (Agricultural) Land

There is a large area of commercial forestry plantation owned and managed by the Forestry Commission Scotland (FCS) on either side of the A83 within the study area. The majority of this woodland is located on the south-western side of the valley.

Laigh Glencroe is a farmstead which, due to its location relative to the A83 and the sheepfold located to the north of the main building, is considered likely to farm livestock in the fields south of the A83.

The agricultural capability within the corridors ranges from Land Class 6_1 to 6_2. This is classified as non-prime agricultural land and is only suitable as rough grazing for livestock.

7.3.3.3 Community Land

The Rest and Be Thankful car park is located at the junction of the B828 and A83 at the northern extent of the Glen Croe valley. The car park is a popular viewpoint for visitors and has picnic facilities. During consultation the Loch Lomond and Trossachs National Park Authority highlighted that the car park, as well as informal lay-bys along the A83, are used by visitors parking for recreational activities such as hill walking.

The study area falls within the Argyll Forest Park (refer to Table 7-1:), which is managed by FCS. The park is used for public recreation, including activities such as hill walking and wildlife watching. The crags on the lower slopes of The Cobbler (Ben Arthur) are popular for abseiling and climbing.

The Croe Water runs directly through the middle of the valley and is used for recreational fishing (Loch Lomond and The Trossachs National Park Authority, pers comm, 03.10.12). [28].

Open Space	Corridor within or in Proximity (within 100m) to Community Land					
	Red	Brown	Yellow	Blue	Purple	Green
Argyll Forest Park	✓	✓	✓	✓	✓	✓
Rest and Be Thankful Car Park			✓	✓	✓	✓

Table 7-1: Areas of Community Land

7.3.3.4 Development Land

Development land has been identified by interrogation of the Loch Lomond and the Trossachs National Park planning application portal for any active planning applications and review of the relevant Local Plan (Loch Lomond National Park Adopted Local Plan, 2011). There are no areas of development land or active planning applications within the study area, therefore it is not considered further in this assessment.

[28] Loch Lomond and The Trossachs National Park Authority, pers comm, 03.10.12

7.3.4 Potential Environmental Effects

7.3.4.1 Construction

(a) All Corridors

For all corridors, potential adverse effects to community land are anticipated as a result of informal lay-bys along the A83 being subjected to temporary land-take during construction (i.e. use for compounds and storage of materials).

(b) Red and Brown Corridors

For the Red Corridor and Brown Corridor no adverse effects in terms of land-take or access are anticipated on residential land during construction. Additionally, no adverse effects on commercial (agricultural) land are anticipated during construction for these corridors.

(c) Yellow Corridor

For the Yellow Corridor there are no adverse effects in terms of land-take or access anticipated on residential land during construction.

The Yellow Corridor could potentially directly affect land used for grazing by Laigh Glencroe farmstead through land-take during construction (i.e. use for compounds and storage of materials).

The Yellow Corridor could potentially result in adverse effects on The Rest and Be Thankful car park through temporary land-take during construction (i.e. use for compounds and storage of materials).

(d) Blue and Purple Corridors

The residential property of High Glencroe is located within the Blue and Purple corridors. Route options within these corridors have the potential for direct effects i.e. temporary property land-take (e.g. for material storage) or access disruption.

During construction, adverse effects could potentially occur within the commercial forestry under the Blue and Purple Corridors as a result of land-take. The Blue and Purple corridors could potentially directly affect land used for grazing by Laigh Glencroe farmstead through land-take during construction (i.e. use for compounds and storage of materials).

The Blue and Purple corridors could potentially result in adverse effects on The Rest and Be Thankful car park through temporary land-take during construction (i.e. use for compounds and storage of materials). The corridors also pass directly through the FCS plantation forestry; therefore there may be a loss of forestry areas used by the community through land-take during construction (i.e. to accommodate the route options and to use for compounds and/or storage of materials).

(e) Green Corridor

For the Green Corridor scenario no adverse effects in terms of land-take or access are anticipated on residential land during construction.

During construction, adverse effects could potentially occur within the commercial forestry under the Green Corridor as a result of land-take. The Green Corridor could also potentially result in adverse effects on The Rest and Be Thankful car park through temporary land-take during construction (i.e. use for compounds and storage of materials).

The Green Corridor passes directly through the FCS plantation forestry; therefore there may be a loss of forestry areas used by the community through land-take during construction (i.e. to accommodate the route options and to use for compounds and/or storage of materials).

Corridor	Residential	Commercial (Agricultural) Land	Community Land
Red	No significant effects anticipated for construction or operation.	No significant effects expected for construction or operation. No effects on prime agricultural land anticipated.	Construction: - Temporary disruption to informal lay-bys along A83 as a result of construction activities. Operation: - No significant effects anticipated for operation.
Brown	No significant effects anticipated for construction or operation.	No significant effects anticipated for construction or operation. No effects on prime agricultural land anticipated.	Construction: - Temporary disruption to informal lay-bys along A83 as a result of construction activities. Operation: - No significant effects anticipated for operation.
Yellow	No significant effects anticipated for construction or operation.	Construction: - Temporary loss of agricultural land at Laigh Glencroe farmstead. Operation: - Potential permanent loss of agricultural land at Laigh Glencroe farmstead.	Construction: - Temporary disruption to informal lay-bys along A83 as a result of construction activities. - Potential disruption to the Rest and Be Thankful car park. Operation: - No significant effects anticipated for operation.
Green	No significant effects anticipated for construction or operation.	Construction: - Temporary land-take from forestry. Operation: - Potential permanent land-take from forestry.	Construction: - Disruption to informal lay-bys along A83 as a result of construction activities. - Temporary land-take from forestry. - Potential disruption to the Rest and Be Thankful car park as a result of construction activities. Operation: - Potential permanent land-take from forestry.

Corridor	Residential	Commercial (Agricultural) Land	Community Land
Blue	Construction: - Temporary disruption to access and temporary land-take at High Glencroe property. Operation: - Potential permanent land-take at High Glencroe property.	Construction: - Temporary land-take from forestry. - Temporary loss of agricultural land at Laigh Glencroe farmstead. Operation: - Potential permanent loss of agricultural land at Laigh Glencroe farmstead. - Potential permanent land-take in forestry plantation.	Construction: - Potential disruption to informal lay-bys along A83 as a result of construction activities. - Land-take from forestry. - Potential disruption to the Rest and Be Thankful car park through storage of materials and temporary severance. Operation: - Potential permanent land-take from forestry. Potential disruption to the Rest and Be Thankful car park through land-take.
Purple	Construction: - Temporary disruption to access and temporary land-take at High Glencroe property. Operation: - Potential permanent land-take at High Glencroe property.	Construction: - Land-take from forestry. - Temporary loss of agricultural land at Laigh Glencroe farmstead. Operation: - Potential permanent loss of agricultural land at Laigh Glencroe farmstead. - Potential permanent land-take from forestry.	Construction: - Potential disruption to informal lay-bys along A83 as a result of construction activities. - Disruption to rest stops along A83 through storage of materials and realignment work. - Permanent land-take from forestry. - Potential disruption to the Rest and Be Thankful car park through storage of materials and temporary severance. Operation: - Potential permanent land-take from forestry. Potential disruption to the Rest and Be Thankful car park through land-take.

Table 7-2: Summary of Potential Land Use Effects During Construction and Operation

7.3.5 Potential Mitigation

Mitigation for land use cannot be defined at this stage, however, the detailed development of options should aim to minimise the amount of land-take required and where possible return land to its former use post construction. Residential properties are located within the Blue and Purple corridors, and alignment design within either of these corridors should aim to avoid land-take from these residential properties if possible.

7.3.6 Summary of Assessment

From the information available at this stage, it is anticipated that the Red and Brown corridors would result in the lowest overall land use impacts. These options affect the least number of land interests and have fewer directs effects on residential and commercial uses. These would therefore be the preferred corridors in terms of land use, as shown in Table 7-3: below.

Corridor Option	Preferred	Intermediate	Least Preferred
Red	✓		
Brown	✓		
Yellow		✓	
Blue			✓
Purple			✓
Green		✓	

Table 7-3: Environmental Impacts Table – Land Use

7.3.7 Recommendations for Further Work

Should a DMRB Stage 2 assessment be progressed following this study, a more detailed assessment should be undertaken to assess the likely effects of the options on residential, community, development and agricultural land. Should the Red and Brown corridors be taken forward, land use may be scoped out.

7.4 Geology, Land Contamination and Groundwater

7.4.1 Introduction

This section describes the assessment of the effects of the six corridors on geology, land contamination and groundwater.

7.4.2 Approach and Methods

This assessment has been undertaken following DMRB Volume 11 Section 3 Part 11. The study area covers the Glen Croe valley and Loch Restil.

This desk-based assessment has included a review of the following information resources:

- A83 Rest and Be Thankful Landslip Remediation Record of Determination (Transport Scotland, 2009).
- Environment Scotland website: www.environment.scotland.gov.uk (Accessed 08/10/12).
- Hydrogeological Map of Scotland (1988) 1:625,000 (British Geological Survey; BGS). http://www.bgs.ac.uk/geoindex. Accessed 08/10/12.
- River Basin Management Plan Protect Area Information Sheet for 150084 (SEPA, 2010).
- River Basin Management Plan Water Body Information Sheet for Water Body 150084 in Clyde (SEPA, 2010).
- SEPA River Basin Management website: http://gis.sepa.org.uk/rbmp Accessed 08/10/12.
- Solid Sheet 37E Lochgoilhead 1:50,000 (BGS). http://www.bgs.ac.uk/geoindex. Accessed 08/10/12.

7.4.3 Baseline Conditions

(a) Geology

There are no designated geological sites within any of the corridors. A designated Geological Conservation Review Site (designated by the Joint Nature Conservation Committee) is located approximately 2km to the east of the A83, centred on Ben Arthur (The Cobbler).

The Glen Croe valley is underlain by bedrock of the Beinn Bheula Schist formation, metasediments of neoproterozoic age and part of the Southern Highland Group. The Southern Highland Group is described as comprising "*A thick pile of psammitic and pelitic greywackes and associated rocks, some volcanic*" (BGS, 2012). The Beinn Bheula Schist formation can be expected to comprise predominantly hard, fine grained rocks and to have been subject to folding and faulting.

In addition, there is a small area of South of Scotland Granitic Suite rocks beneath and to the east of the A83, immediately north of the Geological Conservation Review Site at Ben Arthur (The Cobbler). These are intrusive igneous rocks of Ludlow to Early Devonian age and predominantly comprise pyroxene-mica diorite, with some tonalite. These can be expected to be hard, fine to medium grained crystalline rocks.

Superficial deposits, where mapped, comprise of glaciogenic till of Quaternary age on the valley sides. In the valley bottom are River Terrace deposits (gravel, sand,

silt and clay) of Quaternary age, along with more recent Alluvium (clay, silt, sand and gravel).

(b) Land Contamination

It is not anticipated that there are any areas of contamination due to the rural nature of the area. In addition, no areas of contaminated land were highlighted during the consultation process. Contaminated land is therefore scoped out of this assessment.

(c) Groundwater

The Hydrogeological Map of Scotland (BGS, 1988) classifies the area underlying the site as "*Precambrian concealed aquifers of limited potential*", underlain by "*impermeable rocks, generally without groundwater except at shallow depth*". In addition, the map notes this area to be underlain with "*crystalline basement which offers little potential for groundwater storage and transport other than in cracks and joints which may be associated with tectonic features or near surface weathering. Groundwaters emanating from springs are generally weakly mineralised, although bicarbonate concentrations may attain 120 mg/l*".

Groundwater vulnerability mapping for Scotland (BGS, 2011) identifies the area as falling into vulnerability classes 5 ('Vulnerable to most pollutants with rapid impact in many scenarios') and 4a ('Vulnerable to those pollutants not readily absorbed or transformed'), indicating that the aquifer is vulnerable to individual pollution events, with rapid transmission of impacts (note that this is large scale mapping and not site-specific).

A review of data available on the SEPA website indicates that the groundwater in the Glen Croe valley falls within the Loch Fyne and Loch Long Drinking Water Protection Zone. The groundwater chemistry classification is "Good" for quantity and quality, with no identified pressures. The Drinking Water Protection Area status is recorded as "Pass". Two private properties (High Glencroe and the property to the south of Laigh Glencroe) are located within the valley and may be fed by private groundwater supply. Confirmation should be obtained as part of the next phase of assessment.

The BGS website does not hold any records of water wells in the study area.

7.4.4 Potential Environmental Effects

Potential effects that are generic to each of the corridors are listed below, followed by an analysis of potential effects on groundwater, specific to each of the corridors during both the construction and operational phases. At this stage, the extent of intrusive works is not known, therefore a worst-case scenario in terms of effects is presented below.

Lowering of the groundwater table (over the longer term operational phase as well as temporary dewatering during construction) may impact locally on groundwater flow, any private water supply yields and adjacent surface water features fed by groundwater base flow. The Croe Water is subject to abstraction pressures (refer to Section 7.5 (Water Environment)) and therefore may be locally affected by a reduction in groundwater baseflow.

Groundwater is locally identified as vulnerable to pollution, with potentially rapid transmission of pollutants to the bedrock aquifer. Groundwater could potentially be affected both during construction and through uncontrolled run-off from the road during operation.

If it is confirmed that the two residential properties are fed by a groundwater abstraction source, there is potential for effects on water quality and/or yield.

7.4.4.1 Construction

In the absence of mitigation, the following potential effects are common to all corridors during construction:

- There is the potential risk of contamination from any spillage or leakage of fuel or oil from storage tanks or construction plant. Without suitable mitigation to prevent or contain such spillages pollutants can enter and contaminate aquifers in the area with severe consequences.
- There is the potential risk that contaminants from any spillage or leakage as described above could impact on the groundwater quality of any private water supplies. Any effects on groundwater levels may also affect the yield of any private water supplies.
- Should any cuttings be required, there is potential for groundwater to be intercepted.

For the Yellow corridor there is the potential risk of leaching and migration of contaminants during construction of the viaduct piles through artificial channels.

7.4.4.2 Operation

(a) Red and Brown Corridors

Given that these corridors would involve the upgrading of the existing A83, no operational adverse effects on geology or groundwater are anticipated.

(b) Yellow Corridor

As this corridor is likely to be built on a viaduct, no operational adverse effects on geology or groundwater are anticipated.

(c) Blue Corridor

As this corridor sits within the valley, no areas of cutting are likely to be proposed, therefore no operational adverse effects on geology or groundwater levels are anticipated.

Runoff from the road surface may contain elevated concentrations of pollutants such as oils, suspended solids, metals (e.g. copper and zinc) and, in winter, salt and engine coolants (e.g. ethylene glycol) (low magnitude). However, this would also be the case for the existing A83, and drainage design measures for the new scheme could be implemented.

(d) Purple Corridor

There is a potential long term effect on local groundwater patterns and private water supplies as a result of the tunnel section.

Runoff from the road surface may contain elevated concentrations of pollutants such as oils, suspended solids, metals (e.g. copper and zinc) and, in winter, salt and engine coolants (e.g. ethylene glycol) (low magnitude). However, this would also be the case for the existing A83, and drainage design measures for the new scheme could be implemented.

(e) Green Corridor

Should any road cuttings be required, there is potential for operational adverse effects on local groundwater and private water supplies.

Runoff from the road surface may contain elevated concentrations of pollutants such as oils, suspended solids, metals (e.g. copper and zinc) and, in winter, salt and engine coolants (e.g. ethylene glycol) (low magnitude). However, this would also be the case for the existing A83, and drainage design measures for the new scheme could be implemented.

7.4.5 Potential Mitigation

(a) Construction

Examples of site procedures and mitigation measures which are likely to be required are listed below, taking into account standard appropriate industry practice, legislation and guidance:

- Groundwater monitoring to compare with background groundwater characteristics.
- Providing a suitable alternative water source for any affected private water supplies.

Examples of relevant guidance documents include:

- The Water Environment (Controlled Activities) (Scotland) Regulations 2005 – A Practical Guide (SEPA, 2008);
- SEPA (2003). Groundwater Protection Policy for Scotland. Environmental Policy No. 19; and
- Pollution Prevention Guidelines (PPGs) produced by the Environment Agency, Northern Ireland Environment Agency and SEPA. (http://www.netregs.org.uk/library_of_topics/pollution_prevention_guides/construction_ppgs.aspx).

Consultation should be undertaken with landowners prior to construction to confirm the presence of any private water supplies. Should any private water supplies be affected by the works, damaged well/reservoir structures would be replaced or a connection to the mains provided.

(b) Operation

Mitigation measures during operation may include the lining of the road drainage features where sensitive receptors are nearby, to prevent accidental spillages and/or contaminated runoff from the road surface migrating to the unsaturated zone and reaching the groundwater.

7.4.6 Summary of Assessment

Potential impacts are similar across most of the corridors, with the exception of the Purple corridor, where potential effects on groundwater receptors are anticipated as a result of the required tunnelling works.

Corridor Option	Preferred	Intermediate	Least Preferred
Red	✓		
Brown	✓		
Yellow		✓	
Blue	✓		
Purple			✓
Green		✓	

Table 7-4: Environmental Impacts Table – Geology, Contaminated Land and Groundwater

7.4.7 Recommendations for Further Work

Should a DMRB Stage 2 assessment be progressed following this study, it is recommended that the presence of any private water supplies or areas of land contamination is confirmed.

7.5 Water Environment

7.5.1 Introduction

This section assesses the potential effects on the water environment, taking into account water quality and hydrology / flooding.

7.5.2 Approach and Methods

This assessment has been undertaken following the principles within DMRB Volume 11 Section 3 Part 10. At this stage it is considered appropriate to undertake a 'scoping' exercise to identify if any of the corridors have the potential to result in adverse effects on the surface water environment and to assess what further assessment may be required. The study area includes surface water features which fall within the corridors boundaries and those that are located downstream of the corridors, to take into account any potential downstream effects.

Baseline conditions and identification of potential effects were identified through a qualitative, desk-based assessment. Data were collated from the following sources:

- Ordnance Survey OS Explorer 364 (OS Explorer, 2010);
- SEPA River Basin Management Plan (RBMP) Interactive Map (SEPA, 2011a);
- SEPA Shellfish Datasheet (SEPA, 2011b); and
- SEPA Indicative River and Coastal Flood Map (SEPA, 2010).

SEPA reports baseline conditions for waterbodies following a risk-based classification system, in line with the 2000/60/EC Water Framework Directive (WFD). This assessment is based on the WFD ecological classification system, which includes five quality classes/status ('high', 'good', 'moderate', 'poor' and 'bad'). The sensitivity of the waterbodies identified has been assessed based on SEPA's classification system where this information is available. Where monitoring data is not available, the water quality condition and sensitivity of the waterbody has been inferred from surrounding land use and potential anthropogenic pressures, for example diffuse chemical pollution associated with agricultural runoff.

The objective of the 2000/60/EC is for all waterbodies to achieve or maintain an overall status of 'Good' by 2015 or over agreed timescales. Where a waterbody currently falls short, SEPA has identified the main pressures and sets environmental objectives in order that sustainable improvements to a waterbody's status can be made over time, or alternatively that no deterioration in status occurs. Artificial or highly modified waterbodies have different criteria to meet.

SEPA's Indicative River and Coastal Flood Map identifies areas at risk of flooding from rivers and the sea during a 0.5% Annual Exceedance Probability (AEP) (1 in 200 year return period) or greater flood event.

Assessment of groundwater and ecological receptors is reported in Sections 7.4 and 7.6 respectively. These are intrinsically linked to surface water receptors.

7.5.3 Baseline Conditions

Watercourses and waterbodies within the study area are shown on Drawings B1557610/WP03/001-003.

SEPA was consulted as part of the baseline gathering exercise and provided information on water quality and abstraction licenses.

7.5.3.1 Watercourses

The main hydrological feature in the Glen Croe valley is the Croe Water and its numerous tributaries. The headwaters of the Croe Water are located at the north-west extent of the valley on the slopes of Beinn an Lochain and at Loch Restil (approximate NGR NN 2290 0750). The Croe Water is fed by a number of un-named tributaries originating from higher ground. The watercourse travels along the base of the valley in a south-east direction and flows for approximately 7.7km before discharging into Loch Long at Ardgartan (approximate NGR NN 2750 0280). The Croe Water forms part of the Cowal / Clyde Sealochs Coastal catchment.

Coire Croe Burn is one of the larger tributaries of the Croe Water, which flows in a south-west direction, passing under the A83 via a bridge and the Old Military Road, via a culvert before meeting the Croe Water to the north of Laigh Glencroe. Refer to Table 7-5: below for information on the water quality and hydrological baseline conditions of these watercourses.

7.5.3.2 Waterbodies

Loch Restil is located to the north of the Croe Water and is located within the Beinn an Lochain Site of Special Scientific Interest (SSSI) boundary. The outfall from Loch Restil flows north to the Kinglas Water down Glen Kinglas and into Loch Fyne. The waterbody is not classified under the SEPA system although the Kinglas Water is and has Bad ecological potential (SEPA, 2010b). No flooding is anticipated at Loch Restil in the vicinity of the corridors.

Loch Restil is therefore considered to be of low sensitivity for hydrology/flood risk and high sensitivity for water quality.

Loch Long (North) has an area of approximately 10.15km^2 and a catchment of 166km^2. In 2008, Loch Long achieved an overall status of 'Good'. No pressures are known to exist on this waterbody, and as a result, it is anticipated to maintain overall 'Good' status up until 2027, thereby meeting the requirements of the 2000/60/EC WFD (SEPA, 2011a). However, Loch Long receives a licensed point source discharge from a septic tank at the Ardgartan Youth Hostel in the vicinity of the outfall from the Croe Water (NGR NN 2720 0280) (consent no. WPC/W/11246 – CD11044) (SEPA, 2011b).

Loch Long is also designated as a protected Shellfish Water. The loch has consistently failed to comply with the guideline standard for faecal coliforms between 1999 and 2010. Measures were identified to improve this situation, including the upgrade of Ardenfield septic tank and the installation of Carrick Castle Sewerage Scheme to replace the various septic tanks in the area, as part of Scottish Water's Q&SII improvements programme. As a result, the waterbody has been set the target of achieving a status of 'Pass' by 2027 in respect of the Guideline Shellfish Growing Water Standards, and thereby meeting the requirements of the 2000/60/EC WFD (SEPA, 2011b). No flooding is anticipated at Loch Long in the vicinity of the corridors (SEPA, 2010). Overall, Loch Long is therefore considered to be of low sensitivity for hydrology/flood risk and high sensitivity for water quality.

Refer to Section 7.6 for further information on ecological designations in the vicinity of the corridors.

7.5.3.3 Drainage

At this stage it is understood that there is no formal road drainage treatment system (e.g. filter drains) along the existing road network within the location of the corridors. Untreated runoff is currently considered to be drained from roads through a combination of kerbs and gullies, which is then routed to the Croe Water. There are a number of culverts under the A83 road, which convey the un-named tributaries from the eastern slopes of the valley to the Croe Water.

Table 7-5: below describes the baseline conditions for the two main watercourses that are located within or in close vicinity to each of the corridors, as shown on Drawings B1557610/WP03/001-003, and identifies the sensitivity of these watercourses based on SEPA and DMRB guidance.

Water Feature	SEPA Class	Baseline Description	Overall Sensitivity
Croe Water	Overall status: Bad (2008) Ecological status: Bad Chemical status: Pass	Main watercourse in study area. Hydrology / Flood Risk Localised inundation of the floodplain and encroachment onto the A83 road downstream of the confluence with the Coire Croe Burn (SEPA, 2010). Water Quality Anthropogenic pressures include abstractions for renewable electricity, which results in a change from natural flow conditions. With measures identified by SEPA to control these abstractions, the Croe Water has been set the target of achieving over 'Good' status by 2027 (SEPA, 2011a).	Medium
Coire Croe Burn (tributary of Croe Water)	Not monitored by SEPA	Hydrology / Flood Risk Localised inundation of the floodplain upstream and downstream of the A83 crossing, and encroachment onto the A83 road in this location (SEPA, 2010). Water Quality Small watercourse with headwaters at Coire Croe summit. This tributary is not monitored by SEPA, however it is considered likely to be affected by anthropogenic pressures from abstractions for local renewable energy plants (at time of writing awaiting SEPA to provide information on abstraction licenses in the area). Due to its upland catchment location, the water quality of the tributary is considered to be of good quality. Information obtained through consultation with SEPA suggests that the water quality is of better status than that of the Croe Water.	High

Table 7-5: Baseline Water Features

7.5.3.4 Future Baseline Conditions

As explained in Section 4.2, works are currently underway in the Glen Croe valley to provide additional landside protection to the existing A83 and to enable use of the Old Military Road as an Emergency Diversion Route during any A83 road closures (referred to as the 'Do Minimum' scenario).

Drainage along the Old Military Road, which runs along the bottom of the valley, is currently being upgraded through the replacement of culverts and bridges as part of the improvement works being undertaken by TranServ. These works are anticipated to be complete prior to construction of works on any of the A83 corridor options considered in this Stage 1 report and are therefore considered to be part of the baseline conditions.

7.5.4 Potential Environmental Effects

Construction effects on the surface water environment are often of short-term duration, although in some cases these can have longer term indirect effects on dependent freshwater habitats. Effects are likely to be more intense during construction compared to the long-term operational phase, due to the higher concentration of activities occurring in, or in the vicinity of, surface waters, and the increased potential for pollution and accidental risk of spillages during this period.

Adverse effects on the water environment during the operational phase as a result of each of the corridors may result from various features including road drainage, watercourse crossings and channel realignments, as well as alterations to the floodplain and natural drainage pathways. The text below describes the potential effects to the surface water environment during both the construction and operational phases associated with each corridor. Refer to Sections 7.4 and 7.6 for an assessment of potential effects on groundwater and ecological receptors, respectively.

Effects are anticipated to be of negligible significance on Loch Long as this waterbody is located several kilometres downstream from the nearest corridor. Any increases in pollutants or suspended solids entering the Croe Water or its tributaries, particularly during the construction phase, are anticipated to be significantly diluted and dispersed prior to discharging into Loch Long. No effects are anticipated on Loch Restil as the watercourses potentially affected by the corridors are not hydrologically connected to Loch Restil, with the exception of the Purple corridor. Refer to Section 7.5.4(a)(iii) for potential impacts on waterbodies associated with the Purple Corridor.

7.5.4.1 Construction

(a) All Corridors

In the absence of mitigation, the following potential effects could occur during construction within any of the corridors:

- Earthworks associated with construction activities could potentially result in the release of suspended solids and pollutants, as well as the accidental spillage of fuels, chemicals and unset cement into at least eleven tributaries of the Croe Water.

- There may be requirements for temporary diversion or re-direction of existing flows of the tributaries of the Croe Water, including the Coire Croe Burn, as a result of any new crossings.

(b) Yellow Corridor

Progression of a scheme within the Yellow corridor would include a viaduct. In-channel works associated with culverting are unlikely to be required and effects would likely be limited to accidental spillage of pollutants associated with the viaduct construction.

(c) Purple Corridor

For the Purple corridor, construction activities in the vicinity of Loch Restil could result in the release of suspended solids and pollutants into the loch, potentially affecting populations of brown trout due to smothering of habitat and interfering with breathing and respiratory processes, and downstream tributaries ultimately entering the Kinglas Water (to the north of the study area).

7.5.4.2 Operation

(a) Red and Brown Corridors

Any increase in hardstanding within the catchment would increase the rate and volume of runoff reaching the Croe Water and its tributaries, therefore increasing potential flood risk. However, this risk is considered to be of negligible significance due to the limited floodplain and, apart from the A83 road, the lack of development and critical infrastructure within this upland catchment.

Culvert extensions under the A83 road could result in a change to the natural sediment processes within the watercourses. Under normal flows, sediment could accumulate within the culvert particularly where the culvert has a low gradient and/or a greater width than the natural channel. This is likely to reduce velocities leading to sediment deposition within the culvert, potentially reducing the conveyance capacity of the culvert. This may increase both flood risk and lead to sediment starvation downstream. Where culverting increases channel gradient, scour of the bed and banks at culvert outlets often occurs leading to an increase in the supply of sediment to the downstream reaches of the watercourse. Culverts can also reduce the morphological diversity of the channel due to the creation of artificial bed and banks. As culvert extensions are anticipated to be relatively short in length, these effects are considered to be slight.

Any channel straightening or changes in the vertical alignment (lengthening or shortening) as a result of realignment, to facilitate culvert construction, would result in a change in flow velocity and lead to increased erosion or sedimentation downstream. As any realignment associated with the culvert extensions are anticipated to be relatively short in length, these effects are considered to be slight.

The drainage design for the Brown corridor is still to be confirmed. However at present, for both the Red and Brown corridors, potential road drainage discharge could lead to increased siltation and turbidity in the water column, as well as indirect effects on freshwater habitats, such as smothering of the channel bed. It could also lead to decreased water quality resulting from an increase in sediment load and soluble and insoluble pollution within routine runoff and accidental spillages from vehicles.

However, there may be an opportunity to improve the road drainage quality and conveyance from the existing A83, through the use of Sustainable Drainage Systems (SUDS). This could lead to an improvement in the water quality of the Croe Water and any tributaries currently receiving untreated road drainage.

(b) Yellow Corridor

Potential road drainage discharge from the new road could lead to increased siltation and turbidity in the water column, as well as indirect effects on freshwater habitats, such as smothering of the channel bed. It could also lead to decreased water quality resulting from an increase in sediment load and soluble and insoluble pollution within routine runoff and accidental spillages from vehicles.

As the proposal for this corridor is likely to be a viaduct structure, no long-term flood risk is considered likely to occur as there would be minimal in hardstanding within the catchment (potentially only the viaduct approaches and associated columns) and the flow conveyance would be maintained within the tributaries beneath the viaduct.

(c) Blue, Green and Purple Corridors

Increased hardstanding within the catchment would increase the rate and volume of runoff reaching the Croe Water, its tributaries and Loch Restil, therefore increasing potential flood risk. However, due to the limited floodplain and lack of development and critical infrastructure in this upland catchment (limited to the A83 road), this effect is considered to be of slight significance for the blue, green and purple corridors.

The proposed culverts under the new road could result in a change to the natural sediment processes within the watercourses. Under normal flows, sediment could accumulate within the culvert particularly where the culvert has a low gradient and/or a greater width than the natural channel. This is likely to reduce stream powers leading to sediment deposition within the culvert, potentially reducing the conveyance capacity of the culvert. This may increase both flood risk and lead to sediment starvation downstream. Where culverting increases channel gradient, scour of the bed and banks at culvert outlets often occurs leading to an increase in the supply of sediment to the downstream reaches of the watercourse. Culverts can also reduce the morphological diversity of the channel due to the creation of artificial bed and banks. Long culverts could also result in oxygen sags caused by the lack of light, which restricts aquatic plant photosynthesis, and rapid microbiological degradation of biodegradable matter. Any reduction in surface area through culverts could also reduce the atmospheric oxygenation of the water.

Any channel straightening or changes in the vertical alignment (lengthening or shortening) as a result of realignment, to facilitate culvert construction, could result in a change in flow velocity and lead to increased erosion or sedimentation downstream.

Potential road drainage discharge from the new roads and tunnel (Purple Corridor) could lead to increased siltation and turbidity in the water column, as well as indirect effects on freshwater habitats, such as smothering of the channel bed and interference with breathing and respiratory processes. It could also lead to decreased water quality resulting from an increase in sediment load and soluble and insoluble pollution within routine runoff and accidental spillages from vehicles.

In addition, any forestry felling associated with the Green corridor could have an adverse effect on hydrology and water quality due to an increase in peak flows and volume reaching the watercourses and increased nutrient / sediment release due to erosion during rainfall events.

7.5.5 Potential Mitigation

(a) Construction

The key mitigation strategies that should be considered for implementation during construction would be aimed at avoiding pollution release to the watercourses identified and minimising the risk of occurrence. The primary mechanism for this will be through best practice on site and implementation of DMRB requirements as well as all the relevant Pollution Prevention Guidelines (PPGs) published by SEPA and Construction Industry Research and Information Association (CIRIA) guidance.

(b) Operation

The key mitigation strategies that should be considered for implementation during operation include a drainage design in accordance with 'The SUDS Manual' CIRIA C697 (CIRIA, 2007), culvert design following guidance given in the Culvert Design and Operation C689 (CIRIA, 2010) and consideration should be given to measures to avoid the potential effects on flooding. A regular maintenance regime should be implemented, including the regular clearance of culverts and road drainage facilities, to improve the conveyance of flow and prevent an increase in flood risk in or in the vicinity of the corridors.

7.5.6 Summary of Assessment

During construction, potential effects across the corridors would be of a similar nature, however, implementation of best practice measures as referred to above is likely to reduce construction effects. The Red, Brown and Yellow corridors are more preferable due to either online upgrade or the limited works within the floodplain. The Purple corridor is least preferred due to the largest extent of construction footprint and potential number of waterbodies affected.

During operation, the Yellow corridor is preferable in terms of the water environment as flow conveyance would be maintained within the tributaries beneath the viaduct. The Blue, Purple and Green corridors are least preferable due to the effects associated with an increase in hardstanding, the relatively high number of watercourse modifications and requirements for new road drainage over a large scheme area. The Green corridor also has adverse effects associated with forestry removal.

Overall during both construction and operation, the Yellow corridor is the preferred corridor and the Purple, Green and Blue corridors are the least preferred corridors in terms of the surface water environment.

Corridor Option	Preferred	Intermediate	Least Preferred
Red		✓	
Brown		✓	
Yellow	✓		
Blue			✓
Purple			✓
Green			✓

Table 7-6: Environmental Effects Table – Water Environment

7.5.7 Recommendations for Further Work

It is recommended that a simple assessment is undertaken for any of the corridors taken forward to be assessed at DMRB Stage 2 level should this be progressed following this study.

7.6 Ecology and Nature Conservation

7.6.1 Introduction

This section describes the assessment of the effects of the six corridors on ecology and nature conservation. A desk study has been undertaken to identify the presence and status of ecological habitats, flora and fauna of conservation value. In addition, the value of the nature conservation features (ecological receptors) has been identified and potential effects and approaches to mitigation assessed.

7.6.2 Approach and Methods

7.6.2.1 Overview of Approach

The assessment has been undertaken in accordance with the requirements of DMRB Volume 11, Section 3, Part 4 and best practice guidance for ecological assessment including the Guidelines for Ecological Impact Assessment in the United Kingdom (IEEM, 2006).

A study area of 500m was established around the corridors (up to 2km for statutory designations) to ensure that adequate coverage would be available to inform the assessment of the emerging route options. The level of data available for the study area varies between nature conservation features. A lack of information does not confirm absence of a feature and may instead reflect lack of available data.

7.6.2.2 Legislation

This assessment has been undertaken giving full consideration to relevant European and national legislation/regulations, in particular:

- Conservation of Natural Habitats and Wild Flora and Fauna (the Habitats Directive, 1992) (92/43/3EEC) (as amended).
- Conservation of Wild Birds (the Birds Directive, 1979) (79/409/EEC).
- Conservation (Natural Habitats, &c.) Regulations 1994 (as amended) (Habitats Regulations).
- Wildlife and Countryside Act 1981 (as amended) (WCA).
- Nature Conservation (Scotland) Act (NCSA) 2004.
- Wildlife and Natural Environment (Scotland) Act 2011 (WANE).
- Environmental Protection Act (1990).
- The UK Biodiversity Action Plan (UK BAP) and Local Biodiversity Action Plans (LBAPs).

Comprehensive information in respect of the conservation and legislative status of ecological features is presented in Appendix D1.

7.6.2.3 Desk Study

A desk study was undertaken to identify any statutory and non-statutory designated sites of nature conservation interest and to obtain information on the occurrence of protected species and/or species of nature conservation interest. In addition, information on the quality of watercourses (as classified by SEPA) within the study area was collated.

The desk study comprised review of literature and web-based resources and consultation, as described below.

(a) Consultation

The following organisations were consulted with to provide information on the distribution and status of species and habitats within the study area:

- Argyll and Bute Council.
- Argyll District Salmon Fishery Board.
- BTO.
- FCS.
- Loch Lomond & The Trossachs National Park.
- RSPB.
- Scottish Badgers.
- SNH.
- SEPA.

(b) Web Resources

The following resources were reviewed (see references section for website addresses):

- The National Biodiversity Network (NBN) gateway website;
- The Multi-Agency Geographical Information for the Countryside website;
- Forestry Commission Scotland Map Viewer;
- Joint Nature Conservation Committee (JNCC) website ;
- Scottish Environment Protection Agency (SEPA) River Basin Management Plans Interactive Map;
- Scottish Natural Heritage (SNH) Information Service; and
- UK Biodiversity Action Plan (UK BAP) website.

Aerial photographs (taken in 2012 and provided by Transport Scotland) and Ordnance Survey maps were also studied to identify potential habitat areas of nature conservation importance within the study area.

7.6.2.4 Evaluation of Nature Conservation Features

The evaluation (or assessment of value/importance) of nature conservation features (ecological receptors) was undertaken taking into consideration of professional judgement and advice provided by the DMRB Interim Advice Note 130/10 'Ecology and Nature Conservation: Criteria for Impact Assessment' (Highways Agency et al., 2010) and taking cognisance of guidance published by the Institute of Ecology and Environmental Management (IEEM, 2006). The separate criteria to assess the value of nature conservation features are set out in Table 7-7:.

Ecological Importance	Criteria
International or European Value	Natura 2000 sites including: Sites of Community Importance (SCIs); Special Protection Areas (SPAs); potential SPAs (pSPAs); Special Areas of Conservation (SACs); candidate or possible SACs (cSACs or pSACs[29]); and Wetlands of International Importance (Ramsar sites). Biogenetic Reserves, World Heritage Sites and Biosphere Reserves. Areas which meet the published selection criteria for those sites listed above but which are not themselves designated as such. Resident, or regularly occurring, populations of species which may be considered at an International or European level where: the loss of these populations would adversely affect the conservation status or distribution of the species at this geographic scale; or the population forms a critical part of a wider population at this scale; or the species is at a critical phase[s] of its life cycle at this scale.
UK or National Value	Designated sites including: Sites of Special Scientific Interest (SSSIs) and National Nature Reserves (NNRs). Areas which meet the published selection criteria e.g. JNCC (1998) for those sites listed above but which are not themselves designated as such. Areas of key/priority habitats identified in the UK Biodiversity Action Plan (BAP), including those published in accordance with Section 41 of the Natural Environment and Rural Communities Act (2006) and those considered to be of principal importance for the conservation of biodiversity. Areas of Ancient Woodland e.g. woodland listed within the Ancient Woodland Inventory (AWI). Resident, or regularly occurring, populations of species which may be considered at an International, European, UK or National level where: the loss of these populations would adversely affect the conservation status or distribution of the species at this scale; or the population forms a critical part of a wider population at this scale; or the species is at a critical phase of its life cycle at this scale.
Regional Value	Areas of key/priority habitats identified in the Regional BAP (where available); areas of key/priority habitat identified as being of Regional value in the appropriate Natural Area Profile (or equivalent); areas that have been identified by regional plans or strategies as areas for restoration or re-creation of priority habitats (for example, South West Nature Map); and areas of key/priority habitat listed within the Highways Agency's BAP. Resident, or regularly occurring, populations of species which may be considered at an International, European, UK or National level and key/priority species listed within the HABAP where: the loss of these populations would adversely affect the conservation status or distribution of the species at this scale; or the population forms a critical part of a wider population; or the species is at a critical phase of its life cycle.
County or Unitary Authority Area Value (Loch Lomond and Trossachs National Park)	Designated sites including: Sites of Nature Conservation Importance (SNCIs); County Wildlife Sites (CWSs); and Local Nature Reserves (LNRs) designated in the county or unitary authority area context. Areas which meet the published selection criteria for those sites listed above but which are not themselves designated as such. Areas of key/priority habitats identified in the Local BAP; and areas of habitat identified in the appropriate Natural Area Profile (or equivalent). Resident, or regularly occurring, populations of species which may be considered at an International, European, UK or National level where: the loss of these populations would adversely affect the conservation status or distribution of the species across the County or Unitary Authority Area; or the population forms a critical part of a wider population; or the species is at a critical phase of its life cycle.

[29] pSACs are sites which have been formally advised to UK Government but have not yet been submitted to the European Commission. These sites are valued at a European level on the basis that they meet the relevant selection criteria for a SAC but are not yet designated as such.

Ecological Importance	Criteria
Local Value	Designated sites including: Local Nature Reserves (LNRs) designated in the local context. Trees that are protected by Tree Preservation Orders (TPOs). Areas of habitat; or populations/communities of species considered to appreciably enrich the habitat resource within the local context (such as veteran trees), including features of value for migration, dispersal or genetic exchange.

Table 7-7: Ecological Feature Evaluation

7.6.3 Baseline Conditions

This section provides a description of the baseline conditions over the area which could be affected by any of the six corridors.

7.6.3.1 Statutory Designated Sites

One statutorily designated site lies within the study area; Beinn an Lochain Site of Special Scientific Interest (SSSI) is located at the northern end of Glen Croe (Drawing Number B1557610/WP03/001 – 003). This 1,369 ha site is designated due to the presence of upland habitats: siliceous scree (includes boulder fields), tall herb ledge and upland assemblage vegetation. The site supports an extensive boulder field, which represents one of the best examples of this habitat type in the district (SNH, 2011). The SSSI also provides one of the best representations of upland habitats in Scotland, comprising acid grassland; alpine summit communities; blanket bog; calcareous grassland; mire grassland and rush pasture; subalpine dry dwarf-shrub heath; spring-head; rill and flush. Important National Vegetation Classification (NVC) community types on the site include CG10, CG11, U10, U16, U17, U19, M6, M11 and M23 (W A Fairhurst & Partners, 1999). For further details of NVC communities, see Appendix D2.

The Glen Etive and Glen Fyne Special Protection Area (SPA), is located approximately 970m to the north of the study area. This 81,372 ha site qualifies by regularly supporting a population of Annex 1 species, golden eagle (*Aquila chrysaetos*) (19 active territories in 2003, more than 4.2% of the GB population) (SNH, 2010).

7.6.3.2 Non-statutory Designated Sites

(a) Locally Designated Sites

No locally designated sites of interest for nature conservation or woodlands listed on the AWI (SNH, 2008) are located within the study area.

7.6.3.3 Biodiversity Action Plan

The study area lies within the Loch Lomond and the Trossachs National Park and is covered by a National Park Biodiversity Action Plan (NPBAP) (Loch Lomond & The Trossachs National Park Authority, 2009). The focus of the NPBAP is a Habitats and Species Enhancement Programme which consists of a series of short work programmes designed to focus on habitats and species where there was an immediate need for work. A shortlist of 28 habitats and 38 species was produced (Appendix D3) and work programmes were developed for six habitat groups and seven species. The six habitat groups are:

- Loch, Rivers & Ponds;
- Coastal & Marine;
- Farmland;
- Woodlands & Forests;
- Moorland & Mountains; and
- Built Environment.

The seven species (in six work programmes) are:

- red squirrel (Sciurus vulgaris);
- water vole (Arvicola terrestris[30]);
- black grouse (Tetrao tetrix);
- capercaillie (Tetrao urogallus);
- powan (Coregonus lavaretus) and the Loch Lomond sub-species of river lamprey (Lampetra fluviatilis); and
- freshwater pearl mussel (Margaritifera margaritifera).

7.6.3.4 Terrestrial Habitats and Plants

(a) Terrestrial Habitats

Aerial photography and OS mapping indicates that the western part of Glen Croe is dominated by coniferous plantation woodland of varying ages. The lower part of the eastern side of the glen is also dominated by this habitat. In some parts, the plantation has been felled including an area to the north-east of Loch Restil.

Along the bottom of the glen, on flatter land around the Croe Water and extending down to Laigh Glencroe, there is evidence of agricultural improvement for grazing pasture. The grasslands appear to vary consisting of areas of marshy grassland (rush dominated) and semi-improved grasslands. Other grassland types may also occur.

The steep rocky slopes of Beinn an Lochain, Beinn Luibhean and The Cobbler (Ben Arthur) are comprised of upland habitats including grassland and bracken. It is likely that other upland habitat types are present including heath, bog and flushes.

(b) Plants of Conservation Interest

There are no records on the National Biodiversity Network (NBN) for the following four species of plant listed on the NPBAP juniper: (*Juniperus communis*), lesser butterfly orchid (*Platanthera bifolia*), Scottish dock, (*Rumex aquaticus*) and marsh club moss (*Lycopodiella inundata*).

(c) Invasive Non-Native Plants

Rhododendron (*Rhododendron ponticum*), an invasive non-native species, has been recorded in the riparian zone of the Croe Water (Argyll Fisheries Trust, 2010). Japanese knotweed (*Fallopia japonica*) and giant hogweed (*Heracleum mantegazzianum*) were not recorded at this time and the NBN does not record their presence within the study area.

[30] The taxonomic convention for water vole has been changed to *Arvicola amphibius* (although this is currently not widely used) as it has been recognised that *A. terrestris* and *A. amphibious* previously categorised as two separate species are actually the same species.

7.6.3.5 Aquatic Habitats

The Croe Water is the main waterbody flowing through the study area. SEPA has classified the waterbody as having an overall status of 'Bad' (in 2008), with overall ecological status of 'Bad' and overall chemical status of 'Pass' (SEPA, 2010a). The complete status for the waterbody in 2008 includes the following parameters and their statuses (Table 7-8:).

Parameter	Status	Confidence of Class
Overall Ecology	Bad	Medium
Biological elements	Good	High
Phytobenthos	High	Low
Macrophytes	High	Low
Benthic invertebrates	Good	High
Alien species	High	Low
Fish	High	Low

Table 7-8: Selected SEPA classification parameters and their statuses for the Croe Water in 2008

The Croe Water has been identified as a salmonid river (Argyll Fisheries Trust, 2010). European eel (*Anguilla anguilla*) and lamprey ammocoetes (*Lampetra* spp.) have also been found in the waterbody. For further details see Section 7.6.3.6. However, previous consultation with the Argyll Fisheries Trust (Transport Scotland, 2012) indicated that there is an obstacle to fish passage below the proposed scheme which was caused historically by rock blasting during construction of the A83 road.

Loch Restil is situated at the top of the Rest and Be Thankful and lies within the Ben an Lochain SSSI. It outflows to the north into the Kinglas Water down Glen Kinglas and into Loch Fyne. The waterbody is not classified under the SEPA system although the Kinglas Water is and has Bad ecological potential (SEPA, 2012b). Online fishing forums indicate that the loch holds brown trout.

7.6.3.6 Protected Species

Records of protected species for which location information is available are shown on Drawing Numbers B1557610/WP3/004 - 006.

(a) Mammals

(a).1 Badger (Meles meles)

Scottish Badgers provided details of two dead badgers recorded on the A83, in 2003 and 2011. Records were also provided for badgers within the surrounding area outwith the study area. No evidence of badger was found during surveys undertaken by Transport Scotland (Transport Scotland, 2012) although SNH indicated that badgers have been recorded within the vicinity of Glen Croe and Gleann Mor woodlands (which lie to the west of the site).

NBN gateway holds two historic records of badger within the NN20 10km grid square; one from 1973 and one more from the 1960 – 1994 data range.

(a).2 Bats

Consultation with Forestry Commission Scotland highlighted the presence of bat species in the Glen Croe area. Bats (species unknown) have been recorded flying in the vicinity using the watercourses and the Old Military Road as flight lines (Transport Scotland, 2012). Bridges/culverts on the A83 near the summit of the road were considered to offer potential for roosting bats although no roosts were found (Highland Ecology and Development Ltd (HED), 2012; Transport Scotland, 2012). Activity surveys indicated that soprano pipistrelle (*Pipistrellus pygmaeus*) bats were active around the bridges and elsewhere in the vicinity. It was suggested in the HED report that a nearby cottage at High Glencroe could support a bat roost.

NBN holds records for common pipistrelle (*P. pipistrellus sensu lato*) within the NN20 10KM grid square with a record from 1971 at Allt Ginne Mhoir approximately 2km to the west of the site. Two records were obtained for soprano pipistrelle within Glen Croe dating from 2006 and 2008.

(a).3 Otter (Luta lutra)

Consultations with SNH and Forestry Commission Scotland both highlighted the presence of otter within the Croe Water and its associated tributaries. Field surveys carried out in 2012 (Scotland TranServ, 2012; Transport Scotland, 2012) identified the presence of two otter holts and one couch along the Croe Water within the southern part of the study area. Evidence of otter activity (spraints and prints) was also recorded elsewhere on the Croe Water.

NBN gateway records show that otter are present throughout the glen with records dating from 1991.

(a).4 Pine marten (Martes martes)

Consultations with SNH and Forestry Commission Scotland both highlighted the presence of pine marten within the Glen Croe and Gleann Mor woodlands. One of the identified otter holts was also found to be utilised by pine marten (Scotland TranServ, 2012; Transport Scotland, 2012) and scat was found on forestry tracks on the western side of Glen Croe.

NBN hold historic records of pine marten within the NN20 10km grid square along with an undated record from Glen Loin located approximately 2.75km to the northeast of the study area at its closest point.

(a).5 Red squirrel

Consultations with SNH, Forestry Commission Scotland and the National Park Authority highlighted the presence of red squirrel within the Glen Croe and Gleann Mor woodlands. The National Park Authority indicated that the glen is subject to monitoring for the incursion of grey squirrels (*Sciurus carolinensis*) and that there are currently 12 feeder boxes and one camera trap in place in Glen Croe within the study area. The current front line between grey and red squirrel populations is at Arrochar and Succoth.

Evidence of squirrel feeding was found during walkover surveys (Scotland TranServ, 2012; Transport Scotland, 2012), although the species was not determined. No dreys were recorded.

NBN gateway records show that red squirrels are present throughout the glen with records dating from July 2012.

(a).6 Water vole

No records of water vole within the study area were obtained through consultations and no evidence of water vole was found during surveys (Scotland TranServ, 2012; Transport Scotland, 2012).

The NBN holds a historical record for the NN20 10km grid square for water vole from 1960 – 1994.

(a).7 Wildcat (Felis sylvestris)

No records of wildcat were noted from consultations, however wildcat has been previously recorded in Argyll during surveys in 1983-87 and in the 1990s (Davis & Gray, 2010). A survey undertaken in 2008 noted probable records in Argyll, including north-east of Loch Long, with possible records to the east of Loch Goil (Davis & Gray, 2010).

NBN holds two records for the NN20 10km grid square dating from 1960-1994 and 1985.

(a).8 Birds

SNH has indicated that black grouse and a number of raptor species have been recorded in the area, including peregrine (*Falco peregrinus*), hen harrier (*Circus cyaneus*), short-eared owl (*Asio flammeus*), merlin (*Falco columbarius*), and golden eagle.

With the exception of merlin, all the bird species listed above had been recorded within the 10km OS grid square within which the study area occurs. In addition, golden eagle was observed in OS grid square NN2409 in 2002 near Beinn Chorranach which is approximately 1km north-east of the study area, outwith the SPA. Capercaillie has also been recorded within NN20 OS grid square.

(b) Amphibians and Reptiles

(b).1 Amphibians

No records of amphibians were obtained from the consultations. NBN holds records of the following:

- common frog (*Rana temporaria*) within the NN20 10km grid square dating from as recently as 2009;
- common toad (*Bufo bufo*) within the NN20 10km grid square and in the north of the study area with the most recent record from 1975-1985; and
- palmate newt (*Lissotriton helveticus*) within the NN20 10km grid square with the most recent record from 1975-1985.

(b).2 Reptiles

No records of amphibians were obtained from the consultations. NBN holds records of the following:

- adder (*Vipera berus*) within the NN20 10km grid square dating from as recently as 1975-1985;

- common lizard (*Zootoca vivipara*) within the NN20 10km grid square with the most recent record from 1975-1985; and
- slow worm (*Anguis fragilis*) within the NN20 10km grid square with the most recent record from 1975-1985.

(b).3 Fish

Consultation with Forestry Commission Scotland highlighted the presence of Atlantic salmon (*Salmo salar*) and sea/brown trout (*Salmo trutta*) within the Croe Water catchment and anecdotal evidence from fishing forums has confirmed this. Salmon and trout fry and parr were found in the Croe Water catchment in 2008-2009 (Argyll Fisheries Trust, 2010). European eel and lamprey ammocoetes were also found. Evidence from fishing forums has indicated that brown trout are also present in Loch Restil.

NBN holds records of the following:

- Atlantic salmon within the NN20 10km grid square dating from 1998;
- brown/sea trout within the Croe Water dating from 1985;
- European eel within the NN20 10km grid square dating from 1986; and
- flounder (Platichthys flesus) within the NN20 10km grid square dating from 1986.

7.6.4 Evaluation of Nature Conservation Features

An evaluation of features comprising designated sites, habitats and species in respect to their nature conservation value is presented in Table 7-9: (sites and habitats) and Table 7-10: (species). Value was assessed using methods detailed in Section 7.6.2.4 above. Where the desk study provided no evidence for the current presence of features these were excluded from the evaluation; this applied to water vole and wildcat.

Information for justification of the ecological value is taken from JNCC accounts for UK BAP list of priority habitats and from the UK BAP priority species list (see references section).

Nature Conservation Feature	Ecological Importance	Justification
Designated Sites		
Beinn an Lochain SSSI	National	Nationally designated site for its biological features which is afforded protection under national legislation. Biological features: siliceous scree (includes boulder fields); tall herb ledge and upland assemblage.
Terrestrial Habitats		
Woodland, coniferous plantation	Local	Large areas occur within the study area. The woodland provides important habitat for red squirrel and pine marten.
Grassland, agriculturally improved	Local	Large areas occur within the study area along the valley floor of Glen Croe. It may be utilised for foraging by animals such as raptors.
Upland habitats	Authority	Habitats such as upland heathland, blanket bog, and flushes National priority habitats in the UK BAP and are NPBAP short-listed habitats. However, the extent, composition and quality of these habitats within the study area is unknown.

Nature Conservation Feature	Ecological Importance	Justification
Aquatic Habitats		
Waterbodies, Croe Water	Authority	Rivers are a national priority habitat in the UK BAP and are a short-listed habitat on the NPBAP. It is a salmonid river but may have barriers to migratory species. SEPA has classed the river as having an overall status of 'Bad'. The river is important for otter in respect of commuting and resting, and water features in the area are utilised by bats.
Waterbodies, Loch Restil	Authority	Certain types of lakes are a national priority habitat in the UK BAP which may include Loch Restil. Lakes and standing open waters are NPBAP short-listed habitats. The loch contains brown trout.

Table 7-9: Ecological Importance of Nature Conservation Features (Sites and Habitats) Identified in the Study Area

Nature Conservation Feature	Ecological Importance	Justification
Mammal Species		
Badger	Authority	Badgers are protected under the PBA, the NCSA and the WANE.
Bats	Authority	Soprano pipistrelle and brown long-eared (*Plecotus auritus*) bats are national priority species in the UK and are NPBAP short-listed species. Bats are protected under the Habitats Regulations and the NCSA.
Otter	National	National priority species and NPBAP short-listed species. Historic persecution has led to numbers or range having declined over 50%. Otters are protected under the Habitat Regulations and the NCSA.
Pine marten	National	National priority species. There is a threat to the species from habitat loss, fragmentation and loss of den sites. Numbers and range have declined over 50% of 'natural range' and there are problems from continued persecution and secondary rodenticide. The Scottish range may be expanding slowly. Pine martens are protected under the Habitats Regulations and the WCA.
Red squirrel	National	National priority species and NPBAP short-listed species. The species is vulnerable to grey squirrel invasion and squirrel pox virus epidemics. Red squirrels are protected under the WCA and NCSA.
Fish Species		
European eel	Authority	National priority species. Evidence of species decline although little evidence exists of a reduction in geographical range. 65% decline over 25 years in number of 10 km squares or number of waterbodies known to host this species.
Lamprey	Authority	National priority species river lamprey (*Lampetra fluviatilis*) and sea lamprey (*Petromyzon marinus*) are National priority species in the UK and NPBAP short-listed species. There have been long-term declines in the river and sea lamprey. River, brook (*Lampetra planeri*) and sea lamprey are all are listed in Annex II of the EC Habitats Directive and are protected under the Habitats Regulations. Further to this river lamprey are listed on Annex V of the EC Habitats Directive.
Salmon	Authority	National priority species and NPBAP short-listed species. Considered to be vulnerable, endangered, threatened or extinct in sixteen European countries. Significant declines observed in Pre-Fishery-Abundance (PFA) estimates in UK over the last 25 years – most notably within the multi-sea-winter component. 44% decline in Great Britain which is an international stronghold for this species. Salmon is listed in Annex II of the EC Habitats Directive and are protected under the Habitats Regulations and the Salmon and Freshwater Fisheries Act.
Sea/brown trout	Authority	National priority species and NPBAP short-listed species. The species is threatened in some areas of the UK, particularly north-west Scotland. Ancestral trout populations are under threat from habitat deterioration and stocking.

Table 7-10: Ecological Importance of Nature Conservation Features (Species) identified in the Study Area

7.6.4.1 Future Baseline Conditions

As explained in Section 4.2, works are currently underway in the Glen Croe valley to provide additional landside protection to the existing A83 and to enable use of the Old Military Road as an Emergency Diversion Route during any A83 road closures (referred to as the 'Do Minimum' scenario).

Under the Do Minimum scenario, debris flow events may continue which would result in habitat loss of upland and grassland habitats. However, in the long-term these areas provide opportunities for colonisation by plant species of low fertility/thin soil habitats such as the vegetation types for which the Beinn an Lochain SSSI is designated.

There is the potential for road run-off to reach sensitive habitats downstream of the Old Military Road during periods when it is in use, as it is closer to the Croe Water, than the existing A83. However, given that use of the Old Military Road as the Emergency Diversion Route would be very occasional and temporary, the potential for pollution incidents to occur is anticipated to be extremely low.

It is not considered that either of the above considerations discernibly alter the current baseline for the purposes of Stage 1 ecological assessment.

7.6.5 Potential Environmental Effects

The range of potential effects of road schemes and their significance on nature conservation would depend on the individual circumstances of each scheme/option. However, it is possible to identify a number of main areas of concern, which have general applicability (Highways Agency et al., 1993). These include:

- direct mortality;
- habitat loss;
- habitat fragmentation and isolation;
- disturbance; and
- pollution and other indirect impacts (where applicable).

7.6.5.1 Construction

(a) Effects Common to All Corridors

Certain potential effects are common to some or all corridors, although the exact location and extent may vary.

For all corridors there is the potential for the works to result in the death or injury of protected species such as badger which have both been recorded in the area in the absence of mitigation.

For all corridors, effects on aquatic habitats may lead to negative effects on fish species present in the Croe Water and its tributaries, and on otter that utilise the watercourse for foraging. This could be significant during the process of removing the road culverts in those options where such activities would be required.

(b) Red Corridor

For this corridor, night-time working during construction could lead to disturbance to bat, badger and otter.

(c) Brown Corridor

For this corridor, effects are likely to be the same as those for the Red corridor.

(d) Yellow Corridor

For this corridor, impacts are likely to be similar to those for the Red and Brown corridors, although there may be reduced effects on otter.

(e) Blue Corridor

For this corridor, in the absence of mitigation the works would have the potential to result in the death or injury of protected species such as otter and badger which have both been recorded in the area.

There is also the potential for construction (including night-time working) to cause disturbance to protected mammal species (bats, pine marten, otter, red squirrel) present in the area. This can be caused through various methods including the presence of people on site causing visual and olfactory disturbance and from noise and vibration caused by the operation of construction machinery. This is especially relevant in relation to otter with the presence of two otter holts and one otter couch on the Croe Water near the western boundary of the Blue corridor at its southern end.

Construction activities are also likely to cause fragmentation of habitat used by protected species restricting their free movement.

In addition, in the absence of mitigation sedimentation and run-off could impact on Loch Restil which is part of the Beinn an Lochain SSSI.

(f) Green Corridor

For this corridor, effects are likely to be broadly similar to those determined for the Blue corridor, although the exact locations and extent of the effects are likely to differ.

(g) Purple Corridor

For this corridor, effects are likely to be broadly similar to those determined for the Blue corridor, although the exact locations and extent of the effects are likely to differ. In addition, tunnelling activities may result in the production of dust which may affect aquatic and terrestrial habitats in Beinn an Lochain SSSI, particularly Loch Restil.

7.6.5.2 Operation

(a) Red Corridor

For this corridor there is likely to be a small amount of terrestrial habitat loss of upland habitats along the eastern boundary of the A83.

In the absence of mitigation there is also the potential for road run-off to affect terrestrial and aquatic habitats which may lead to negative effects on fish species present in the Croe Water, and on otter that utilise the waterbody for foraging.

(b) Brown Corridor

For this corridor, potential operational effects are likely to be the same as those for the Red corridor.

(c) Yellow Corridor

For this corridor, potential operational effects are likely to be similar to those for the Red and Brown corridors, although habitat loss is anticipated to be greater. There may also be additional habitat loss from the footprint of the viaduct piers and shading from the viaduct itself.

(d) Blue Corridor

For this corridor there is likely to be a loss of land included within the statutorily designated site (Beinn an Lochain SSSI) which may result in the loss of habitats for which the SSSI is designated, including the mire vegetation types M6 and M23.

There is also the potential for habitat loss of coniferous plantation woodland and marshy and semi-improved grassland. This may lead to fragmentation of red squirrel and pine marten habitat, and loss of habitat (foraging areas, dreys and dens). There is also the possibility that a potential bat roost at High Glencroe may be lost or be subject to disturbance.

In addition, there is the potential for direct mortality of otters during operation where the corridor crosses the Croe Water or tributaries of it, and direct mortality of pine marten and red squirrel through road traffic accidents (RTAs).

It is possible that one or more crossings of the Croe Water or tributaries may result in habitat fragmentation (severance of commuting routes) and habitat loss (holts and couches) of otter, and habitat loss and/or fragmentation of non-migratory fish.

There is also the potential for road run-off to affect terrestrial and aquatic habitats which may lead to negative effects on fish species present in the Croe Water, and on otter that utilise the waterbody for foraging.

(e) Green Corridor

For this corridor, effects are likely to be generally similar to those determined for the Blue corridor. However, the Green corridor is likely to result in greater loss of woodland and lower grassland loss. In contrast to the Blue corridor, there are also not anticipated to be any effects on bats that may potentially utilise High Glencroe as a roost.

(f) Purple Corridor

For this corridor, effects are likely to be similar to those determined for the Blue corridor except that effects on the Beinn an Lochain SSSI are likely to be greater for the Purple corridor.

There is also likely to be a loss of land included within the statutory designated site (Beinn an Lochain SSSI) which may result in the loss of habitats for which the SSSI is designated. There is also the potential for road runoff to impact on Loch Restil

which forms part of the SSSI, and on associated riparian habitats. Habitats potentially lost include the mire vegetation types M6 and M23.

A summary of the potential effects on nature conservation features can be found in Table 7-11: (construction) and Table 7-12: (operation).

Nature Conservation Feature	Corridors					
	Red	Brown	Yellow	Blue	Green	Purple
Designated sites	-	-	-	Sedimentation and run-off	Sedimentation and run-off	Pollution (dust) Sedimentation and run-off
Terrestrial habitats	Sedimentation and run-off	Sedimentation and run-off	Sedimentation and run-off	Sedimentation and run-off	Sedimentation and run-off	Sedimentation and run-off
Aquatic habitats	Sedimentation and run-off	Sedimentation and run-off	Sedimentation and run-off	Sedimentation and run-off	Sedimentation and run-off	Sedimentation and run-off
Badger	Direct mortality Disturbance	Direct mortality Disturbance	Direct mortality Disturbance	Direct mortality	Direct mortality	Direct mortality
Bat	Disturbance	Disturbance	Disturbance	Habitat fragmentation Disturbance	Habitat fragmentation Disturbance	Habitat fragmentation Disturbance
Otter	Disturbance Sedimentation and run-off	Disturbance Sedimentation and run-off	Sedimentation and run-off	Direct mortality Habitat fragmentation Disturbance Sedimentation and run-off	Direct mortality Habitat fragmentation Disturbance Sedimentation and run-off	Direct mortality Habitat fragmentation Disturbance Sedimentation and run-off
Pine marten	-	-	-	Habitat fragmentation Disturbance	Habitat fragmentation Disturbance	Habitat fragmentation Disturbance
Red squirrel	-	-	-	Habitat fragmentation Disturbance	Habitat fragmentation Disturbance	Habitat fragmentation Disturbance
Fish	Sedimentation and run-off	Sedimentation and run-off	Sedimentation and run-off	Sedimentation and run-off	Sedimentation and run-off	Sedimentation and run-off

Table 7-11: Summary of Potential Effects to Nature Conservation Features during Construction

Nature Conservation Feature	Route Corridors/Options					
	Red	Brown	Yellow	Blue	Green	Purple
Designated sites	-	-	-	Habitat loss	Habitat loss	Habitat loss
Terrestrial habitats	Habitat loss Run-off	Habitat loss Run-off	Habitat loss Run-off	Habitat loss	Habitat loss	Habitat loss
Aquatic habitats	Run-off	Run-off	Run-off	Habitat loss	Habitat loss	Habitat loss
Badger	-	-	-	Direct mortality	Direct mortality	Direct mortality
Bat	-	-	-	Habitat loss Disturbance	-	Habitat loss Disturbance
Otter	Run-off	Run-off	Run-off	Direct mortality Habitat loss and fragmentation Disturbance Sedimentation and run-off	Direct mortality Habitat loss and fragmentation Disturbance Sedimentation and run-off	Direct mortality Habitat loss and fragmentation Disturbance Sedimentation and run-off
Pine marten	-	-	-	Direct mortality Habitat loss and fragmentation Disturbance	Direct mortality Habitat loss and fragmentation Disturbance	Direct mortality Habitat loss and fragmentation Disturbance
Red squirrel	-	-	-	Direct mortality Habitat loss and fragmentation Disturbance	Direct mortality Habitat loss and fragmentation Disturbance	Direct mortality Habitat loss and fragmentation Disturbance
Fish	Run-off	Run-off	Run-off	Habitat loss and fragmentation Run-off	Habitat loss and fragmentation Run-off	Habitat loss and fragmentation Run-off

Table 7-12: Summary of Potential Effects to Nature Conservation Features during Operation

7.6.6 Potential Mitigation

The objective of potential mitigation is to identify anticipated 'standard' or 'generic' measures taking into account best practice, legislation and guidance.

Site-specific mitigation would need to be developed as the scheme is progressed, but might include habitat recreation to mitigate for habitat lost under the footprint of an option (such as woodland planting), creation of location appropriate species-rich grasslands, and creation of low fertility habitats suitable for upland vegetation assemblages.

Potential pollution incidents affecting all nature conservation resources during construction can be mitigated through the adherence to standard best practice and guidelines, such as the SEPA Pollution Prevention Guidelines (PPGs). Potential pollution impacts during operation (e.g. road run-off) can be mitigated through the provision of Sustainable Drainage Systems (SUDS).

Effects on species during construction can be mitigated through the provision of appropriate protection systems and/or exclusion zones. Mammal-proof fencing can be provided to mitigate for direct mortality of badger and otter. Exclusion zones around habitats and features such as resting places would minimise the impact on protected species and their habitats, and reduce disturbance. Limits on night-time working or the provision of directional lighting would also reduce disturbance to protected species such as badgers, bats and otter.

The loss of protected species lying-up/resting/roosting sites can be mitigated through the provision of alternative sites, e.g. artificial holts or bat/pine marten/red squirrel boxes. In addition, planting would provide opportunities for above ground lying-up sites for otter and foraging habitat for other species.

Severance of otter commuting routes can be mitigated through the provision of mammal ledges in culverts and under bridges. Where ledges are inappropriate or where no culverts exist dry mammal underpasses can be provided instead. Specific mitigation may be required to mitigate for the fragmentation of red squirrel and pine marten habitat or severance of bat commuting routes, such as the provision of wildlife bridges.

7.6.7 Summary of Assessment

Analysis of the Stage 1 assessment findings indicates that the Red, Brown and Yellow corridors would have the lowest impact on nature conservation features, although the Yellow corridor option may result in greater habitat loss due to the footprint of the scheme. However, all three corridors would have a reduced effect compared to the Green, Blue and Purple corridor options.

The Green, Blue and Purple corridor options are likely to have a significant negative effect on the Beinn an Lochain SSSI including loss of M6 and M23 mire vegetation (particularly the Purple option). A table showing a summary of the preferred options can be found below (Table 7-13:).

Corridor Option	Preferred	Intermediate	Least Preferred
Red	✓		
Brown	✓		
Yellow	✓		
Blue			✓
Purple			✓
Green			✓

Table 7-13: Environmental Impacts Table – Ecology and Nature Conservation

7.6.8 Recommendations for Further Work

Should a DMRB Stage 2 assessment be progressed following this Study it is recommended that field surveys are undertaken to determine the extent, composition and quality of terrestrial habitats, particularly in areas of the Beinn an Lochain SSSI which may be affected by one or more of the routes to be assessed. Protected species surveys are also likely to be required, particularly where occurrence within the study area is likely but where historical data is poor and current activity is poorly understood e.g. bats and badger.

In addition, it is recommended that further consultations with statutory and non-statutory bodies are carried out, for instance to access the information on red squirrel feeding locations and camera traps within Glen Croe, and on species and species groups where further work maybe required e.g. wildcat and bryophytes.

Should the Purple corridor be taken forward to Stage 2 it is recommended that further consultation is undertaken with SNH regarding the Glen Etive and Glen Fyne SPA.

7.7 Landscape and Visual

7.7.1 Introduction

This section assesses the potential effects of each of the six corridors on the landscape character of Glen Croe and the surrounding area and also considers the potential for visual impacts on key local receptors (such as residential properties, footpaths and recreation areas).

7.7.2 Approach and Methods

The landscape and visual assessment was undertaken in accordance with DMRB Volume 11, Section 3, Part 5, Landscape & Visual Assessment and Guidelines for Landscape and Visual Impact Assessment (Landscape Institute and Institute for Environmental Management & Assessment, 2002).

The assessment was carried out through a combination of desk based and field assessment. The study area for the assessment is Glen Croe, Loch Restil and its environs. There is no potential for landscape or visual impacts beyond these areas due to the enclosing topography.

7.7.3 Baseline Conditions

Between Ardgartan and the Rest and Be Thankful, the A83 runs through Glen Croe along the lower western slopes of The Cobbler (Ben Arthur) and Beinn Luibhean. The steep slopes of the surrounding hills create a strong sense of enclosure for the glen, which supports grazing for cows, sheep and horses. The Old Military Road runs along the floor of the valley, with the iconic twisting hill climb up to the Rest and Be Thankful visible at the northern end of the glen. The whole of the study area is situated within the Loch Lomond and Trossachs National Park.

To the east of the A83, the rugged slopes are covered by rocky outcrops, with evidence of landslides along the length of the road. At the time of the assessment, construction of measures to limit road closures in the event of further landslides was ongoing, with debris flow barriers being installed above the road. There are numerous rocky outcrops on the lower slopes of the hills within the glen and at the northern end on the slopes below the Rest and Be Thankful, which contribute to the rugged upland character of Glen Croe.

On the western and southern edges of the glen, much of the hillside is covered by well established coniferous forestry plantations. A series of tracks run through the plantations to provide access for Forestry Commission Scotland (FCS) vehicles, as well as being well used by walkers and cyclists as part of the Core Path network. Several smaller blocks of woodland are situated at the eastern and northern edges of the glen. Within the glen itself, vegetation generally consists of grassland with scattered blocks of scrub vegetation and several mature trees on the boundaries of the current and ruined buildings.

Settlement within the glen is limited to two residential properties (High Glencroe and another house south of Laigh Glencroe) at opposite ends of the valley. The remains of the stone walls of former buildings are evidence of more historic settlement within the glen. The glen has been utilised for grazing land for many years, with the traditional drystone walls running across the valley now reinforced or replaced in many areas by wire mesh fencing. While the Old Military Road, which was built in the 1740s by Major William Caulfeild, is no longer in use as a public road, it is a

popular route with walkers. While the road is not designated, it does represent an important historical feature in the area, with the iconic, twisting route used as part of a rallying route and a famous hill climb. At the time of writing work was underway to resurface the road to allow it to be used as an emergency diversion route if the A83 is closed by landslides.

At the northern end of the glen, the Rest and Be Thankful car park is a popular tourist viewpoint that receives many visitors each year, including coach parties. It is considered to be a sensitive receptor to change. To the east of the A83, The Cobbler (Ben Arthur) is a mountain that reaches 884m AOD, and is part of the group of mountains known as the 'Arrochar Alps.' It is one of the Corbetts (peaks in Scotland between 762m (2500 feet) and 914m (3000 feet)), and its rocky summit makes it one of the most distinctive mountains in the area. Easy access to the slopes and summit, which provide panoramic views of the surrounding landscape, including Glen Croe, makes it one of the most popular mountains for walkers in Scotland, as well as a popular destination for rock climbers. It is therefore sensitive to any change to views.

The largest watercourse in the study area is the Croe Water, which runs down into the glen from the north, before meandering through the southern end of the glen and flowing into Loch Long at Ardgartan. A number of other tributary burns run down the hills surrounding the glen, feeding into the Croe Water. Numerous waterfalls are visible to travellers along the glen during or following periods of wet weather. There is an artificial cascade towards the northern end of the glen to help control drainage as part of the slope stabilisation measures.

The majority of Glen Croe is identified in the SNH 'Commissioned Report, Review: Loch Lomond and The Trossachs National Park Landscape Character Assessment' (SNH and the Loch Lomond and The Trossachs National Park Authority, 2009) as being of the Forested Upland Glens Landscape Character Type (LCT), with the upper slopes of the valley part of the Hills LCT.

7.7.3.1 Future Baseline Conditions

As explained in Section 4.2, the current baseline conditions will be modified by works currently underway to provide additional landside protection measures and to enable use of the Old Military Road as an Emergency Diversion Route during A83 road closures (the 'Do Minimum' scenario).

The operation of the Do Minimum scenario would be unlikely to significantly alter the landscape character of the area, as the A83 would generally operate without any notable changes to the road corridor. While the slope stabilisation measures and debris flow barriers would be visible features on the hillside to the east of the road, these would not detract from the scenic views to the west across Glen Croe.

The Do Minimum scenario is unlikely to result in significant changes to visual amenity as it is not anticipated to be discernibly different to the existing infrastructure in the majority of views. The slope stabilisation measures would largely be seen against the backdrop of the hillside in views from The Cobbler so would not alter the appearance of Glen Croe itself and would be unlikely to represent a change to the current baseline visual amenity for walkers. The scenic views from the Rest and Be Thankful car park would be unlikely to be altered, as the A83 would appear largely unchanged within the views along the glen.

Views from the woodland Core Paths and the Old Military Road in the future baseline would also be largely unaltered, as the road would appear generally unchanged, with the visibility of the slope stabilisation measures likely to be limited by the backdrop of the hillside.

If a landslide occurred and it was necessary to utilise the Emergency Diversion Route through the glen, the increase in traffic using the Old Military Road would potentially have short-term and temporary effects (for the duration of the diversion) on the landscape character and visual amenity of the glen.

7.7.4 Potential Environmental Effects

7.7.4.1 Construction

The potential effects of each corridor on the landscape character and visual amenity during the construction phase are assessed below.

(a) Red Corridor

Minor effects on the landscape character of the road corridor and the glen and from local visual receptors are anticipated as a result of the construction works in the Red corridor. While additional slope stabilisation measures would be likely to increase the extents of the man-made structures on the hillside, the construction operations are likely to be largely contained within the existing corridor of disturbance for the A83, which would limit the extent of the development corridor within the rural upland glen.

(b) Brown Corridor

While the Brown corridor would utilise the existing road corridor, the works would require the construction of more substantial structures along the road in the form of landslide shelters, which may result in significant effects on the setting of the glen. While the construction operations are likely to be largely contained within the existing corridor of disturbance for the A83, which would limit the extent of the development corridor within the rural upland glen, the construction of the landslide shelters would require more extensive construction operations to build the structures. Landscape effects are likely to be more significant for the landscape character of the glen if construction required any significant earthworks or rock cuttings around the iconic hill climb below the Rest and Be Thankful car park, which is characterised by the undulating, twisting route and rocky outcrops around the road.

The more extensive construction operations to build the structures would be notable from the summit of The Cobbler, and could potentially have significant effects on the scenic views across the area. Views from the Rest and Be Thankful viewpoint and for walkers using the Old Military Road and sections of the woodland Core Paths could also be significantly affected by the construction works for the landslide shelters, although the significance of the effects would be dependent on the extent of the structures along the road corridor.

(c) Yellow Corridor

The construction of the road in the Yellow corridor may have significant effects on the landscape character of Glen Croe and the adjacent mountains. In order to construct the viaduct structure along the length of the corridor, on the steep slopes

around the existing A83, there is likely to be a requirement for significant heavy plant and potentially haul roads for access to each viaduct pier, which would result in significant direct impacts on the landscape, including changes to the landform and the loss of established plantation woodland. The majority of impacts are likely to be temporary, although if any of the construction roads are required to be retained for maintenance use, these would have a long-term impact on the landscape beneath the viaduct.

The two residential properties within the glen may experience significant visual effects during the construction due to the visibility of the large scale construction activity that would take place on the upper slopes of the glen. Despite the proximity of the existing A83, both properties retain a rural character as a result of their attractive, scenic views across the glen, which would be significantly disrupted during construction by the movement of heavy plant on the high ground at the edge of the glen. Walkers using the Old Military Road would experience similar effects as a result of the works on the slopes above them. The construction of the viaduct would also be notable from sections of the woodland Core Paths on the western side of the glen. Effects are likely to be lower than for receptors within Glen Croe, but may still be significant. The large scale construction works along the corridor may also have a significant effect on the scenic views of the glen from the Rest and Be Thankful car park and from the summit of The Cobbler.

(d) Blue Corridor

The construction of the road in the Blue corridor may have significant effects on the landscape character of Glen Croe. As all of the construction activities would take place within the glen itself, the works would result in a major disturbance of the rural setting of the glen, where activity is normally limited to landowner access, with large numbers of construction vehicles and heavy plant likely to be visible. In order to create a connection between the valley floor and the road level at the Rest and Be Thankful car park, the road would need to rise approximately 100m, which would require major earthworks, rock cuttings and a viaduct at the northern end of the glen, resulting in changes to the distinctive rugged landform and the loss of part of the plantation woodland. The new road would also affect the setting of the historic hill climb and the Rest and Be Thankful car park. The majority of effects are likely to be temporary, although the construction would potentially have longer term effects on the landscape than options where work would take place within the existing road corridor.

The large scale construction works at the northern end of the glen may have significant effects on views from High Glencroe, with the construction of the twisting road potentially taking place on the hillside adjacent to the property. The property to the south-east of Laigh Glencroe may also be significantly affected by the construction operations that would take place within their views across the glen, with the construction traffic through the glen likely to affect the setting of the property. Views for walkers using the Old Military Road may be significantly disrupted by construction operations within the glen, with views from the northern end of the glen on the twisting hill climb likely to be the most significantly affected, although the path would potentially be closed during construction for safety.

Construction within this corridor may be visible within Glen Croe from the summit of The Cobbler, and would potentially have a significant effect on views across the area. The changes to the landform around the Rest and Be Thankful car park as a result of the earthworks at the northern end of the glen would be particularly notable. Sections of the woodland Core Paths would gain views of the construction

operations within the glen, although potentially effects would only be significant at the northern end of the scheme as a result of the earthworks and lost woodland associated with the road alignment as it rises up the hillside. The scenic views from the Rest and Be Thankful car park may be significantly affected by the construction of the new road within the glen, with the changes to the landform below the car park likely to represent an adverse change to the setting of the viewpoint.

(e) Purple Corridor

The construction of the road in the Purple corridor may have significant effects on the landscape character of Glen Croe. As all of the construction activities would take place within the glen itself, the works could result in a major disturbance of the rural setting of the glen, with large numbers of construction vehicles and heavy plant likely to be visible moving through the glen, when activity within the glen is normally limited to landowner access. The excavation required for the tunnel at the northern end of the glen would require large numbers of construction vehicles to be working within the rural valley, which would significantly alter the existing tranquil setting. While the works would limit the change to the rugged landform at the northern end of the glen, the potential for the realignment of the B828 around the western side of Loch Restil would require significant earthworks that would alter the character of the loch and the change the appearance of the lower slopes of Beinn an Lochain. The majority of effects are likely to be temporary, although the construction would potentially have longer term impacts on the landscape than options where work would take place within the existing road corridor, with impacts to the landscape north of Rest and Be Thankful that would not be associated with any of the other options.

The large-scale construction works at the northern end of the glen may have significant effects on views from High Glencroe, with the excavations for the tunnel likely to be highly visible from the property and disruptive of their tranquil setting. The property to the south-east of Laigh Glencroe may also be significantly affected by the construction operations that would take place within their views across the glen, with the construction traffic through the glen likely to affect the setting of the property. Views for walkers using the Old Military Road may also be significantly disrupted by construction operations within the glen, with views from the northern end of the glen on the twisting hill climb potentially the most significantly affected by the tunnelling operations, although the path may be closed during construction for safety.

Construction within this corridor is likely to be visible within Glen Croe from the summit of The Cobbler, and would potentially have a significant effect on views across the area, with the tunnelling operations below the Rest and Be Thankful car park likely to be particularly notable. Sections of the woodland Core Paths would gain views of the construction operations within the glen, although would generally not be significant due to the screening by the forestry. The scenic views from the Rest and Be Thankful car park could be significantly affected by the construction of the new road within the glen, with the excavations for the tunnel below the car park likely to represent an adverse change to the setting of the viewpoint, and the earthworks for the realignment of the B828 to the north of the car park potentially resulting in significant changes to the relatively undisturbed appearance of Beinn an Lochain in views.

(f) Green Corridor

Construction of the road in the Green corridor may result in the loss of a significant area of plantation woodland on the western side of the glen. Effects on the landscape character of the glen as a result of the construction on the hillside may be significant, due to the scale of the earthworks and/or structures required to build the road on the steep slopes of the hillside. However, as the woodland is part of a commercial forestry plantation, it would not be completely out of character for vehicles to be visible on the hillside, with the remaining sections of forestry potentially providing a degree of screening of the works. The significance of impacts would be dependent on the degree of clearance required within the woodland. The majority of effects are likely to be temporary, and while the construction would potentially have longer term effects on the landscape than options where work would take place within the existing road corridor, the long-term effects are likely to be less than those caused within the Blue corridor.

The construction of the road may have significant visual effects on the Core Path network through the woodland, as the works may result in the loss of a significant area of woodland and alter the character and shape of the hillside, as well as potentially severing the paths.

Views from the properties within Glen Croe may be significantly affected by the construction works on the hillside, although the properties would benefit from a degree of screening from the woodland plantation in the foreground of their views. Effects would be limited to a degree by the commercial nature of the forestry, as the plantations are likely to be felled at some point in the near future. Walkers using the Old Military Road would experience similar views, although the more open nature of their views would allow more extensive views of the works. The construction works would be visible on the hillside from the Rest and Be Thankful car park, but are anticipated to have minor effects on views of the glen itself.

The construction would be visible across the valley for traffic on the existing A83, and would represent a change to the appearance of the hillside to the west, with potentially significant effects if the construction requires significant earthworks. The works would also be visible from the summit of The Cobbler, with potentially significant effects due to the earthworks on the hillside that are likely to be notable.

7.7.4.2 Operation

The potential effects of each corridor on the landscape character and visual amenity during operation are assessed below.

(a) Red Corridor

The Red corridor is not anticipated to result in significant effects on the landscape character of the road corridor and the glen. While the more substantial slope stabilisation measures would potentially result in a widening of the road corridor, the A83 corridor would remain largely unchanged. If the slope stabilisation measures did not prove effective and a landslide resulted in the closure of the road, requiring the use of the Emergency Diversion Route through the glen on the Old Military Road, the increase in traffic through the valley may have a significant effect in the character of the glen, although these impacts would be short-term.

As with the Do Minimum scenario, visual effects are generally not anticipated to be significant, as the scenario is unlikely to be discernibly different to the existing A83 in

the majority of views. The slope stabilisation measures would largely be seen against the backdrop of the hillside in views from The Cobbler, and would not affect the appearance of Glen Croe itself, so would be unlikely to represent a change to the visual amenity for walkers. The scenic views from the Rest and Be Thankful car park are not anticipated to be affected by this corridor, as the A83 would appear largely unchanged within the views along the glen.

Visual effects on the woodland Core Paths and the Old Military Road are also anticipated to be minor. If the additional slope stabilisation measures require more substantial structures, these may be visible across the glen but visibility would be likely to be limited by the backdrop of the hillside so the road would appear generally unchanged. If it is necessary to utilise the Emergency Diversion Route through the glen, the increase in traffic using the Old Military Road could potentially have significant effects on views across the glen, although these effects would be temporary. Effects on the two properties within the glen would only be likely to occur in the event of it being necessary to use the Emergency Diversion Route, with potential for short-term, significant effects due to the introduction of traffic to their views.

(b) Brown Corridor

Whilst the Brown corridor would be largely contained within the existing road corridor, the introduction of the notable new structures to the hillside above the glen could have potential significant effects on the landscape character of the road corridor and the glen, although the significance of effects would be dependent on the appearance and extents of the landslide shelters, and how well they integrate into the landscape. While the structures would not directly affect the valley floor, the setting of the glen would potentially be altered by the introduction of substantial structures on the hillside above, although effects would be dependent on the appearance of the structures and their fit within the landscape.

The landslide shelters would be visible on the hillside above the two properties in the glen, with the new structures likely to have significant effects on their views, although the significance of effects would depend on the extents and appearance of the structures and how well they are visually integrated into their surroundings. Walkers using the Old Military Road would be likely to experience similar views.

The new landslide shelters along the road corridor would be visible from the viewpoint at the Rest and Be Thankful car park, which would potentially have significant effects on the views as a result of the introduction of substantial new structures to the largely undeveloped glen, although the significance of the effects would be dependent on the appearance and extents of the structures. The new structures along the road would be visible across the glen from sections of the woodland Core Paths, and would be likely to have significant effects on views, dependent on the appearance of the structures and how well they integrate visually with their surroundings. Effects on views from The Cobbler would depend on the extent and appearance of the landslide shelters from this elevated viewpoint, but would potentially be significant if the structures result in the introduction of prominent development within the rural glen.

(c) Yellow Corridor

The introduction of a large viaduct structure to the relatively undeveloped valley is anticipated to have a significant effect on the landscape character. The new structure would be prominent on the hillside above the glen, as well as representing

a notable feature within views from the surrounding hills that would affect the setting of the Hill LCTs around the glen, although the significance of effects would depend on the appearance of the viaduct, and how well it is visually integrated with its surroundings.

The visual effect of the viaduct on the two properties is anticipated to be significant, as the large structure would represent a major change to the views that would be out of character with the rural setting of the properties and change their scenic views, although effects would be dependent on the appearance of the viaduct and how well it is visually integrated with its surroundings. Walkers using the Old Military Road and the woodland Core Paths could experience similar effects as a result of the changes to their scenic setting.

The visual amenity of the Rest and Be Thankful viewpoint at the car park and the views from the summit of The Cobbler are anticipated to be adversely affected by the introduction of the viaduct, as the large structure would be a prominent feature that would be out of character with the scenic setting of the glen.

(d) Blue Corridor

The Blue corridor is anticipated to have a significant effect on the landscape character of Glen Croe and the surrounding hills. The introduction of the road corridor to the valley floor could substantially alter the tranquil, rural character of the glen, with the earthworks and rock cuttings at the northern end of the glen changing the appearance of the rugged hillside below the Rest and Be Thankful car park. The setting of the surrounding hills and the Old Military Road and hill climb would also be disrupted by the changes to the character of the glen.

Routeing the road through the glen could have significant visual effects on the two properties situated within the glen. The road would likely require several direction changes in order to make the level change between the valley floor and the Rest and Be Thankful, with significant changes to the landform around the property of High Glencroe that would alter the setting of the property as well as the views. The property to the south-east of Laigh Glencroe would also be significantly affected by the introduction of traffic through their views, which would affect the setting of the property. Views for walkers using the Old Military Road would also be significantly disrupted by the introduction of traffic to the valley floor, which could substantially reduce the scenic value of the route, particularly at the northern end of the glen.

The scenic views from the Rest and Be Thankful viewpoint could be adversely affected by the introduction of the road through the glen, with the alterations to the landform on the hillside below the car park likely to be very notable, particularly around the iconic hill climb on the Old Military Road. The introduction of the new road into Glen Croe would represent a notable change to views from The Cobbler, which may result in significant effects, particularly from the changes to the landform at the northern end of the glen. Sections of the woodland Core Paths would gain views of the new road through the glen, although impacts would only be likely to be significant at the northern end of the scheme as a result of the changes to the landform and the loss of woodland associated with the road alignment as it rises up the hillside.

(e) Purple Corridor

The Purple corridor is anticipated to have a significant effect on the landscape character of part of Glen Croe and the surrounding hills as a result of the

introduction of the road corridor to the valley floor, which would completely alter the tranquil, rural character of the glen. The tunnel would help to limit effects on the rugged landscape at the northern end of the glen to the area immediately around the tunnel entrance, although the potential realignment of the B828 around the western side of Loch Restil would alter the landscape character of the largely undisturbed hillside of Beinn an Lochain.

The introduction of the road to the valley floor could potentially have significant visual effects on the two properties situated within the glen. While the tunnel would help to limit the extent of earthworks around the property of High Glencroe, there would still be alterations to the landform, which in combination with the visible traffic could have a potentially significant effect on the property. The property to the south-east of Laigh Glencroe may also be significantly affected by the introduction of traffic through their views, which could affect the setting of the property. Views for walkers using the Old Military Road may be significantly disrupted by the introduction of traffic to the valley floor, which could substantially reduce the scenic value of the route.

The scenic views from the Rest and Be Thankful car park are anticipated to be adversely affected by the introduction of the road through the glen, with the realignment of the B828 to the north of the car park potentially causing additional effects to the north of the viewpoint. The introduction of the new road into Glen Croe would represent a notable change to views from The Cobbler, which may result in significant effects on views, although the tunnel would help to limit changes at the northern end of the glen. Sections of the woodland Core Paths would gain views of the construction operations within the glen, although these would generally not be significant due to the screening by the forestry.

(f) Green Corridor

While the introduction of the road in the Green corridor to the hillside on the western side of the glen may result in the loss of a significant area of plantation woodland, the screening provided by any woodland retained around the road corridor may help to reduce effects on the landscape character of the glen. If the road can be designed to achieve a good landscape fit, the effect of moving the road to the opposite hillside is not anticipated to represent a significant change to the character of the glen. The significance of effects would be dependent on the extent of the woodland clearance along the road.

There may be significant effects on the Core Path network through the woodland on the hillside as a result of the introduction of the road, assuming several of the paths may be closed or realigned, and the loss of woodland opening up views across the glen. While the road would be visible on the opposite side of the glen in views from The Cobbler, it is not anticipated to have a significant effect on the scenic quality of the views across the valley, with the woodland setting of the route likely to appear more in keeping with the A83 route to the south of the mountain.

Visual effects on the properties within Glen Croe are not anticipated to be significant if sufficient woodland could be retained to provide screening of the new route on the hillside, with the new road representing a similar feature within their views to the existing A83. Walkers using the Old Military Road would experience similar views, although the more open nature of their views would allow more extensive views of the road. As the road would avoid direct effects on the glen itself, visual effects on the viewpoint at the Rest and Be Thankful car park are not anticipated to be

significant, as the new road is unlikely to have greater prominence within views than the existing road.

7.7.5 Potential Mitigation

(a) Brown Corridor

While the Brown Corridor would be largely constructed on the line of the existing road corridor, the introduction of new structures to the largely undeveloped hillside would be likely to result in significant effects on receptors. Opportunities for mitigation would be limited to sensitive design of the structures to achieve a good landscape fit and limit their visual prominence. Mitigation for other elements of a scheme in the Brown Corridor are as described below for 'All Corridors'.

(b) Yellow Corridor

Other than through sensitive design, there would be no practical way to mitigate the introduction of the viaduct structure to the glen, which would be required for a scheme within the Yellow corridor. Mitigation for other elements of a scheme in the Yellow corridor are as described below for 'All Corridors'.

(c) All Corridors

Potential landscape and visual mitigation measures that could be applied to all corridors include:

- protection and retention of as much existing woodland along the road corridor as possible to provide screening and minimise/replace habitat loss;
- ensuring that any of the stone wall field boundaries disturbed by the works be replaced to retain the character of the farmland; and
- appropriate measures to ensure that any rock cutting undertaken be carried out to ensure that the appearance of the exposed rock reflect the natural rugged terrain, avoiding the creation of uniform, smooth faces.

7.7.6 Summary of Assessment

The on-line Red corridor is anticipated to result in the least significant effects on landscape character and visual receptors as it is not expected to result in major changes to the sensitive character of the area, providing the best balance of effective slope stabilisation and landslide control systems against the introduction of new structures.

While the Green corridor would result in the creation of a new road corridor, the route through the woodland would provide opportunities to achieve a good landscape fit for the road as well as provide appropriate mitigation of the road.

The major earthworks required for the Blue and Purple corridors, which would also involve the introduction of a road to the tranquil setting of Glen Croe, are anticipated to result in the most significant effects for the study area.

The introduction of the large scale viaduct structure associated with the Yellow corridor and the landslide shelters for the Brown corridor into the largely undeveloped area is also anticipated to result in significant effects that would adversely affect the study area.

Corridor Option	Preferred	Intermediate	Least Preferred
Red	✓		
Brown			✓
Yellow			✓
Blue			✓
Purple			✓
Green		✓	

Table 7-14: Environmental Impacts Table - Landscape and Visual

7.7.7 Recommendations for Further Work

Should a DMRB Stage 2 assessment be progressed following this study, a more detailed landscape and visual assessment should be undertaken, describing each route option and considering the potential significance of its effect on the landscape.

7.8 Cultural Heritage

7.8.1 Introduction

A cultural heritage assessment has been undertaken based on the guidance contained in DMRB Volume 11, Section 3, Part 2 (Highways Agency et al., 2007) for a Scoping exercise. The purpose of the scoping exercise is to determine whether further study is required and if so, at what level of detail. To inform the scoping exercise, baseline data has been collated and used to determine the potential effects of each corridor on cultural heritage.

In line with the guidance provided by HA 208/07, cultural heritage is considered under three separate sub-topics:

- archaeological remains;
- historic buildings; and
- historic landscape.

Collectively the individual archaeological remains, historic buildings or historic landscape types are known as cultural heritage 'assets'.

7.8.2 Approach and Methods

In accordance with the guidance provided by Section 5.4 of HA 208/07, the cultural heritage study area extends 300m from the two outermost corridors (see Drawing Number B1557610/WP03/007). To establish baseline conditions for this study area the following sources of information were referred to:

- Historic Scotland's data services for information on nationally designated heritage assets (Scheduled Monuments, Listed Buildings, Gardens and Designed Landscapes, Registered Battlefields).
- The West of Scotland Sites and Monuments Record for information on known heritage assets.
- Previous reports: Rest and Be Thankful Diversion Route Record of Determination (Transport Scotland 2012) and Old Military Road, Rest and Be Thankful Diversion Route: Cultural Heritage Assessment (CFA Archaeology Ltd 2012).
- Historic Land Use Data supplied by the Royal Commission on the Ancient and Historical Monuments of Scotland was used to identify Historic Landscape Types.

The value of all identified heritage assets and significance of the potential effect that the corridors could have on them was assessed based on the guidance provided by Annexes 5, 6 and 7 of HA 208/07. The potential for unknown archaeological remains has been assessed using professional judgement, in the absence of specific guidance.

All works were also undertaken in accordance with the Institute for Archaeologist's Code of Conduct and its Standard and Guidance for Historic Environment desk-based assessment (IfA 2011) and Managing Change in the Historic Environment Setting (Historic Scotland 2010).

7.8.3 Baseline Conditions

A total of 16 cultural heritage assets were identified within the study area comprising:

- 13 archaeological sites;
- one historic building: the Rest and Be Thankful Memorial Stone, a Category $C_{(S)}$ Listed Building; and
- two historic landscape types.

The identified assets are listed in Table 7-15: and their location shown on Drawing Numbers B1557610/WP03/007-009.

Site No.	Site Name	SMR/NMRS ref	Site Type	Designation	Value
1	Loch Restil	SMR: 46003 NMRS: NN20NW 21	Building (remains)	None	Low
2	Rest and Be Thankful Stone	SMR: 1789 NMRS: NN20NW 1	Memorial Stone	Category C(S) Listed Building	Low
3	High Glen Croe	SMR: 44648 NMRS: NN20NW 19	Farmstead, en-closures and kiln	None	Low
4 (A, B, C and D)	Mid Glen Croe	SMR: 44649 NMRS: NN20NW 18	A: Hut Circles or Cairn (possible) B: Rig – Bank and track C: Enclosures D: Buildings (possible longhouses)	None	Low
5	Gleann Mor	SMR: 21284 NMRS: NN20NW 7	Sheiling Huts	None	Low
6	Croe Water	SMR: 43329 NMRS: NN20NW 15	Sheiling Huts	None	Low
7	Laigh Glencroe	SMR: 21589 NMRS: NN20NW 11	Farmstead, sheepfold	None	Low
8	Laigh Glencroe	SMR: 21588 NMRS: NN20NW 10	Farmstead	None	Low
9	Croe Water	SMR: 21282 NMRS: NN20NW 5	Farmstead, Head Dyke	None	Low
10	Glen Croe	SMR: 21285 NMRS: NN20NW 8	Settlement, Sheiling Huts	None	Low
11	Dumbarton–Tarbet–Inveraray–Tyndrum Military Road	SMR: 21692 NMRS: NN20SW 8	Military Road	None	Low
Historic Landscape Type A	-	N/A	Moorland and Rough Grazing	None	Negligible
Historic Landscape Type B	-	N/A	Coniferous Plantation	None	Negligible

Table 7-15: Known Cultural Heritage Assets identified within the Study Area

The cultural heritage of the study area is characterised by assets associated with medieval or post-medieval farming and comprises farmsteads and associated structures, field systems and sheiling huts (Sites 1, 3, 4B, 5, 6, 7, 8, 9 and 10).

Sheiling huts were associated with the seasonal movement of people with their livestock when cattle and sheep would be driven from the lower winter fields to the higher summer pastures. Shielings provided shelter for herdsmen and dairy girls. The locations of these sites on the slopes of Glen Croe reflect this function and define the setting of these sites, although the settings of Sites 5 and 10 have been altered in the recent past by forestry plantation.

The Dumbarton–Tarbet–Inveraray–Tyndrum Military Road (Site 11) was constructed between 1747 and 1749 during the period known as the 'Pacification of the Highlands' that followed on from and was a reaction to the Jacobite Rebellion of 1745. Government measures at this time included the banning of bagpipes, a proscription against the wearing of tartan and carrying of arms and also included the construction of a network of roads to facilitate the movement of troops into what had previously been fairly inaccessible areas that facilitated the risings of the Jacobite Rebellions of 1716, 1719 and 1745. The present A83 replaced the Military Road in the 1930s.

Sites 4A, 4C and 4D are of possible pre-historic or early historic date and comprise two possible hut circles (low circular or oval banks of turf, earth or stone, which may be the remains of prehistoric roundhouses), field systems and the possible remains of two longhouses or the robbed out remains of a long cairn.

The setting of these sites is characterised by their valley floor location which in turn reflects the location of more sheltered areas, the location of better agricultural land and easier communications.

The Rest and Be Thankful Memorial Stone is a Category C(S) Listed Building (Site 2). It is a granite stone approximately 0.6m high which commemorates the transfer of responsibility for the Dumbarton–Tarbet–Inveraray–Tyndrum Military Road (Site 11) from the military to the Commissioners for Highland Roads and Bridges in 1814. It replaces an earlier stone, the whereabouts of which is no longer known.

The setting of the Rest and Be Thankful Memorial Stone is located in a car park adjacent to the existing A83. The setting of this asset is characterised by an upland location with extensive views to the southeast and its association with the Dumbarton–Tarbet–Inveraray–Tyndrum Military Road (Site 11) and the A83. This asset also has historical and cultural associations with communications along Glen Croe.

The historic landscape of the study area is characterised by 20th century coniferous plantation (Historic Landscape Type B) with areas of Moorland and Rough Grazing (Historic Landscape Type A) also present.

7.8.3.1 Future Baseline conditions

As explained in Section 4.2, works are currently underway in the Glen Croe valley to provide additional landside protection to the existing A83 and to enable use of the Old Military Road as an Emergency Diversion Route during any A83 road closures (referred to as the 'Do Minimum' scenario). The works on the Old Military Road would be completed prior to construction of any of the A83 options considered as

part of this Stage 1 assessment, and the value assigned to this site takes this into account.

7.8.3.2 Potential for the Presence of Unknown Archaeological Remains

The potential for unknown archaeological remains within the Purple and Blue Corridors is considered to be Medium as both these corridors are located on the floor of Glen Croe. Modern settlements are located here to take advantage of the shelter, better land and ease of communications afforded by this location. It is likely that an earlier settlement was also located here to take advantage of these factors and this is attested by the concentration of sites, including potentially prehistoric sites, in this area.

The potential for unknown archaeological remains within the Green Corridor is considered to be Low. This is due to the fact that the Green Corridor is located within the area of forestry on the south-west side of the valley. Forestry operations such as planting and drainage are likely to have destroyed or truncated any unknown archaeological remains that may have been present.

The potential for unknown archaeological remains within the Yellow Corridor is considered to be Negligible. This is due to the steep slope and poor ground of the north-east side of the valley.

While shielings have been identified on the steeper slopes, the distribution of known sites suggests that activity is located on the lower slopes and glen floor. In addition, construction of the existing A83 is likely to have removed or truncated any archaeological remains within its footprint. Based on this, the potential for the presence of unknown archaeological remains within the Red and Brown Corridors has been assessed to be Negligible.

7.8.4 Potential Environmental Effects

7.8.4.1 Construction

It is likely that the design of route options within the corridors would enable physical impacts on known assets to be avoided or reduced. However, for the purposes of this assessment a worst-case scenario approach has been taken and it is assumed that where assets are located within corridors they would be removed by construction of the scheme.

The significance of effect on cultural heritage assets potentially affected within the corridors is listed in Table 7-16: to Table 7-19:.

(a) Red and Brown Corridors

No archaeological remains or historic buildings are located within the Brown or Red corridors. While these corridors are located within the Historic Landscape Type A, given the nature of the works proposed (landscape planting, debris flow barriers or the construction of shelters), the significance of effect on this historic landscape type has been assessed to be Neutral.

While shielings have been identified on the steeper slopes, the distribution of known sites suggests that activity is located on the lower slopes and glen floor. In addition, construction of the existing A83 is likely to have removed or truncated any archaeological remains within its footprint. Based on this, and the nature of

construction works identified above, no impacts on unknown archaeological remains are predicted.

In addition, construction activities associated with the Brown and Red corridors are not anticipated to affect the setting of any identified cultural heritage assets.

(b) Yellow Corridor

Site No.	Site Name	Site Type	Value	Magnitude of Impact	Significance of Effect
11	Dumbarton–Tarbet–Inveraray–Tyndrum Military Road	Military Road	Low	Moderate	Slight
Historic Landscape Type A		Moorland and Rough Grazing	Negligible	Negligible	Neutral

Table 7-16: Potential Effects on Cultural Heritage Assets within the Yellow Corridor (Construction)

The Yellow corridor could potentially affect two cultural heritage assets. The significance of the impact on the north-eastern end of the Tyndrum Military Road (Site 11) has been assessed to be Slight.

Given the small area of Historic Landscape Type A that would be potentially affected, the impact on this asset has been assessed to be Neutral.

While the potential for the presence of unknown archaeological remains within this corridor has been assessed to be Negligible, alignments within the Yellow corridor still have potential to impact on unknown archaeological remains. At present it is not possible to assess the significance of this effect.

(c) Blue Corridor

Site No.	Site Name	Site Type	Value	Magnitude of Impact	Significance of Effect
2	Rest and Be Thankful Stone	Memorial Stone	Low	Major	Moderate
3	High Glen Croe	Farmstead, enclosures and kiln	Low	Major	Slight
4 (A, B and D)	Mid Glen Croe	A: Hut Circles or Cairn (possible) B: Rig – Bank and track D: Buildings (possible longhouses)	Low Low Low	Major Major Major	Slight Slight Slight
7	Laigh Glencroe	Farmstead, sheepfold	Low	Major	Slight
11	Dumbarton–Tarbet–Inveraray–Tyndrum Military Road	Military Road	Low	Major	Slight
Historic LandscapeType A		Moorland and Rough Grazing	Negligible	Negligible	Neutral

Site No.	Site Name	Site Type	Value	Magnitude of Impact	Significance of Effect
Historic LandscapeType B		Coniferous Plantation	Negligible	Negligible	Neutral

Table 7-17: Potential Effects on Cultural Heritage Assets within the Blue Corridor (Construction)

The Blue corridor could potentially affect nine cultural heritage assets. The significance of the effect on any physical impact on the Rest and Be Thankful Memorial Stone (Site 2) has been assessed to be Moderate. The significance of any physical impact on six additional archaeological sites has been assessed to be Slight.

Construction activities, including the movement of construction traffic would not significantly change the glen floor or valley site location, which is a defining characteristic of their setting of the other assets. The magnitude of impact on the setting of these sites has been assessed to be No Change and the significance of effect as Neutral.

Alignments within the Blue corridor also have potential to impact on unknown archaeological remains. At present it is not possible to assess the significance of this effect.

Given the small areas of Historic Landscape Types A and B that would be potentially affected the impact on these sites has been assessed to be Neutral.

(d) Purple Corridor

Site No.	Site Name	Site Type	Value	Magnitude of Impact	Significance of Effect
1	Loch Restil	Building (remains)	Low	Major	Slight
3	High Glen Croe	Farmstead, enclosures and kiln	Low	Major	Slight
4 (A, B and D)	Mid Glen Croe	A: Hut Circles or Cairn (possible) B: Rig – Bank and track D: Buildings (possible longhouses)	Low Low Low	Major Major Major	Slight Slight Slight
7	Laigh Glencroe	Farmstead, sheepfold	Low	Major	Slight
11	Dumbarton–Tarbet–Inveraray–Tyndrum Military Road	Military Road	Low	Major	Slight
Historic Landscape Type A		Moorland and Rough Grazing	Negligible	Negligible	Neutral
Historic Landscape Type B		Coniferous Plantation	Negligible	Negligible	Neutral

Table 7-18: Potential Effects on Cultural Heritage Assets within the Purple Corridor (Construction)

The Purple corridor could potentially affect nine cultural heritage assets. The impact of the removal of seven archaeological sites has been assessed to be Slight. Given the small areas of Historic Landscape Types A and B that would be potentially affected, the impact on these assets has been assessed to be Neutral.

While construction activities would be visible and heard from the Rest and Be Thankful Memorial Stone (Site 2), the views to the southeast, connection with the A83, the Dumbarton–Tarbet–Inveraray–Tyndrum Military Road (Site 11) and the cultural associations with communications through the glen would be maintained. The magnitude of impact on the setting of this site has been assessed to be No Change and the significance of effect as Neutral.

Construction activities, including the movement of construction traffic would not significantly change the glen floor or valley site location which is a defining characteristic of their setting of the other assets. The magnitude of impact on the setting of these sites has been assessed to be No Change and the significance of effect as Neutral.

Alignments within the Purple corridor also have potential to impact on unknown archaeological remains. At present it is not possible to assess the significance of this effect.

(e) Green Corridor

Site No.	Site Name	Site Type	Value	Magnitude of Impact	Significance of Effect
9	Croe Water	Farmstead, Head Dyke	Low	Major	Slight
11	Dumbarton–Tarbet–Inveraray–Tyndrum Military Road	Military Road	Low	Major	Slight
Historic Landscape Type A		Moorland and Rough Grazing	Negligible	Negligible	Neutral
Historic Landscape Type B		Coniferous Plantation	Negligible	Negligible	Neutral

Table 7-19: Potential Effects on Cultural Heritage Assets within the Green Corridor

The Green Corridor could potentially affect four cultural heritage assets. The significance of the impact resulting from the removal of remains associated with the Dumbarton–Tarbet–Inveraray–Tyndrum Military Road (Site 11) and the Croe Water Farmstead and Head Dyke (Site 11) has been assessed to be Slight.

While construction activities would be visible and heard from Rest and Be Thankful Memorial Stone (Site 2), the views to the south-east, connection with the A83 Dumbarton–Tarbet–Inveraray–Tyndrum Military Road (Site 11) and the cultural associations with communications through the glen would be maintained. The magnitude of impact on the setting of this site has been assessed to be No Change and the significance of effect as Neutral.

Construction activities, including the movement of construction traffic would not significantly change the glen floor or valley site location which is a defining characteristic of their setting of the other assets. The magnitude of impact on the setting of these sites has been assessed to be No Change and the significance of effect as Neutral.

While the potential for this corridor to have unknown archaeological remains has been reduced by forestry plantation, alignments within the Green corridor still have potential to impact on unknown archaeological remains. At present it is not possible to assess the significance of this effect.

Given the small areas of Historic Landscape Types A and B that would be potentially affected, the impact on these sites has been assessed to be Neutral.

7.8.4.2 Operation

For the purposes of this assessment, it is assumed that the Dumbarton–Tarbet–Inveraray–Tyndrum Military Road (Site 11) would be removed by an alignment within the Blue and Purple corridors, although this may not be the case.

Operation of a scheme within Green, Yellow, Red or Brown corridors is not anticipated to have an effect on the glen floor or side location which is a defining characteristic of their setting of the majority of heritage assets. In addition, the views to the south-east, connection with the A83 Dumbarton–Tarbet–Inveraray–Tyndrum Military Road (Site 11) and the cultural associations with communications through the glen that define the setting of the Rest and Be Thankful Memorial Stone (Site 2), would be maintained. The magnitude of effect on the setting of these sites has been assessed to be No Change and the significance of effect as Neutral.

7.8.5 Potential Mitigation

The preferred mitigation for any archaeological site is preservation in situ and this could be achieved by design to avoid or reduce effects to the cultural heritage assets.

However, where this is not feasible, preservation by record would be the appropriate alternative mitigation strategy. This could be achieved by the following measures;

- Recoding works in advanced of construction such as archaeological topographic survey, photographic survey or set piece excavations.
- Recording works during construction such as an archaeological watching brief.

7.8.6 Summary of Assessment

In terms of cultural heritage, the Red or Brown corridors are preferred as they are not anticipated to have a direct effect on any known cultural heritage assets or the setting of any known assets. In addition, on the basis of available information these corridors are located in areas of Negligible archaeological potential and it unlikely that the works would have an effect on any unknown remains that may be present.

Both the Yellow and Green corridors have potential to physically have an effect on known cultural heritage assets and unknown archaeological remains. In comparison with the Green corridor, the Yellow corridor is slightly more preferable as this

corridor would have effects on fewer known assets and is located in an area of lower potential for the presence of unknown archaeological remains.

The Purple and Blue corridors are the least preferred due to the potential physical effects on the highest number of archaeological remains and these corridors are also located in areas with the highest potential for the presence of unknown archaeological remains. Of these two corridors, the Blue is the least preferred due to the potential for a physical effect on the Rest and Be Thankful Stone (Site 2), a Category C (S) Listed Building.

Corridor Option	Preferred	Intermediate	Least Preferred
Red	✓		
Brown	✓		
Yellow		✓	
Blue			✓
Purple			✓
Green		✓	

Table 7-20: Environmental Impacts Table – Cultural Heritage

7.8.7 Recommendations for Further Work

The scoping level of assessment undertaken is considered appropriate to inform the further stages of assessment for the Brown and Red corridors. Therefore, no further assessment is required for either of these corridors if they are taken forward to Stage 2.

Should a DMRB Stage 2 assessment be progressed following this study, a Simple assessment for the sub-topics of archaeological remains and historic buildings should be undertaken to inform further assessment of the Purple, Blue, Green or Yellow corridors. This should be based on a desk-based assessment and potentially a walkover survey.

The scoping level of assessment undertaken is also considered appropriate to inform further assessments for the Purple, Blue, Green or Yellow Corridors on the Historic Landscape sub-topic. Therefore, should Stage 2 be progressed no further Historic Landscape assessment is required for these corridors.

7.9 Air Quality

7.9.1 Introduction

This section describes the assessment of potential effects of the six corridors on air quality, taking into consideration the local effect on humans, vegetation and ecosystems and global effects in terms of greenhouse gases.

The two main traffic-related pollutants which can affect human health are nitrogen dioxide (NO_2) and PM_{10} (particulate matter, which includes smoke).

The Air Quality Strategy for England, Scotland and Northern Ireland (DEFRA, 2007) sets the policy framework for air quality in the UK. The strategy identifies air quality standards for priority pollutants such as NO_2 and PM_{10}.

For sites designated for their flora or fauna conservation value, the airborne concentration (critical level) of nitrogen oxides (NOx) is regulated as the pollutant can have an adverse effect on sensitive vegetation. A limit value for the protection of vegetation is set within the Air Quality Strategy. Also the deposition of nitrogen alters ecosystems, since it is a plant nutrient. 'Critical loads' of the mass of pollutant deposition per hectare per year are defined for various habitats in Europe. Where critical loads are exceeded, habitat changes are likely, and the relevant authority may object to development proposals which increase the exceedence of critical loads.

Combustion of fossil fuels by road transport gives rise to emissions of carbon dioxide (CO_2). CO_2 is the main greenhouse gas in the atmosphere. A global change in climate and the Earth's average temperature is attributed mainly to the man-made emissions of CO_2 from fossil-fuel combustion since the industrial revolution.

7.9.2 Approach and Methods

A scoping assessment, based on DMRB Volume 11, Section 3, Part 1 (Highways Agency et al., 2007) has been undertaken. The objective of scoping is to determine whether there are likely to be significant effects associated with broadly defined corridors. As part of the DMRB assessment method, 'affected roads' are determined against the following criteria:

- Road alignment will change by 5m or more; or
- Daily traffic flows will change by 1,000 annual average daily traffic (AADT) or more; or
- Heavy Duty Vehicle (HDV) flow will change by 200 AADT or more; or
- Daily average speed will change by 10 km/h or more; or
- Peak hour speed will change by 20 km/h or more.

At this scoping stage, not all these criteria can be evaluated explicitly, but the implications of likely changes can be assessed by comparing the 'Do Minimum' (DM) scenario (the existing A83 alignment) to the six proposed 'Do Something' (DS) route corridors.

Residential properties and nature conservation sites ('designated sites') within 200m of the existing A83 have been identified, and potential for air quality change at these receptors as a result of the six proposed route corridors has been assessed.

7.9.3 Baseline Conditions

Baseline air quality in Argyll and Bute is generally very good, as there are few sources of pollution and background concentrations are low. Argyll and Bute Council has not declared any Air Quality Management Areas or any areas exceeding the air quality standards.

Given that the A83 has an AADT flow of approximately 4,000 vehicles (Transport Scotland, 2010), the current effect of traffic emissions on airborne pollutant concentrations would be relatively small. The consequence of this is that the air quality is well within the standards for NO_2 and PM_{10}.

There are two residential properties in the Croe Valley to the south-west of the A83:

- A property at High Glencroe is situated at the northern extent of the valley (grid ref. 223325, 706979), approximately 270m from the A83.
- A property to the south of Laigh Glencroe (referred to as 'Laigh Glencroe') is situated further south adjacent to the Old Military Road (grid ref. 224421, 706979), approximately 26m from the A83.

In the absence of monitored background pollutant concentrations for the scheme area, background concentration data for the pollutants NO_x, NO_2 and PM_{10} are taken from national background maps contained on the Defra UK-AIR: Air Information Resource website.

The data is obtained from model predictions for 2010. Year adjustment factors are applied to the predictions to forecast background concentrations in 2013 (the assessment year).

Data from the 1km grid square which is most representative of the residential receptors identified in this assessment (grid reference 224500, 705500) are presented in Table 7-21: below. The table shows that background concentrations fall well below the air quality standards.

Pollutant	Concentration ($\mu g/m^3$)	Air Quality Objectives Concentration ($\mu g/m^3$)	Measured as
PM_{10}	8.7	18 .0	Annual Mean
		50.0	24 Hour Mean (not to be exceeded more than 7 times a year)
Nitrogen dioxide (NO_2)	2.7	40 .0	Annual Mean
		200	1 Hour Mean (not to be exceeded more than 18 times a year)
Nitrogen oxides NOx – for the protection of vegetation and ecosystems)	3.4	30	Annual Mean

Note: AQS Objective for the protection of vegetation and ecosystems considers the presence of lichen communities and bryophytes.

Table 7-21: Mapped Background Pollutant Concentrations at grid reference 224500, 705500 for 2013 from the Defra UK-AIR: Air Information Resource (UK-AIR)

Background nitrogen deposition and acid deposition rates along with critical loads are available from the UK Air Pollution Information System (APIS) web site (APIS.ac.uk). These data are specific to habitat types and locations.

The Beinn an Lochain Site of Special Scientific Interest (SSSI) contains habitats which are vulnerable to nutrient nitrogen deposition. The specific nutrient nitrogen deposition and acid deposition for the site is presented in Table 7-22: below. The data has not been pro-rated to 2013 and as such is a conservative approach.

National Grid Reference	Notified Natural Features	Assessed Habitat Type	N Deposition (kgN/ha/yr)	N Deposition Critical Load range (kgN/ha/yr)	Acid N Deposition (keqN/ha/yr)	Acid N Deposition Critical Level (keqN/ha/yr)
NN204080	Biological Upland Habitats	Upland Assemblage	18.36	5 - 10	1.3	0.8

Table 7-22: Current Habitat Type Deposition Site Conditions for Beinn an Lochain SSSI (APIS, 2005)

Exceedence of a critical load (CL) is not a quantitative estimate of damage to a particular habitat, but represents the potential for damage to occur.

The critical loads for nutrient nitrogen deposition are as low as 5 kgN/ha/year for the habitat assessed so are currently likely to be exceeded within the site. Acidity critical loads are also shown to be currently exceeded. The deposition is due to long-range transport of combustion pollutants.

7.9.3.1 Future Baseline

As explained in Section 4.2, works are currently underway in the Glen Croe valley to provide additional landside protection to the existing A83 and to enable use of the Old Military Road as an Emergency Diversion Route during any A83 road closures (referred to as the 'Do Minimum' scenario).

The Old Military Road is approximately 150m and 98m respectively, from the residential receptors High Glencroe and Laigh Glencroe. When traffic is re-directed onto the Old Military Road, traffic emissions are temporarily moved closer to the residential receptors, consequently increasing airborne pollutant concentrations during this period. It is unlikely that such temporary diversions would contribute to a significant change in air quality or result in an exceedence of air quality standards, given the anticipated volume of traffic.

7.9.4 Potential Environmental Effects

7.9.4.1 Construction

The only potentially significant effects on air quality arising from the construction of any of the corridors are anticipated to be a result of the generation of nuisance dust. Nuisance dust may affect locations up to 200m from the dust source, dependent on meteorological conditions and the source strength. As High Glencroe is located within the boundaries of the Blue and Purple corridors, there is potential for nuisance dust effects on this receptor during construction. However, nuisance dust

does not have significant public health implications, and would be of short duration, and can be mitigated.

7.9.4.2 Operation

(a) Local Air Quality

In terms of 'affected roads', it is assumed that the only affected road to be considered is a section of the A83. None of the corridors are anticipated to increase traffic flows or speeds.

Emissions from road traffic would typically affect local air quality at residential receptors within 200m. The proposed corridor options would in most cases result in a change in distance from pollution source to the receptor. To inform qualitative consideration of the likely changes to air quality at these receptors, the nearest and furthest points of each of the corridors as they pass the receptors has been estimated, as tabulated below.

The existing A83 road alignment is approximately 270m and 26m respectively from the nearest façade of the identified residential receptors, High Glencroe and Laigh Glencroe. The SSSI is situated within 10m of the existing A83 road alignment.

Receptor	Distance (m)	Corridor					
		Red	Brown	Yellow	Blue	Purple	Green
High Glencroe	Nearest	270	270	180	within	within	165
	Furthest	270	270	248	within	within	436
Laigh Glencroe	Nearest	500	497	667	60	65	257
	Furthest	500	497	667	273	274	512
SSSI	Nearest	320	320	130	within	within	within

Table 7-23: Distances (m) to Receptors and Designated Site (SSSI)

(a).1 Red Corridor, Yellow Corridor and Brown Corridor

Realignment of the A83 within the Red, Yellow and Brown corridors would be at sections to the north, approximately 500m or more from Laigh Glencroe. The façade of Laigh Glencroe is approximately 26m away from the current A83 centreline at its nearest point, and this would be unchanged under any of these corridor options. As such, no changes to local air quality at this receptor are anticipated.

The realignment of the A83 within the Red and Brown corridors is unlikely to affect air quality at High Glencroe as the receptor distance remains unchanged. However, the yellow corridor brings the road alignment closer to High Glencroe and therefore a slight change in air quality is possible.

For the Red corridor, the Old Military Road would still be used for emergency diversions in the event of a road closure. As discussed above, temporary traffic diversions are not anticipated to have any significant implications for local air quality.

(a).2 Blue Corridor and Purple Corridor

These off-line corridors which remove the traffic from the current A83 are anticipated to improve air quality at Laigh Glencroe, and potentially worsen it at High Glencroe,

which is located within the Blue and Purple corridors. The degree to which the air quality is affected at High Glencroe depends on how far the route alignment selected is located from the property. However, the net change is unlikely to be classified as significant, as the background air quality is good, and the road traffic is relatively low.

(a).3 Green Corridor

The potential effect of the Green corridor on local air quality at High Glencroe is anticipated to be non-significant as the alignment is likely to be at least 165m away. It is anticipated that air quality may improve at Laigh Glencroe with this corridor, as pollution source (road alignment) and receptor distance is increased from 26m to approximately 257m at the nearest façade.

(b) Designated Sites

(b).1 Red Corridor, Brown Corridor and Yellow Corridor.

These on-line corridors are not anticipated to have any adverse effects on the SSSI.

(b).2 Blue Corridor, Purple Corridor and Green Corridor

These off-line corridors could potentially increase nitrogen deposition slightly within the SSSI. This effect could be potentially significant (the increase would be more than 1% of the lower critical load) in accordance with the Environment Agency Horizontal Guidance Note – H1 Annex F.

(b).3 Regional Emissions (all corridors)

For regional emissions, any option which increases the distance travelled by vehicles would potentially increase emissions. There are no criteria published for determining the significance of effects on regional emissions. Internal comparisons between options are therefore likely to be more useful once these have been generated. At this stage route alignments are not available therefore the contribution to regional emissions for each corridor cannot be quantified. Although a quantitative assessment of the effect is not possible at the scoping stage, a judgement based on changes in corridor length and potential emissions can be undertaken, as set out below.

The longest alignment will be likely to have the greater effects on greenhouse gas emissions. The northern extent of the Blue and Green corridors to the foot of Loch Restil is approximately 3.9km. A route in the Blue or Purple corridor could potentially be shorter than the existing A83, thus reducing emissions. The Green corridor is likely to be longer than the current A83 (approximately 3.7km), therefore increasing emissions compared to the on-line corridors (Red, Brown and Yellow).

The Emergency Diversion Route (Old Military Road) is 4.0km in length. It is not included in the regional assessment as it is an emergency corridor and therefore traffic will only be using it for short periods of time.

7.9.5 Potential Mitigation

During construction the Contractor should apply best practice mitigation measures to control dust and air pollution. Examples of this may include implementing a Dust and Air Quality Management Plan to reduce the effects of dust from the

transportation and storage of materials and to limit emissions from construction plant and vehicles. Also, agreeing a haul route for construction traffic, specific site access and egress points and hours of operation with the local authority.

For human health and nature conservation receptors, air quality effects of road schemes can generally be mitigated only by selecting the road alignment. Once the alignment is chosen, there are no post-design mitigation measures which are known to be effective in reducing airborne concentrations of pollutants arising from traffic emissions. The greater the distance between receptor and pollutant source (road traffic), the lower its effect will be on that receptor.

7.9.6 Summary of Assessment

7.9.6.1 Local Air Quality

There is little to distinguish the corridors in terms of their effect on local air quality at the two identified receptors. In general, the off-line corridors would improve air quality at Laigh Glencroe, and worsen it at High Glencroe, but this change is not considered to be significant.

7.9.6.2 Designated Sites

The Blue, Purple and Green corridors would potentially worsen nutrient nitrogen deposition at Beinn an Lochain SSSI. These effects are anticipated to be significant for a narrow section along the road. It is unlikely that nutrient nitrogen deposition would change significantly as a result of the Red, Brown and Yellow corridors.

7.9.6.3 Regional Emissions

The qualitative judgement of potential changes relevant in the context of contribution to regional emissions indicated that the Blue corridor may give rise to comparatively higher greenhouse gas emissions as it is the longest route, and that a route in the Purple corridor could potentially be shorter than the existing A83, thus reducing emissions. The Red, Brown and Yellow corridors are similar and intermediate in terms of corridor length.

7.9.6.4 Air Quality Impact Tables

A summary of the least/most and intermediate preferred corridor against local air quality, designated sites and regional emissions is tabulated below.

Corridor Option	Preferred	Intermediate	Least preferred
Red			✓
Brown			✓
Yellow			✓
Blue		✓	
Purple		✓	
Green	✓		

Table 7-24: Environmental Impact Table - Human Health (Air Quality)

Corridor Option	Preferred	Intermediate	Least preferred
Red	✓		
Brown	✓		
Yellow	✓		
Blue		✓	
Purple			✓
Green			✓

Table 7-25: Environmental Impact Table -Ecological (Air Quality)

Corridor Option	Preferred	Intermediate	Least preferred
Red		✓	
Brown		✓	
Yellow		✓	
Blue	✓		
Purple	✓		
Green			✓

Table 7-26: Environmental Impact Table - Regional (Air Quality)

A review of the information presented in the impact tables above demonstrates that the Blue corridor is the most preferred option in terms of overall air quality effects. The Red, Brown, Yellow and Purple corridors are intermediate options and the Green corridor is the least preferred option, with the exception of the human health air quality where it is the preferred.

7.9.7 Recommendations for Further Work

On the basis of this scoping assessment, once the route alignments have been chosen, a Simple Assessment is recommended to quantify the effects on the two residential properties and the designated SSSI, Beinn an Lochain, to quantify the change in emissions. If the screening for the Simple Assessment determines that there are no qualifying changes arising from the route alignment chosen, then there is no requirement for any further assessment of air quality.

Effects on regional emissions should therefore be assessed in completeness at DMRB Stage 2, should this be progressed, once further information is available.

7.10 Noise and Vibration

7.10.1 Introduction

This section assesses the potential noise and vibration effects on sensitive receptors as a result of the six proposed corridors.

7.10.2 Approach and Methods

This assessment has been undertaken in accordance with DMRB, Volume 11, Section 3, Part 7 guidance for a Scoping Assessment. To determine whether the assessment continues to the next stage, the Scoping Assessment should identify whether the threshold values (see below) are likely to be met or exceeded:

- whether there is likely to be a change in noise level of 1 dB $L_{A10,18h}$ or more in the short-term or 3 dB $L_{A10,18h}$ in the long-term at any sensitive receptor within the study area;
- whether there is likely to be a change in noise level of 3 dB $L_{night,outside}$ or more in the long term at any sensitive receptor within the study area where an $L_{night,outside}$ greater than 55 dB is predicted; and
- whether there is likely to be an increase in the peak particle velocity (PPV) level of ground-borne vibration at any sensitive receptors within the study area to above a level of 0.3 mm/s, or an existing level above 0.3 mm/s is predicted to increase.

This can be determined by examining if any of the following conditions are likely to be met:

- the road project alters the alignment of any existing carriageways. This would include new sections of road, additional junctions and slip roads, and hence could result in the introduction of a new noise or vibration source, or a change to noise or vibration levels from an existing road source;
- changes in traffic volume on existing roads or new routes may cause either of the threshold values for noise to be exceeded. A change in noise level of 1 dB $L_{A10,18h}$ is equivalent to a 25% increase or a 20% decrease in traffic flow, assuming other factors remain unchanged and a change in noise level of 3 dB $L_{A10,18h}$ is equivalent to a 100% increase or a 50% decrease in traffic flow;
- changes in traffic speed or proportion of heavy vehicles on the existing roads or new routes may cause a change in noise level of 1 dB $L_{A10,18h}$ in the short-term or 3 dB $L_{A10,18h}$ in the long-term either during construction, including temporary diversion routes, or when the road project is completed;
- changes in traffic volume, composition and speed on existing roads or new routes during the night may cause the long-term night time threshold value to be exceeded; and
- any physical changes to the infrastructure surrounding the road or any change in the way in which the existing road is used that could cause a change in noise level of 1 dB $L_{A10,18h}$ in the short-term or 3 dB $L_{A10,18h}$ in the long-term. This could include, but not be restricted to, such works as re-

surfacing, congestion management schemes, bridge building and barrier installation.

For the purposes of this assessment, it is assumed that there would be no change to traffic flows, speed or composition for any of the corridors. The assessment is therefore based on the likely changes resulting from the proposed road re-alignments and associated changes in topography between the road and nearby sensitive receptors.

Beinn an Lochain Site of Special Scientific Interest (SSSI) has been included as a sensitive noise receptor due to the likelihood of hillwalkers in this area.

Consultation was undertaken with Argyll and Bute Council Environmental Health Officer (EHO).

7.10.3 Baseline Conditions

No noise monitoring has been undertaken as part of this assessment and the Scottish Government's noise maps do not extend to this area. However, it is anticipated that the main source of noise in this area is from road traffic on the existing A83.

This section of the A83 is very remote and there are only two residential properties within the Glen Croe valley (Laigh Glencroe and High Glencroe), as shown on Drawing Number B1557610/WP03/001-003:

- The residential property to the south of Laigh Glencroe (referred to as Laigh Glencroe) is situated approximately 26m away from the existing A83, at a lower level than the road and therefore partially screened from road traffic.
- Residential property High Glencroe is situated approximately 270m away from the existing A83, at a lower level than the road towards the bottom of the valley. This property is also partially screened from road traffic using the existing A83.

Beinn an Lochain SSSI is located to the northwest of Glen Croe valley, as shown on Drawing Number B1557610/WP03/001-003.

7.10.3.1 Future Baseline

The future baseline, referred to as the Do Minimum, includes changes from the existing baseline such as use of the Old Military Road as an Emergency Diversion Route in the event of landslides on the A83. During such events, road traffic would pass by High Glencroe at closer proximity than it does on the A83, resulting in temporary adverse noise effects for this property.

7.10.4 Potential Environmental Effects

Argyll and Bute Council Environmental Health Officer (EHO) did not respond to the consultation letter and specific queries regarding noise; it is therefore assumed they have no issues or concerns regarding this assessment.

The potential for significant noise and vibration effects for each of the corridors has been assessed for construction and operation, as described below.

7.10.4.1 Construction

Given the steep local topography and rocky nature of the area, there is the potential for noisy construction activities such as rock blasting to be necessary, depending upon the corridor and works required.

(a) Red Corridor and Brown Corridor

The Red and Brown corridors would entail online improvements to the A83 approximately 270m from High Glencroe. No works are proposed to the A83 in the vicinity of Laigh Glencroe, with the nearest extent of the Red and Brown corridors being approximately 497m and 500m respectively to the north of this property.

The northern extent of the Red and Brown corridors is approximately 320m from the boundary of the SSSI.

Construction works would be at least 497m away from the nearby receptors. As such, construction effects associated with the Red and Brown corridors are likely to be relatively minor compared to the other corridors considered.

(b) Yellow Corridor

The closest distance between the Yellow corridor and Laigh Glencroe is over 667m. The corridor is approximately 130m from the SSSI. The Yellow corridor would bring the A83 closer to High Glencroe, the closest distance being 180m, depending on where the route alignment sits within the corridor.

In construction noise terms, the construction works would be approximately 180m away from High Glencroe. On this basis, minor to moderate construction effects are anticipated for this corridor option.

(c) Purple Corridor

The closest distance between the Purple corridor and Laigh Glencroe is approximately 65m. High Glencroe is located within the Purple corridor and therefore construction activities could potentially be within very close proximity to this receptor.

The Purple corridor is also located within the SSSI at its north-western end. In the absence of mitigation, there is the potential for substantial construction noise and vibration effects on nearby receptors.

(d) Blue Corridor

The closest distance between the Blue corridor and Laigh Glencroe is approximately 60m. High Glencroe is located within the Blue corridor and therefore construction activities could potentially be within very close proximity to this receptor.

Construction works are likely to take place within the SSSI itself. Construction works are likely to be for a considerable duration for this corridor.

In the absence of mitigation, potentially substantial construction noise and vibration effects on receptors could therefore occur.

(e) Green Corridor

The Green corridor is off-line within Glen Croe in the area of forestry on the south-west side of the valley, at a similar height to the Laigh Glencroe residence on the near side of the valley. Potential route options in this corridor would provide a new 3.5km single carriageway from the start of the Emergency Diversion Route to the B828 which would be upgraded to become the A83 before joining the existing road north of the car park at Rest and Be Thankful.

The closest distance between the Green corridor and Laigh Glencroe is approximately 257m. The closest distance between this corridor and High Glencroe is approximately 165m. The Green corridor is located within the SSSI at its north-western end.

Construction works could therefore be approximately 257m away from Laigh Glencroe. The works could potentially be as close as 165m or as far away as 436m for High Glencroe. Construction works would take place within the SSSI itself.

7.10.4.2 Operation

As detailed previously, the nearby Laigh Glencroe residence is situated approximately 26m away from the existing A83, at a lower level than the road and is partially screened from road traffic using it as a result. The High Glencroe residential property is situated approximately 270m away from the existing A83, at a lower level than the road towards the bottom of the valley. The property is also partially screened from road traffic using the existing A83 as a result.

(a) Red Corridor and Brown Corridor

As these are both on-line corridors and the assessment at this stage assumes no alteration of traffic flows, speed or composition, there are not anticipated to be any significant changes in operational noise levels for either of the residential properties or for the SSSI.

(b) Yellow Corridor

The Yellow corridor would not involve any changes to the A83 in the vicinity of Laigh Glencroe, with the nearest extent of the Yellow corridor being over 667m from Laigh Glencroe. Therefore there are not anticipated to be any significant changes in operational noise levels for the Laigh Glencroe residence. The northern extent of the Yellow corridor could move the A83 marginally closer the SSSI, but no significant noise changes are anticipated.

High Glencroe would be in closer proximity to the re-aligned A83 for the Yellow corridor, with the road being moved up to 90m closer depending on its location within the corridor. It is anticipated that this may result in a negligible to slight adverse noise effect at High Glencroe.

(c) Blue Corridor

High Glencroe is located within the Blue corridor and, as such, could be located in very close proximity to the re-aligned A83. Therefore, there is the potential for an increase in noise levels at this property from road traffic.

A realigned A83 within the Blue corridor would be approximately 60 to 273m away from Laigh Glencroe. The property would be elevated, overlooking the re-aligned A83, whereas currently it is partly screened from it. There may therefore be adverse or beneficial effects, depending on where the alignment sits within the corridor.

The Blue Corridor extends into the SSSI at its north-western end and could potentially result in increased noise levels in the SSSI.

(d) Purple Corridor

High Glencroe is located within the Purple corridor and, as such, could be located in very close proximity to the re-aligned A83. Therefore, there is the potential for a significant increase in noise levels at this property as a result.

The Purple corridor is approximately 65 to 274m away from Laigh Glencroe. Laigh Glencroe would sit on the valley side overlooking the road below, potentially as close as 65m but could also be 274m away. There may therefore be adverse or beneficial effects, depending on where the alignment sits within the corridor.

The Purple Corridor includes a section passing through the SSSI and could therefore potentially have the greatest noise effect on the SSSI.

(e) Green Corridor

The Green corridor is approximately 257 to 512m away from Laigh Glencroe and 155 to 460m away from High Glencroe. The Green corridor is located within the SSSI at its north western end.

The considerable increased distance from the A83 is likely to have a significant beneficial effect on the noise levels experienced at Laigh Glencroe.

High Glencroe is located at 270m from the existing A83. With this corridor, High Glencroe is likely to be at a similar distance, but could potentially be closer or further away. Therefore, the noise effect would range from minor beneficial to minor adverse, depending upon the exact alignment within this corridor.

Noise levels would be increased within the SSSI adjacent to the route corridor.

7.10.5 Potential Mitigation

Construction mitigation relates generally to implementation of best practice such as the measures detailed in BS 5228: 2009 parts 1 and 2. There is the potential to construct temporary barriers or screening mounds, depending upon the route and relative heights of the construction works and receptors.

As part of the operational scheme, there is the potential for the inclusion of noise screening, although its effectiveness is likely to be limited where sensitive receptors are elevated and overlooking the road. There is also the potential for screening effects to be created using the existing topography, although again the effectiveness is likely to be limited where sensitive receptors are elevated and overlooking the road.

7.10.6 Summary of Assessment

As noted previously, the area is very remote and only two residential properties and a SSSI have been identified as sensitive receptors. As such, the table provided in Table 7-27: below should be considered in that context.

There is considered to be little difference between the anticipated overall noise effects for the Brown, Green, Yellow and Red corridors. As one of the residential properties is located within the Blue and Purple corridors, the potential noise effect is anticipated to be greater for these two corridors. A section of the Purple corridor is located within the SSSI and also involves tunnelling through this area. As such, it is considered to have the greatest potential for adverse noise effects compared to the other corridors.

Corridor Option	Preferred	Intermediate	Least Preferred
Red	✓		
Brown	✓		
Yellow	✓		
Blue			✓
Purple			✓
Green	✓		

Table 7-27: Environmental Impacts Table - Noise and Vibration

7.10.7 Recommendations for Further Work

Potentially significant noise effects are anticipated for the Yellow, Blue, Purple and Green corridors (depending upon the exact location within the corridor). It is therefore recommended further assessment is undertaken if any of these corridors are taken forward to Stage 2.

7.11 Pedestrians, Equestrians, Cyclists and Community Effects

7.11.1 Introduction

This section assesses the potential effects on journeys made by pedestrians, cyclists and equestrians. For ease of reference the term 'Non-Motorised Users' (NMUs) is used to describe this group.

7.11.1.1 Land Reform (Scotland) Act 2003

The Land Reform (Scotland) Act 2003 Part 1 ("the 2003 Act") came into effect in February 2005 and establishes statutory rights of responsible access on and over most land, and inland water. The legislation offers a general framework of responsible conduct for both those exercising rights of access and for landowners.

Local authorities are granted new powers and duties to uphold and facilitate responsible access rights. There is a duty on local authorities to prepare a plan for a path network and to keep a list of 'core paths'. Sections 13 and 19 of the 2003 Act state: *"It is the duty of the local authority to assert, protect and keep open and free from obstruction or encroachment any route, waterway or other means by which access rights may reasonably be exercised"* and "*The local authority may do anything which they consider appropriate for the purposes of maintaining a core path and keeping a core path free from obstruction or encroachment"*.

Section 10 of the 2003 Act states that it is the duty of SNH to draw up and issue a Scottish Outdoor Access Code setting out guidance in relation to access rights and responsibilities. It is the duty of SNH and local authorities to publicise the Code and for SNH to promote understanding of it. The Scottish Outdoor Access Code was drawn up by SNH and approved by the Scottish Parliament in July 2004.

7.11.1.2 Countryside (Scotland) Act 1967

Under Part III of the Countryside (Scotland) Act 1967 ('the 1967 Act') it is the duty of the local authority to ensure that public paths within their district are in *"a fit condition for use by the public"* and shall be maintained in such a condition. In addition, under the 1967 Act duty is also placed on the local authority to assert, protect and keep open and free from encroachment any public rights of way within its area.

7.11.2 Approach and Methods

This assessment has been undertaken following the guidance in DMRB Volume 11, Section 3, Part 8. Potential effects on NMUs focuses on the following three main aspects:

- changes in journey lengths and times (as a result of severance);
- likely changes in the amenity value of journeys; and
- changes in links between communities and their facilities.

An assessment of community severance is not required at Stage 1 (though would be considered at Stage 2).

Change in amenity value has been assessed qualitatively based on changes in air quality, noise, landscape/visual and safety.

The study area for this assessment is defined by the corridor boundaries, therefore only paths that fall within the corridors are discussed below.

Baseline data have been collected through review of:

- Ordnance Survey (OS) Explorer Map 364;
- Jacobs' GIS Database;
- Loch Lomond and the Trossachs National Park Core Path Plan (2010);
- Scottish Paths Record (SNH); and
- Various online information resources.

Consultation was undertaken with Argyll and Bute Council, Loch Lomond and the Trossachs National Park (LLTNP), SNH, Scotways and the Forestry Commission Scotland. Information on core paths, rights of way and other undesignated paths was provided through the consultation process.

7.11.3 Baseline Conditions

Drawings B1557610/WP03/007-010 show the paths in and around the study area.

7.11.3.1 NMU Routes

Glen Croe is within the boundaries of LLTNP and is therefore very popular with hillwalkers. It is surrounded by numerous Munros and Corbetts including Beinn Luibhean, Ben Donich and The Cobbler. There are therefore a number of designated and undesignated paths in the valley, as described below.

There is one core path located in the Glen Croe valley, known as the Gleann Mor to Glencroe core path. The core path heads in a north-west direction along the west side of the valley, through the coniferous plantation woodland. At the northern extent of the valley, the path heads west to Gleann Mor. The path is also promoted by the Forestry Commission Scotland as a cycling path.

There are no rights of way or National Cycle Routes (NCR) which fall within any of the corridors. However, during a site visit it was noted that the A83 is used by cyclists.

A number of undesignated paths have been identified within the Glen Croe valley referred to as 'other paths' within the LLTNP Core Path Plan, and noted on SNH's Scottish Paths Record. It is therefore assumed that the B828 is also used by cyclists, which has been taken into consideration within this assessment.

Table 7-28: lists each of the paths described above, noting which corridor they fall within. It should be noted that path references for the undesignated routes have been provided by consultees. For the purposes of this assessment, paths which follow the same route alignment, but may be split by different reference numbers, are assessed as one path.

Path Reference	Description	Corridor
Core Paths		
Gleann Croe to Glen Mor	Core path heads in a north-west direction along the western slopes of the Glen Croe valley, through the coniferous plantation woodland. At the northern extent of the valley, the path heads west to Gleann Mor.	Green Corridor Blue Corridor Purple Corridor
Undesignated Paths		
ARTT/313/1/ ARTT/347/1/ ARTT/478/1	Old Military Road leading to the Rest and Be Thankful car park.	Blue Corridor Yellow Corridor Purple Corridor Green Corridor
ARTT/263/1	Short section of path leading off the Old Military Road providing access to High Glencroe.	Blue Corridor Purple Corridor
ARTT/202/1	Path leading off core path, providing access to the summit of Ben Donich.	Green Corridor Blue Corridor
ARTT/332/1/ ARTT/398/1/ ARTT/368/1	Path heads in a north-west direction along the western slopes of the Glen Croe valley, through the coniferous plantation woodland, joining up with the core path at the northern extent of the valley.	Green Corridor
ARTT/187/1/ ARTT/87/1	Path connects ARTT/332/1/ ARTT/398/1/ ARTT/368/1 and ARTT/313/1/ ARTT/347/1/ ARTT/478/1.	Green Corridor
CNDW/81/1	Path leading off the A83 north of Loch Restil and heads north-east into plantation woodland, where it appears to end.	Purple Corridor

Table 7-28: All Paths Identified within the Corridors

7.11.3.2 Community Facilities

The Rest and Be Thankful car park and viewpoint, located at the northern extent of the valley, is a popular attraction for people travelling through this area as it provides clear views along the Glen Croe valley. There is also an information board and at times a catering van within the car park area.

The closest community facilities in terms of shops and post offices are located in Arrochar, approximately 5km from the Glen Croe valley.

7.11.3.3 Future Baseline Conditions

As explained in Section 4.2, works are currently underway in the Glen Croe valley to provide additional landside protection to the existing A83 and to enable use of the Old Military Road as an Emergency Diversion Route during any A83 road closures (referred to as the 'Do Minimum' scenario). The works on the Old Military Road will be completed prior to construction of any of the A83 options considered as part of this Stage 1 assessment.

Access along this path (ARTT/313/1/ ARTT/347/1/ ARTT/478/1) may, therefore, be temporarily disrupted if and when the Emergency Diversion Route is in use. This has been taken into account in the assessment of the six corridors.

7.11.4 Potential Environmental Effects

7.11.4.1 Construction

(a) Red and Brown Corridors

As indicated in Table 7-28: above, no paths or designated cycleways fall within the Red corridor. However, as the A83 trunk road is known to be used by cyclists and works within this corridor would be online, there is the potential for temporary disruption to journeys during construction. Journey times for cyclists using the A83 may increase during traffic management operations. Adverse amenity impacts on cyclists could potentially arise as a result of construction activities e.g. dust and noise.

These potential effects are temporary and cyclists are currently already experiencing journey disruption as a result of road closures, effects are therefore considered to be non significant.

(b) Yellow Corridor

A short section of path ARTT/347/1 (the Old Military Road), is located along the boundary of the Yellow corridor. NMUs using this path may therefore experience adverse amenity effects in the form of noise and dust as a result of construction activities. This path provides access to the Rest and Be Thankful viewpoint.

These potential effects are temporary and are likely to be experienced along a short section of the path only, effects are therefore considered to be non significant.

(c) Blue Corridor

The Glen Croe to Gleann Mor core path passes through the north-west section of the Blue corridor. NMUs using this core path could therefore potentially experience adverse amenity effects in terms of noise and dust during construction. As the path is located close to the edge of the corridor boundary no temporary adverse effects on journey length are anticipated.

Three undesignated paths, the Old Military Road, ARTT/263/1 and ARTT/202/1, are situated within the Blue corridor. NMU journeys along these paths may therefore be disrupted during construction in terms of severance and/ or amenity effects. These potential effects are temporary and are therefore considered to be non significant.

NMU journeys along the B828 road may also be temporarily disrupted during construction of the Blue corridor. There may also be adverse impacts on NMUs (e.g. cyclists) in terms of amenity along the B828 as a result of noise and dust during construction.

(d) Purple Corridor

The potential effects of the Purple corridor during construction and operation are the same as those described for the Blue Corridor above. The following additional effects could also potentially occur as a result of the Purple Corridor.

NMU access to path CNDW/81/1 could be temporarily disrupted during construction with some adverse effects on amenity.

(e) Green Corridor

NMU journeys along the northern section of the Glen Croe to Gleann Mor core path and two undesignated paths could potentially be affected during construction through temporary severance. Adverse amenity effects such as noise and dust may also occur on NMUs as a result of construction activities.

Cyclists travelling along the B828 may also experience temporary disruption during construction as a result of traffic management and adverse effects as a result of noise and dust during construction.

7.11.4.2 Operation

(a) Red Corridor

The Red corridor aims to improve the operation of the road and reduce delays to journey times, which would be beneficial to cyclists using this route. Safety provision for cyclists may also be improved by the installation of debris flow barriers and / or planting, reducing the risk of landslide debris falling onto the road.

(b) Brown Corridor

The Brown corridor aims to improve the operation of the road and reduce delays to journey times, which would be beneficial to cyclists using this route. Safety for cyclists may also be improved by the installation of landslide shelters. However, amenity in terms of views from the road may be adversely affected when cycling through the shelters.

(c) Yellow Corridor

During operation, NMUs using the northern section of the Old Military Road would be closer to traffic using the new A83 viaduct and may therefore experience adverse amenity effects in terms of visual and noise effects. No adverse effects on journey length are anticipated.

These potential effects are likely to be experienced along a relatively short section of the Old Military Road, effects are therefore considered to be non significant.

(d) Blue Corridor

As the Glen Croe to Gleann Mor core path is located close to the edge of the corridor boundary, no permanent adverse effects on journey length are anticipated. However, NMUs travelling along a short section of the core path may experience adverse visual effects as result of being closer to traffic on the new A83.

There is potential for NMU journeys along the two undesignated paths noted above to be disrupted as a result of severance by the new A83. In addition, NMUs could potentially experience adverse amenity effects in terms of visual, noise and air quality as a result of being closer to traffic on the new A83.

(e) Purple Corridor

Potential operational effects of the Purple corridor are as per those of the Blue Corridor (see above).

(f) Green Corridor

During operation, there is potential for permanent severance of the core path and one undesignated path to occur, affecting NMU journeys, however as both are located close to the western boundary of the corridor, it is possible that both paths could be avoided. Adverse amenity effects could remain as a result of change in views (due to tree felling), noise and air quality, depending on how close the new road would be to the path.

7.11.5 Potential Mitigation Measures

7.11.5.1 Construction

Mitigation during construction may include temporary diversions, this would maintain access along paths, although may result in increased journey lengths. To reduce effects on amenity, mitigation would include those specified for the landscape and visual, air quality and noise assessment (Sections 7.7, 7.9 and 7.10 respectively).

7.11.5.2 Operation

As noted in the Introduction, under the Land Reform (Scotland) Act 2003, access along core paths should be kept '*free from obstruction or encroachment*'.

Access along the Glen Croe to Gleann Mor core path should therefore be maintained and any diversion requirements agreed with the local authority and LLTNP. It may be feasible to incorporate other access mitigation measures or enhancement opportunities as part of the scheme design, and depending on which corridor option is taken forward.

Due to the popularity of the Glen Croe valley for hillwalkers, maintaining access along undesignated paths should also be subject to further consideration as the scheme proposals are progressed at Stage 2.

7.11.6 Summary of Assessment

In summary, the Yellow and Red corridors are preferred as access for cyclists using the A83 would be maintained and no paths would be affected.

The Brown corridor would maintain access for cyclists on the A83 and avoid effects on other paths. However, the amenity of cyclist journeys along this section of the A83 could be affected as a result of travelling through the landslide shelters, adversely affecting views.

The Green, Blue and Purple corridors are least preferred as there are a number of paths located within them which could be potentially affected. However, following development of an alignment in these corridors these paths could potentially be avoided.

Corridor Option	Preferred	Intermediate	Least Preferred
Red	✓		
Brown		✓	
Yellow	✓		
Blue			✓
Purple			✓
Green			✓

Table 7-29: Environmental Impacts Table - Pedestrians, Equestrians, Cyclists and Community Facilities

7.11.7 Recommendations for Further Work

Should a DMRB Stage 2 assessment be progressed following this study, a more detailed assessment should be undertaken and the magnitude and significance of effects assessed.

7.12 Vehicle Travellers

In accordance with DMRB, the two impacts with respect to vehicle travellers that should be considered are view from the road and driver stress. These shall be assessed in turn.

7.12.1 View from the road

7.12.1.1 Introduction

This section provides a description of potential views from the road that would be available from each of the proposed corridors, which would indicate the ability of travellers to see and experience the landscape around the routes.

7.12.1.2 Approach and Methods

The view from the road assessment was undertaken in accordance with DMRB Volume 11, Section 3, Part 9.

The assessment was carried out through a combination of desk study and field survey.

7.12.1.3 Baseline Conditions

Between Ardgartan and the Rest and Be Thankful, the A83 follows a meandering route along Glen Croe, with travellers experiencing a scenic journey through a section of the Loch Lomond and The Trossachs National Park that is largely undeveloped.

At the southern end of the glen near Ardgartan, the road runs through the narrow wooded valley around the Croe Water as it runs south-east towards Loch Long, with views partially restricted by the established mixed and scrub woodland on the rugged hillside to each side of the road. Views open up more as the road passes the Ardgartan Visitor Centre, with the sparser scrub vegetation around the Croe Water allowing views towards the surrounding hills and the established coniferous forestry plantations across the lower slopes of the rising landform, although views to the north are largely contained by the steep slopes of The Cobbler (Ben Arthur).

As the road turns north, views become more restricted by coniferous forestry plantations, before opening up at the edge of the Forestry Commission Scotland land, with travellers gaining attractive views to the west across the open valley. The open views allow travellers to look down into Glen Croe, with the Old Military Road visible along the valley floor, and the iconic, twisting hill climb up to the Rest and Be Thankful car park visible at the northern end of the glen. The western side of the glen is covered by established forestry plantations, with the open slopes of Ben Donich visible above the tree line. To the east of the road, travellers can look up the steep rugged slopes of Beinn Luibhean and The Cobbler, with the stabilisation measures introduced to the slope to prevent landslides visible on the hillside, and the scars of previous landslides evidence of the instability of the slopes. At the northern end of the glen, travellers gain attractive views along the length of the open glen, with a car park provided so drivers can stop to take in the popular, iconic viewpoint.

After passing the Rest and Be Thankful car park, the road runs along the eastern edge of Loch Restil, with views to the west across the loch to the steep slopes and

rocky summit of Beinn an Lochain. Views to the east of the road are largely contained by the steep slopes of Beinn Luibhean. To the west of the Rest and Be Thankful car park, a meandering minor road (B828) runs through the narrow Gleann Mor valley along the Allt Glinne Mhoir watercourse, with travellers experiencing short range views across the steep slopes of the surrounding hills that are often contained by the coniferous forestry plantations on the lower slopes.

(a) Future Baseline Conditions

As explained in Section 4.2, the current baseline conditions will be modified by works currently underway to provide additional landside protection measures and to enable use of the Old Military Road as an Emergency Diversion Route during A83 road closures (the 'Do Minimum' scenario).

As the Do Minimum scenario would not alter the alignment of the A83, views from the road would be essentially unchanged by the works. The scenario may require additional slope stabilisation measures to the east of the road, but views would be likely to remain restricted by the rising topography, with the quality of the views to the west across the glen unaffected.

In the event of the road being closed as a result of a landslide, traffic would be diverted along the Emergency Diversion Route on the Old Military Road, which would allow more travellers to experience open views to both sides of the road from the valley floor, although these views would be short-term.

7.12.1.4 Potential Environmental Effects

(a) Construction

As several of the proposed corridors would be new off-line routes, it is not practicable to provide a comparison of views from the road during the construction phase. Construction of the on-line options would result in disruption of views for travellers. Whilst the off-line options would be visible from the existing A83 during construction and would potentially adversely affect the quality of the view, the traveller's ability to see the surrounding landscape is unlikely to be altered.

(b) Operation

The potential views from the road during the operation of each corridor are described below.

(b).1 Red Corridor

The Red corridor would not alter the alignment of the road, so views from the road would be essentially unchanged by the works. The scenario would involve more extensive slope stabilisation measures and debris flow barriers to the east of the road, but views would be likely to remain restricted by the rising topography, with the quality of the views to the west across the glen unaffected.

(b).2 Brown Corridor

While the Brown Corridor would not alter the alignment of the road, the views available from the road would be dependent on the design of the proposed landslide shelters. If the shelters were fully enclosed structures, views to the west across the glen would be restricted or completely enclosed so that there was no view.

However, if the structures were designed with pillars to allow views across the glen, the available views would be likely to be intermittent. Views of the hillside to the east are likely to be contained within the shelters, resulting in no views.

(b).3 Yellow Corridor

The Yellow corridor would result in the A83 being relocated to the west of its existing alignment, but would be unlikely to significantly alter views from the road. As the road is likely to be at a similar level as the existing route, raised on a viaduct, views to the west across the glen would remain open. Moving the road away from the hillside would open up views to the east of the road slightly, although the extent of views would remain restricted by the rising hillside.

(b).4 Blue Corridor

At the southern end of the Blue corridor, travellers would be likely to gain views to the west across the Croe Water, with views likely to be partially contained by any retained woodland. When the road reached the more open farmland at the northern end of the glen, travellers would experience open views to either side of the road, looking up the steep slopes of the surrounding hills. At the northern end of the glen, the road would curve around the northern slope to rise up from the valley floor to the Rest and Be Thankful car park, which would be likely to provide open views to the south along the glen, with views to the north contained by the rising topography.

(b).5 Purple Corridor

At the southern end of the Purple corridor, travellers would be likely to gain views to the west across the Croe Water, with views likely to be partially contained by any retained woodland. When the road reaches the more open farmland at the northern end of the glen, travellers would experience open views to either side of the road, looking up the steep slopes of the surrounding hills. At the northern end of the glen, the road would enter a tunnel, with no views available until the road emerges at Loch Restil. This would remove the opportunity for travellers to gain views along the length of the glen from the Rest and Be Thankful unless they divert onto the realigned B828 to visit the viewpoint, which would reduce the scenic value of the road. Southbound travellers would gain views along the road when they emerged from the tunnel, although the lower elevation would be likely to slightly reduce the scenic value of the view.

(b).6 Green Corridor

The Green corridor would realign the road along the western slopes of Glen Croe, running through the forestry plantations on the lower slopes of Ben Donich. Views from the southern end of the road would be likely to be largely contained by the retained woodland on the valley floor, with potential glimpses across the Croe Water. As the road continues to the north, travellers would potentially gain views to the east across the glen, although views would likely be intermittent if any woodland can be retained on the hillside below the road. Views to the west would be contained by the rising hillside, with the extent of available views likely to be limited by the retained forestry.

7.12.1.5 Potential Mitigation

No mitigation has been identified at this stage of the assessment. However, sensitive design and landscape proposals as summarised in Section 7.7 (Landscape and Visual) may enhance view from the road for vehicle travellers.

7.12.2 Driver Stress

7.12.2.1 Introduction

Driver stress is defined for the purposes of environmental assessment as the adverse mental and physiological effects experienced by a driver traversing a road network. Driver stress has three main components: frustration, fear of potential accidents, and uncertainty relating to the route being followed.

7.12.2.2 Approach and Methods

The available research evidence does not permit the use of finely graded assessments of driver stress. A three point descriptive scale – Low, Moderate or High – has, therefore, been used to assess the level of stress that each route option corridor would likely produce.

7.12.2.3 Potential Environmental Effects

(a) Red Option

The key potential environmental effects of the Red Option during construction are listed below.

- As a result of road works, congestion and corresponding delays can be expected at locations where the soil stabilisation methods are being implemented. Congestion would be limited due to the low traffic volumes along this route and so the effect of increasing frustration amongst drivers would be low.
- Fear of potential accidents is unlikely to be affected during construction if appropriate traffic management measures are implemented.
- Full road closures would not be required during construction, so the route being followed would not change. Therefore, uncertainty relating to the route would not change.
- The above factors are likely to result in a low level of driver stress for vehicular users during construction.

The key potential environmental effects of the Red Option during operation are listed below.

- Soil stabilisation measures would have no negative impact on vehicular users during operation.

(b) Brown Option

The key potential environmental effects of the Brown Option during construction are listed below.

- As a result of road works, congestion and corresponding delays can be expected during construction. Driver frustration would depend on the type of

traffic management, but it can be expected that there would be some road closures and the emergency diversion route implemented. This may result in a moderate level of driver stress.

- Fear of potential accidents is unlikely to be affected during construction if appropriate traffic management measures are implemented.
- If full road closures are required during construction, a diversion route would be required. The emergency diversion route along the Old Military Road may be used, resulting in uncertainty relating to the route not changing. However, if a different diversion route is required, this may result in a high level of both driver frustration and uncertainty of the route.
- The above factors are likely to result in a moderate level of driver stress for vehicular users for short lengths of time during construction.

The key potential environmental effects of the Brown Option during operation are listed below.

- Landslide shelters would have no negative impact on vehicular users during operation.

(c) Yellow Option

The key potential environmental effects of the Yellow Option during construction are listed below.

- As this option is off-line, most of it can be constructed without affecting the travelling public. However, as a result of road works, congestion and corresponding delays can be expected at locations where the proposed route would join the existing A83. This has the effect of increasing frustration amongst drivers.
- Fear of potential accidents is unlikely to be affected during construction if appropriate traffic management measures are implemented.
- Uncertainty of the route being followed is unlikely to be a factor during construction as most construction work is offline and diversions on existing routes shall not be necessary.
- The above factors are likely to result in a low level of driver stress for vehicular users at certain locations on the route during construction.

The key potential environmental effects of the Yellow Option during operation are listed below.

- The Yellow Option would have no negative impact on vehicular users during operation.

(d) Purple Option

The key potential environmental effects of the Purple Option during construction are listed below.

- As this option is off-line, most of it can be constructed without affecting the travelling public. However, as a result of road works, congestion and corresponding delays can be expected at locations where the proposed route would join the existing A83. This has the effect of increasing frustration amongst drivers.

- Fear of potential accidents is unlikely to be affected during construction if appropriate traffic management measures are implemented.
- Uncertainty of the route being followed is unlikely to be a factor during construction as most construction work is offline and diversions on existing routes shall not be necessary.
- The above factors are likely to result in a low level of driver stress for vehicular users at certain locations on the route during construction.

The key potential environmental effects of the Purple Option during operation are listed below.

- The Purple Option includes a tunnel and this may cause a low level of fear of potential accidents, as incidents in tunnels can have a greater severity.
- Uncertainty of the route being followed is unlikely to be a factor during operation as the route runs parallel to the existing route and no driver decisions are necessary.

(e) Blue Option

The key potential environmental effects of the Blue Option during construction are listed below.

- As this option is off-line, most of it can be constructed without affecting the travelling public. However, as a result of road works, congestion and corresponding delays can be expected at locations where the proposed route would join the existing A83. This has the effect of increasing frustration amongst drivers.
- Fear of potential accidents is unlikely to be affected during construction if appropriate traffic management measures are implemented.
- Uncertainty of the route being followed is unlikely to be a factor during construction as most construction work is offline and diversions on existing routes shall not be necessary.
- The above factors are likely to result in a low level of driver stress for vehicular users at certain locations on the route during construction.

The key potential environmental effects of the Blue Option during operation are listed below.

- The Blue Option would have no negative impact on vehicular users during operation.

(f) Green Option

The key potential environmental effects of the Green Option during construction are listed below.

- As this option is off-line, most of it can be constructed without affecting the travelling public. However, as a result of road works, congestion and corresponding delays can be expected at locations where the proposed route would join the existing A83. This has the effect of increasing frustration amongst drivers.
- Fear of potential accidents is unlikely to be affected during construction if appropriate traffic management measures are implemented.

- Uncertainty of the route being followed is unlikely to be a factor during construction as most construction work is offline and diversions on existing routes shall not be necessary.
- The above factors are likely to result in a low level of driver stress for vehicular users at certain locations on the route during construction.

The key potential environmental effects of the Green Option during operation are listed below.

- The Green Option would have no negative impact on vehicular users during operation.

7.12.2.4 Potential Mitigation

Driver stress due to frustration and fear of accidents can be mitigated by appropriate traffic management and diversion routes. For any diversions, frequent signage can be used to minimise uncertainty of the route.

7.12.3 Summary of Assessment

Views from the Red corridor would be unlikely to be altered by the proposals, with the views to the west across the glen remaining open. Traffic management for this online option may slightly increase driver frustration.

The landslide shelters on the Brown corridor would potentially result in a loss of scenic views across the glen, although this would be dependent on the design of the structures. Landslide shelters may result in increased driver frustration during construction, and it is likely to require a significant construction period. If road closures are required and the Old Military Road is not available as a diversion route, an alternate diversion route outside Glen Croe would result in high level of driver stress.

The Yellow corridor would provide similar views to that of the Red corridor, from the viaduct structure. A viaduct would be unlikely to have a significant effect on driver stress.

The Blue corridor would provide travellers with open views across the valley from much of the corridor, with views to the south along the glen as the road rises up the hillside. A scheme in the Blue corridor would be unlikely to have a significant effect on driver stress.

As a result of the tunnel on the Purple corridor, the iconic views from the Rest and Be Thankful would not be experienced by travellers, which would affect the scenic value of the route. A scheme in the Purple corridor would be unlikely to have a significant effect on driver stress.

The Green corridor would be likely to provide similar views for travellers, but from the opposite side of the glen, although the retained woodland would potentially result in more intermittent views. A scheme in the Green corridor would be unlikely to have a significant effect on driver stress.

7.12.4 Recommendations for Further Work

Should a DMRB Stage 2 assessment be progressed following this study, the Vehicle Travellers assessment should be updated where necessary to take account of any further landscape assessment or selected route options.

7.13 Policies and Plans

7.13.1 Introduction

This section provides a description of the current national, regional and local planning policies relevant to the corridors, and assesses the potential compliance of each against relevant policies.

7.13.2 Approach and Methods

The assessment has been undertaken in line with DMRB Guidance Volume 11, Section 3, Part 12 – Impact on Plans and Policies. This requires details of the national, regional and local policies to be provided alongside a broad assessment of the likely effect of the corridors on the achievement of the policy objectives.

7.13.3 National Planning Policy

7.13.3.1 National Planning Framework 2

The Second National Planning Framework (NPF2) (Scottish Government, 2009) is a statutory document under the Town and Country Planning (Scotland) Act 1997 as amended by the Planning etc (Scotland) Act 2006. NPF2 guides Scotland's spatial development to 2030, setting out strategic development priorities to support the Scottish Government's central purpose of promoting sustainable economic growth.

Paragraph 106 of the NPF2 indicates that Scotland needs an effective national transport infrastructure which will facilitate economic growth. Journey times need to be reduced and made more reliable, connections should be made which build and sustain economic growth and links improved between cities, towns and rural communities throughout Scotland (paragraph 107).

Paragraph 108 identifies that the strategic outcomes set out in the National Transport Strategy include to improve journey times and connections, to tackle congestion and the lack of integration in transport.

Paragraph 133 states that "*the A82 and A83 trunk roads are key strategic routes for the Highlands and Islands….Many roads in the Highlands and Islands and the South of Scotland are lifeline routes for rural communities and of critical importance to the local economy. Their continued maintenance and improvement is essential to ensure the safety of the network and to support long-term development*".

The Scottish Government commenced work in 2012 on the preparation of the next National Planning Framework (NPF3) which when complete will update and replace NPF 2 in setting out national development priorities for the next 20-30 years.

7.13.3.2 Scottish Planning Policy

The Scottish Planning Policy (Scottish Government, 2010) (SPP) contains thematic policy on transport highlighting that the relationship between transport and land use has a strong influence on sustainable economic growth.

The strategic transport network is identified as critical in supporting a level of national connectivity that facilitates sustainable economic growth. The primary purpose of the strategic transport network is to provide for the safe and efficient movement of strategic long distance traffic (paragraph 174).

The SPP also contains thematic policy on rural development, indicating that the planning system has a significant role in supporting sustainable economic growth in rural areas (paragraph 92). The policy aims to maintain and improve the viability of communities and to support rural businesses, in addition all new development within rural areas should respond to the specific local character of the location and fit in the landscape (paragraph 95).

In addition, the SPP contains thematic policy on a number of other relevant topics including the historic environment, landscape and natural heritage, open space and flooding.

A review of the SPP was announced by the Minister for Local Government and Planning in September 2012 with an anticipated completion by the end of 2014. It is intended that this review will update policy, focusing on sustainable economic growth and also emphasising place-making.

7.13.4 Regional and Local Planning Policy

The Planning Etc. (Scotland) Act 2006 introduced changes to the development plan system in Scotland. Structure and Local Plans are being replaced by Strategic Development Plans (SDPs) and Local Development Plans (LDPs). SDPs are prepared for four city regions, and outwith those regions the development plan is comprised only of the LDP.

Loch Lomond and the Trossachs National Park is outside of a city region, however an LDP has not yet been prepared. At this time, the development plan for the study area comprises the Argyll and Bute Structure Plan, approved 2002 and the Loch Lomond and the Trossachs National Park Local Plan, adopted 2011.

The National Park Authority also has a duty to prepare a National Park Plan under the provisions of the National Parks (Scotland) Act 2000. The local plan should be read in the context of the current National Park Plan 2007-2012 for Loch Lomond and the Trossachs as this guides the policies and actions of all organisations involved in the management of the National Park.

7.13.4.1 Argyll and Bute Structure Plan 2002

The Argyll and Bute Structure Plan ”Developing Our Future” (“the structure plan”) was approved by the then Scottish Executive (now Scottish Ministers) in November 2002. Page 1 of the structure plan sets out its overall aims, including:

- “Promoting appropriate planning responses to the strategic economic, environmental and land use issues facing the island, peninsular, mainland and conurbation edge areas of Argyll and Bute.
- Promote ‘sustainable development’ within short and long term economic, social and environmental perspectives.
- Promote the safeguarding and enhancement of the natural and historic environment and the maintenance of biodiversity within Argyll and Bute.
- Guide the preparation of a future Local Lomond and the Trossachs National Park Local Plan.”

An assessment of the compliance of each of the corridors in relation to the policies of the structure plan is provided in Appendix E.

7.13.4.2 National Park Plan 2007-2012 for Loch Lomond and the Trossachs

This is the first National Park Plan for Loch Lomond and the Trossachs, and was approved by Scottish Ministers in March 2007. The National Park Plan sets out policies and initiatives to seek to secure positive change, consistent with the four National Park aims established by the National Park (Scotland) Act 2000 (the 2000 Act):

- "To conserve and enhance the natural and cultural heritage of the area.
- To promote sustainable use of the natural resources of the area.
- To promote understanding and enjoyment (including enjoyment in the form of recreation) of the special qualities of the area by the public.
- To promote sustainable economic and social development of the area's communities."

The National Park Plan explains that all four aims carry equal weight, but if it appears that there is unavoidable conflict between the aims then the National Park Authority must accord greater weight to conservation interests. This is a statutory requirement under Section 9(6) of the 2000 Act.

7.13.4.3 Loch Lomond and the Trossachs National Park Adopted Local Plan, 2011

The Loch Lomond and the Trossachs National Park Local Plan ("the local plan") was adopted by the National Park Board in December 2011 and is relevant to the A83 Rest and Be Thankful scheme.

The local plan provides a spatial framework for development and use of land in the National Park to 2015.

The overall vision is that the local plan will provide *"A robust development and land-use planning framework to 2015 that will deliver high quality, sustainable development in an area of outstanding landscape and environmental quality. New development will contribute to the Park's special qualities, directly supporting the social and economic development of the Park's communities and a growing rural economy, contributing to Scotland's prosperity, improving the range and quality of opportunities to experience the National Park, and enhancing its standing as an international visitor destination"* (page 9).

7.13.5 Summary Assessment of Compliance

An assessment of the potential compliance of each of the corridors in relation to relevant policies in the SPP, structure plan, National Park Plan and local plan is provided in Appendix E of this report. At this DMRB Stage 1, there is little detail on each option other than a broad description of the possible works within each corridor. The assessment therefore considers where there is a possibility of non-compliance. It should be noted that this may be revised at later DMRB stages as further design detail (including mitigation) is developed and some areas of potential non-compliance may be addressed. This current assessment is based on the worst-case scenario.

A summary of the assessment of each corridor is provided in this section.

7.13.5.1 All Corridors

All corridors comply with policies in the National Park Plan and Development Plan which seek to address existing infrastructure constraints (NPP Policy INF1) and improve travel options (Local Plan Policy TRAN2). The scheme as a whole is for improvements to an existing strategic trunk road which will enable better and safer access for users of the route, which will also help improve access for the rural communities in the West Highlands area. The scheme is broadly consistent with Scottish Planning Policy on rural development.

However, for each corridor there are potential issues of non-compliance which have been identified, as summarised in the paragraphs below.

7.13.5.2 Red Corridor

This corridor generally complies with planning policies as it would have limited environmental effects due to the works within this corridor being online upgrade to the existing road. There is the potential that there would be adverse effects on protected species which would be contrary to Structure Plan Policy STRAT DC7, National Park Plan Policy BD1 and Local Plan Policy ENV4, however it is likely that potential construction and operational effects can be addressed with appropriate mitigation. There is also potential conflict with Local Plan Policy ENV13 on culverts as extensions to existing culverts and channel realignments may be necessary.

7.13.5.3 Brown Corridor

This corridor is assessed similarly to the Red corridor, although more potentially significant effects are predicted as a result of potential habitat loss for the Brown corridor and therefore potential conflict with Local Plan Policy ENV5 on species and habitats.

7.13.5.4 Yellow Corridor

There are several areas of potential non-compliance of this off-line corridor with policy which should be reviewed as the scheme options are progressed. There is the potential for effects on known and unknown archaeological remains which if not addressed through the design could be contrary to Structure Plan Policy DC9, National Park Plan Policy BH1, and Local Plan Policies ENV26-27.

The viaduct structure proposed within this corridor within a relatively undeveloped area may have significant effects on the landscape character, and also create adverse visual effects from the Rest and Be Thankful car park. There is potential non-compliance with Structure Plan Policy STRAT DC8, National Park Plan Policies LS1-LS3, and Local Plan Policies L1 and ENV23.

Effects from habitat loss and on protected species without appropriate mitigation could be contrary to Structure Plan Policy STRAT DC7, National Park Plan Policy BD1, and Local Plan Policies ENV4 and 5.

However it is noted that this is the preferred corridor in terms of effects on the water environment, and the corridor is likely to comply with policies in the development plan on protecting rivers and other water features.

Overall, this corridor may not comply with policies which seek to protect the special qualities of the National Park, including National Park Plan Policy SQ1, Local Plan

Policies NP1 and TRAN4 (the latter seeks to ensure that road engineering principles are sensitive to the Park's special qualities).

7.13.5.5 Blue Corridor

The Blue corridor is assessed as having similar potential issues of non-compliance as the Yellow corridor, however some additional effects are predicted from this off-line corridor which is within the wider valley area.

A potential direct effect on the Category C(s) listed Rest and Be Thankful Stone is predicted, contrary to Local Plan Policy ENV21.

The loss of woodland to accommodate this corridor could be contrary to Structure Plan Policy STRAT FW2 and Local Plan Policy ENV9 in respect of woodland protection. There are also potential consequent effects on the water environment and habitats and species arising from the loss of woodland contrary to Local Plan Policies ENV10 and ENV5.

This corridor includes part of the Beinn an Lochain SSSI, and it is predicted that there may be habitat loss, air quality and other construction effects which could harm the designation, contrary to Local Plan Policy ENV2.

The corridor option may lead to the severance of undesignated paths within the study area, contrary to policies seeking to protect public access to the countryside (Structure Plan Policy PROP TRANS1, Local Plan Policy TRAN7).

7.13.5.6 Purple Corridor

The Purple corridor is assessed as having similar potential issues of non-compliance to the Blue corridor.

7.13.5.7 Green Corridor

The Green corridor is assessed as having similar potential issues of non-compliance to the Blue corridor, with the exception of policies protecting landscape character as effects are predicted to be less significant if the road design is sensitive to the existing landscape.

7.13.5.8 Overall Summary

The Red and Brown corridors, which are for online upgrades to the existing road are broadly compliant with planning policies, and are the corridors for which the fewest potential environmental effects are predicted. There are some potential areas of non-compliance with planning policies relating to nature conservation and in particular safeguarding priority habitats and protected species. However these effects may be avoided, reduced or mitigated at later DMRB stages when the design is more developed which would satisfy these policy requirements.

The Yellow, Blue, Purple and Green corridors, which would all require off-line construction of a new length of road, have each been assessed as being potentially non-compliant with a higher number of policies, some of which may be considered significant. In particular, for each of these there are effects predicted to varying degrees on landscape character, ecology and nature conservation, and cultural heritage. These effects could raise issues of non-compliance with policies which not only seek to safeguard those aspects but also the overarching policies which seek

to protect the special qualities of the National Park. It is uncertain at this stage whether these policy compliance issues could be fully addressed and this would require consideration at future DMRB stages when further detail is available.

Corridor Option	Fully Compliant	Partially Compliant	Potential Significant Non-Compliance
Red		✓	
Brown		✓	
Yellow			✓
Blue			✓
Purple			✓
Green			✓

Table 7-30: Compliance with Planning Policies

7.13.6 Recommendations for Further Work

Should a DMRB Stage 2 assessment be progressed following this study, the assessment should be updated taking into account any updates to the development plan and other policy documents (including national policy). It should also re-assess the compliance of each of the options taking into account the updated environmental assessments.

8 APPRAISAL SUMMARY

8.1 Introduction

In line with the nature of a DMRB Stage 1 Assessment, the appraisal of the options has been carried out using mainly qualitative descriptions supplemented with quantitative data where available. Any option(s) emerging from this study taken forward for further development would be subject to more detailed assessment.

The Appraisal Summary Tables are detailed in Appendix B and a summary of the appraisal is outlined in this section of the report.

8.2 Summary of Appraisals

The appraisal has been carried out in accordance with Scottish Transport Appraisal guidance, against the following criteria:

- Transport Planning Objective:
- Reduce the impact on journey times by reducing the frequency and duration of road closures caused by landslides; and
- Reduce the economic impact to the A83 study area by reducing the frequency and duration of road closures caused by landslides.

- Implementability Appraisal:
- Technical;
- Operational;
- Financial; and
- Public.

- Appraisal Criteria:
- Environment;
- Safety;
- Economy;
- Integration; and;
- Accessibility and Social Inclusion.

The options have been appraised against the criteria utilising the standard seven point scale:

- Major Benefit ✓✓✓
- Moderate Benefit ✓✓
- Minor Benefit ✓
- No benefit or impact 0
- Minor Negative Impact ×
- Moderate Negative Impact ××
- Major Negative Impact ×××

A summary of the option appraisal against the Transport Planning Objectives and appraisal criteria together with the rationale for selection or rejection of each option is detailed in Table 8-1 below.

Options	Planning Objective	Environment	Safety	Economy	Integration	Accessibility and Social Inclusion	Rationale for Selection or Rejection of Proposal
Red Option – additional protection to existing road	✓	0	✓	✓✓	0	✓	The Red Option represents the continuation of the landslide management strategy adopted since 2008 following publication of the Scottish Road Network Landslides Study: Implementation Report. This option contributes towards the Transport Planning Objective and demonstrates minor benefits against the criteria of Safety, Economy, Accessibility and Social Inclusion. This proposal is **selected** for further consideration as it is expected to significantly reduce the frequency of occurrence of landslide debris reaching the A83 Trunk Road at a much lower cost than the other options.
Brown Option – debris flow shelter	✓	×	✓✓	✓ / ××	0	✓/ ×	The Brown Option maintains the existing alignment of the A83 and involves the construction of debris flow shelters over a length of 1km. This option contributes towards against the Transport Planning Objective and demonstrates benefits against the criteria of Safety, Economy, Accessibility and Social Inclusion for the completed scheme. However, during construction there are moderate environmental and economic impacts for a period of at least 30 months. This proposal is **rejected** for further consideration since the impacts during construction are considered to outweigh the longer term benefits and the estimated cost is greater than other proposals with similar long term benefits.
Yellow Option – off-line viaduct	✓	×	✓✓	✓	0	✓	The yellow corridor option provides a new 1.2km long single carriageway on viaduct set at a sufficient level to permit debris flow events to pass below the viaduct. This option contributes towards the Transport Planning Objective and demonstrates benefits against the criteria of Safety, Economy, Accessibility and Social Inclusion for the completed scheme. Environmental Impact is noted due to the potential effect on local landscape and views. This proposal is **selected** for further consideration since the likelihood of landslide debris reaching the A83 Trunk Road would be negligible since it would instead pass below the road.

Options	Planning Objective	Environment	Safety	Economy	Integration	Accessibility and Social Inclusion	Rationale for Selection or Rejection of Proposal
Purple Option – tunnel	✓	××	✓✓	✓	0	✓/×	The Purple Corridor Option follows the Glen Croe valley floor parallel to the line of the Old Military Road. It enters a tunnel close to the Rest and Be Thankful car park and emerges from tunnel to rejoin the existing road at the north end of Loch Restil. This option contributes towards the Transport Planning Objective and demonstrates benefits against the criteria of Safety, Economy, Accessibility and Social Inclusion for the completed scheme. Moderate environmental impact is noted due to the potential effect on landscape, ecology and noise. This proposal is **rejected** for further consideration since similar benefits can be achieved with the Yellow Corridor Option at lower cost and with a lower potential environmental impact.
Blue Option – off-line corridor parallel to Old Military Road	✓	××	✓	✓	0	✓	The Blue Corridor Option follows the Glen Croe valley floor parallel to the line of the Old Military Road and the route sweeps through two long hairpins at the top of Glen Croe. This option contributes towards the Transport Planning Objective and demonstrates benefits against the criteria of Safety, Economy, Accessibility and Social Inclusion for the completed scheme. Moderate environmental impact is noted due to the potential effect on landscape, ecology and noise. The route alignment is the poorest of all the options and is longer than the Do Minimum scenario and all the other options. It would have sections of alignment with the steepest gradient of 8%. This proposal is **rejected** for further consideration since similar benefits can be achieved with the Red and Yellow Options with a better overall route alignment and with a lower potential environmental impact.

Options	Planning Objective	Environment	Safety	Economy	Integration	Accessibility and Social Inclusion	Rationale for Selection or Rejection of Proposal
Green Option – off-line corridor parallel to Forestry Commission track	✓	××	✓	✓	0	✓	The Green Corridor Option follows the south-west side of the Glen Croe valley in a corridor generally following the route of existing forestry tracks. This route provides a new 4.0km single carriageway from the Old Military Road junction to the to the B828 junction. This option contributes towards the Transport Planning Objective and demonstrates benefits against the criteria of Safety, Economy, Accessibility and Social Inclusion for the completed scheme. Moderate environmental impact is noted due to the potential effect on landscape and ecology. This proposal is **selected** for further consideration along with the Red and Yellow options. This option would significantly reduce the likelihood of landslide debris reaching the road with a better route alignment than the Blue option and a lower capital cost than the Yellow Option.

Table 8-1 Appraisal against Planning Objectives and STAG Criteria

8.3 Risk and Uncertainty

Following the appraisal process detailed above an initial high level review of potential project delivery risks has been considered with regard to significant technical or statutory risks. Funding issues are not considered. Table 8-2 below summarises the initial risk review findings. This list is not exhaustive.

Proposal Title	Risks and Uncertainty
All Options	Ground investigations and detailed topographic surveys have not been carried out. The results of these may affect the cost and construction periods. As all of the options other than the red option involve significant structures, the feasibility may be affected by the results of the ground investigation.
All Options	All of the options involve work outside the existing trunk road boundary and would require land acquisition or land owner agreement. This may affect the start of the construction period.
All Options	Rockfall and boulder stability not assessed.
All Options	The frequency of future debris flow events at Rest and Be Thankful is uncertain. The "central assumption" in the economic analysis, based on the evidence of the past five years, is closure of the A83 due to landslides for an average period of 5½ days each year. This is not a prediction of future events. Future events may cause more or less disruption than this.
All Options	Landslide hazard elsewhere on the A83 is not addressed
All Options (except Red)	Statutory processes would be required, and this could result in the need for a Public Local Inquiry.
Red Option	The red option includes construction of 440m of debris flow barrier and improved drainage at the higher risk areas. It is possible that debris flow events will occur at other areas within Glen Croe.
Brown Option	The extent of full road closures during construction cannot be quantified at this stage and the disruption due to construction may be comparable or worse than the disruption due to landslides in the Do Minimum option.
Yellow Option	The optimal alignment for the yellow option may be above or below the existing A83. If an alignment above the A83 is preferred, this would result in some disruption to trunk road traffic during construction.
Purple, Blue and Green Options	There may be a requirement at the detailed design stage for climbing lanes and arrester beds under these options.
Purple Option	It has not been determined how the B828 and the Rest and Be Thankful car park would be accessed from the A83 trunk road under this option.
Blue Option	The horizontal alignment requires Departures from Standards which may not be granted by Transport Scotland Standards Branch.
Green Option	The green corridor has limited historical information on landslides. High cost precautions are likely to be required to prevent future disruption due to debris flow events.
Green Option	This option passes through a timber forest. Future logging may reduce the stability of the south-west side of the valley allowing debris flow events to disrupt the proposed A83 trunk road.

Table 8-2: Risk and Uncertainty in each Proposal

8.4 Monitoring and Evaluation

As has been noted, annual slope monitoring is undertaken by the Operating Company on behalf of Transport Scotland to assess the condition of this hillside and note changes from the previous year.

The record of road closures on the A83 due to landslides should be maintained by Transport Scotland and their Operating Company in order to monitor the annual duration of road closures due to landslides.

The Do Minimum scenario includes use of the Emergency Diversion Route that is being brought into use. The following should be monitored to facilitate evaluation of the operation of the Emergency Diversion Route:

- Traffic flows on the A83 and A82/A85/A819 during use of the Emergency Diversion Route to assess the distribution of traffic during future road closures due to landslides.
- Detailed journey time records during convoy operation on the Emergency Diversion Route to assess the average journey time delay experienced by road users.

9 TRAFFIC AND ECONOMIC ASSESSMENT

9.1 Introduction

Following the mainly qualitative appraisal presented in Chapter 8, a more detailed economic assessment has been carried out on the three options which emerged from this process. The economic appraisal has been conducted using standard economic welfare techniques and provides a comparison of the performance of the options against the Do Minimum scenario. The Do Minimum scenario includes the use of the Old Military Road as the diversion route during road closures due to landslides.

9.2 Impact of landslides

Since 1st January 2007 there have been six landslide related closures (including one precautionary closure). The details of the closures are provided in Table 9-1 below.

Date Closed	Date Opened	Length of Closure	Additional Comments
01-Aug-12	03-Aug-12	2 days, 2 hours	
22-Jun-12	23-Jun-12	18 hours, 15 minutes	High risk of landslide
22-Feb-12	24-Feb-12	2 days, 22 hours, 30 minutes	
01-Dec-11	03-Dec-11	2 days, 1 hour, 30 minutes 11 x 16½ hours	A83 open from 08:30 to 16:00 only from 03-Dec-11. This restriction was lifted from 14-Dec-11.
08-Sep-09	10-Sep-09	2 days, 2 hours, 30 minutes	
28-Oct-07	13-Nov-07	17 days	

Table 9-1: Record of road closures – 1st January 2007 – 31st October 2012

The duration of road closures ranges from 18 hours to 17 days. The average duration of a road closure due to a landslide is estimated at approximately 5½ days (the 11 days where the road was open between 08:30 and 16:00 have, for appraisal purposes, been treated as 11 half day closures given that the actual traffic flows were roughly half that of what would have been expected).

9.3 Diversion Route

When the road is closed due to a landslide there is a pre-planned diversion route. The current diversion route for the A83 at Rest and Be Thankful follows the A82 between Tarbet and Tyndrum, the A85 Tyndrum to Dalmally and finally the A819 between Dalmally and Inveraray before rejoining the A83 as shown in Figure 9-1. The typical journey time for this pre-planned route has been estimated at 66 minutes to cover the 49 mile journey from Tarbet to Inveraray. However, it has been argued that this is an underestimate of the journey time as it does not take into account the increased congestion on the diversion route when the A83 is closed. Consequently, the journey time via the pre-planned diversion route has been taken as 75 minutes for this appraisal.

Due to the significant length of the current pre-planned diversion route improvements are being made to the Old Military Road which will enable it to become a shorter diversion route at only an additional 0.7km. However, those using the Old Military Road will travel in convoy resulting in an impact on the diverted

traffic through increased travel time. Table 9-2 demonstrates the impacts on the diverted traffic.

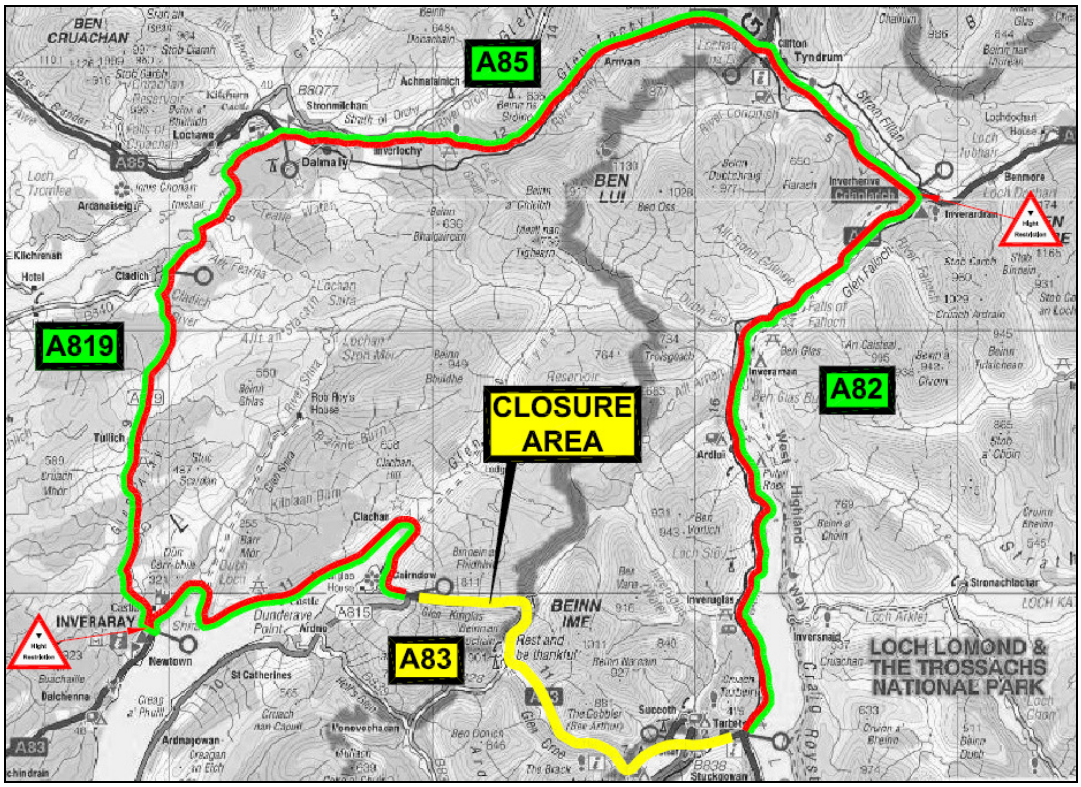


Figure 9-1: A83 Diversion Route via A82/A85/A819.

	A83 between Tarbet and Inveraray	A82/A85/A819 Diversion route	A83 and diversion via Old Military Road
Journey in kilometres	37.5	78.1	38.2
Journey in minutes	32	75	52

Table 9-2: Journey time and distance impacts on diverted traffic for journey between Tarbet and Inveraray

It should be noted that the journey time for the Old Military Road may vary significantly from the 52 minutes in Table 9-2. As the Old Military Road will be travelled in a convoy in one direction at a time, the duration of an individual journey depends mostly on when the vehicle joins the queue. It is estimated that the journey time between Tarbet and Inveraray via the Old Military Road diversion route could range from 37 minutes to 66 minutes.

9.4 Summary of Do-Minimum and Options

For the purpose of the economic assessment it is necessary to define a "Do-Minimum" scenario, what will most likely happen without the intervention, to test the specific options against.

9.4.1 Do Minimum Scenario

The Do Minimum scenario is the existing condition of the A83 at Rest and Be Thankful along with the use of the Old Military Road as the diversion route during future road closures due to landslides. This is expected to reduce the journey time delays and subsequent economic impact compared to the previous road closures

due to landslides. This diversion route is a temporary measure until a longer term solution is implemented.

9.4.2 Red Option

This option involves substantial hazard reduction measures along the line of the existing road to reduce the occurrence of landslides and/or the frequency and duration that landslides cause road closures. These measures represent a significant step-change in the provision of landslide hazard reduction and include an additional 440m of debris flow barriers, drainage and culvert improvements and slope vegetation.

The implementation of these measures should reduce the frequency of occurrence of landslide debris reaching the road causing a full road closure. It is difficult to predict the frequency of future landslides, however recent landslide closures at Rest and Be Thankful have been approximately once a year. For the purpose of the economic evaluation in order to asses the economic benefits of this option, it has been assumed that these measures would reduce the frequency of landslide closures to once every ten years. This should not be taken as a prediction of the effectiveness or otherwise of these measures.

9.4.3 Yellow Option

This option involves the construction of a new 1.5km single carriageway alignment with 1.2km on viaduct, running generally parallel to the existing A83 section.

The likelihood of future road closures due to landslides is considered to be negligible and for the purpose of the economic evaluation it has been assumed that there would be no future landslide closures under this option.

9.4.4 Green Option

This option involves the construction of a new 4.0km single carriageway within the forestry on the south-west side of the valley. For the purpose of the economic appraisal, two possible scenarios have been considered for this corridor relating to the extent to which the landslide hazard on the south-west side of the valley is mitigated.

The “Green Low” option represents a solution with a lower capital cost of £27 – 30 million (2012 prices, excluding VAT) and with a similar level of landslide closure risk as the Red Option. For the purpose of the economic evaluation it has been assumed that these measures would reduce the frequency of landslide closures to once in every ten years. This should not be taken as a prediction of the effectiveness or otherwise of this solution.

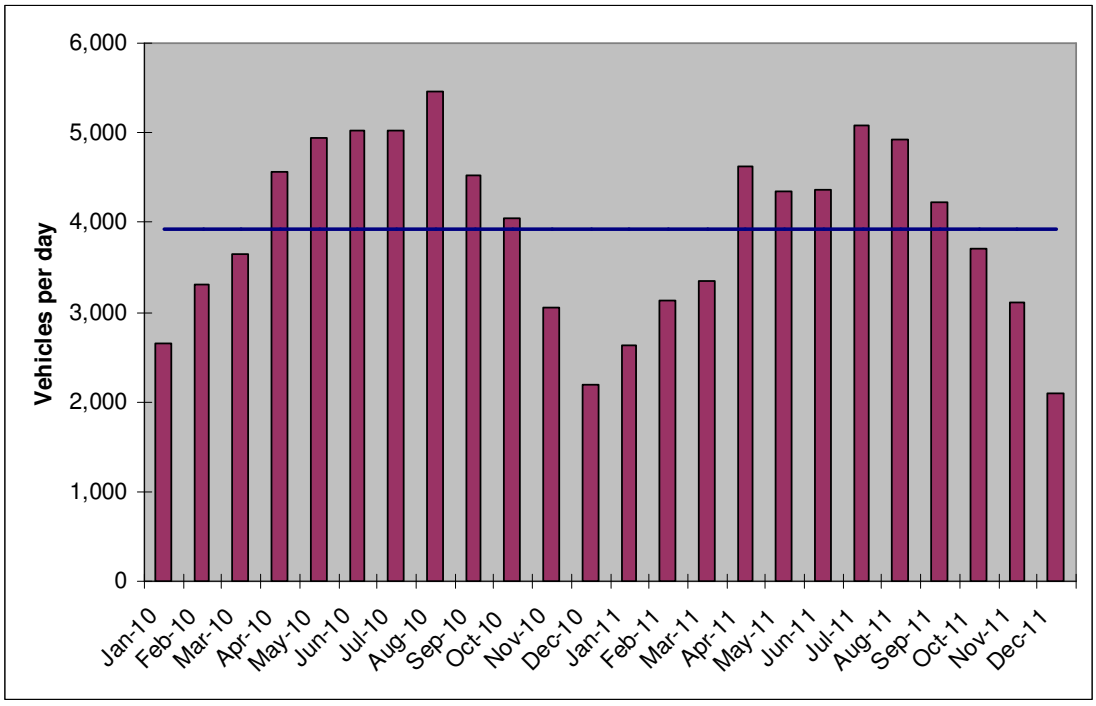
The “Green High” option represents a solution with a higher capital cost of £81 – 91 million (2012 prices, excluding VAT) and with a similar level of landslide closure risk as the Yellow Option. This considers the likelihood of future landslide closures to be negligible and for the purpose of the economic evaluation it has been assumed that there would be no future landslide closures under this option.

9.5 Economic Assessment methodology

The economic appraisal has been conducted using standard economic welfare techniques, as set out in the Scottish Transport Appraisal Guidance (STAG). In this

analysis the change in economic welfare can be approximated using the change in travel time and vehicle operating costs. In the case of the landslides at the Rest and Be Thankful site this change in costs is determined by the number of journeys affected, the type of journeys affected (e.g. car, bus, freight) and whether or not they use the diversion route. Changes in accidents and emissions have been estimated only for the existing, longer diversion route. There is assumed to be no net change in these if the Old Military Road is used as the diversion route. The appraisal has assumed that there is no change in the number of tourists who visit Scotland as a result of the landslide; rather the road closures due to the landslides cause people to use the diversion route or travel to alternative destinations.

Estimates of the number of journeys affected by a landslide have been based on traffic count data from the nearest automated traffic counter to the Rest and Be Thankful site[31]. Figure 9-2, below, shows the monthly mean two-way traffic counts for January 2010 to December 2011. The average of the monthly mean two-way traffic counts is 3,918 vehicles per day. Approximately 89% of these vehicles were cars or vans, with 9.5% being a LGV and HGV. The daily flow is very seasonal with flows reaching a peak in August 2010 at 5,460.



Note: The horizontal line represents the average of the monthly mean traffic counts from Jan 2010 to Dec 2011.

Figure 9-2: 7 Day Average Traffic Count Data on the A83 – 2010-11

Changes in travel costs have been calculated using the travel times and distances provided in Table 9-2, with standard vehicle operating cost formulae being used to calculate fuel and non-fuel related costs. Standard values of time have been applied. These changes are provided in Table 9-3 below. These differ due to the different levels of contribution to total travel costs of vehicle operating costs as compared to travel time costs, which are the primary costs of using the Old Military Road as a diversion route. For example, travel costs associated with HGVs are dominated by vehicle operating costs, while for the other modes journey time costs are the most prevalent.

[31] The counter is JTC08338, sited on the A83 West of Arrochar.

Motorbike	Car / Van	Car + Trailer	LGV / Rigid HGV	HGV	Bus
63%	39%	39%	35%	25%	42%

Note: These increases in costs do not include the fuel cost of idling while waiting to join the convoy at the Old Military Road.

Table 9-3: Increases in Travel Costs between Tarbet and Inveraray in 2012

In order to calculate the total economic disbenefits of a landslide it is necessary to estimate the number of trips that use the diversion route compared to those who decide to delay or change their plans. A previous study[32] into the landslide during the first week of November in 2007 estimated from the local count data that 51% of traffic diverted while 49% made alternative plans and may have changed their destination, delayed their trip or cancelled their trip. The report found that individuals' travel costs increased by 107% due to the diversion they were facing. As shown by Table 9-3 the individual travel cost change is significantly lower in this analysis due to the significant improvement in the pre-planned diversion route. Assuming a linear relationship between a change in travel costs and the number of trips using the diversion route, it is estimated that the proportion of trips using the diversion would increase in the region of 80%, with the estimates shown in Table 9-4. The differences follow from the differences in the change in travel costs for the various vehicle types, as shown in Table 9-3.

Motorbike	Car / Van	Car + Trailer	LGV / Rigid HGV	HGV	Bus
71%	82%	82%	84%	88%	81%

Table 9-4: Proportion of the base journeys that use the diversion route

Using the proportions above and the traffic count data in Figure 9-2, the number of trips diverted due to a landslide can be estimated. It is then assumed that those trips that do divert bear the full change in transport costs, whilst the cost for all the trips that are cancelled, delayed or made to an alternative destination are assumed on average to be half of this, as standard in transport appraisal[33]. These values can then be multiplied by the projected number of days a year that the road would be closed due to a landslide to give the annual estimate of disbenefits of landslides in the Rest and Be Thankful area. These annual disbenefits are then grown over the 60 year appraisal period using standard growth values for the various variables from STAG.

Other impacts, such as that on drivers' costs and hours if additional rest periods are required or scheduling impacts[34], are not typically assessed as part of this analysis. However, they have been assessed in section 2. The two analyses are complementary and essentially measure the same impacts using different methods, showing similar annual results. Data is not available to allow the assessment of additional costs if ferry connections are missed.

Once the disbenefits of landslides at the Rest and Be Thankful area are estimated, the benefits associated with the different options can be calculated. These have been calculated by estimating the proportion of the landslide disbenefits that would be avoided by introducing each option. For example, by implementing the red option, it is predicted that the netting would reduce the road closures due to the landslides and therefore reduces the level of disbenefits from the landslides. Table

[32] Transport Scotland (2009)
[33] http://www.dft.gov.uk/webtag/documents/expert/unit3.5.3.php
[34] For example if two return trips per day are normally operated per vehicle, but only one return trip is possible when diversions are in place.

9-5 outlines the estimated impact of each option on the number of landslide related road closures. These are based on engineering judgement made for the purposes of appraisal and must be treated with caution.

Option	Reduction in the average number of landslide related road closures per year
Red	90%
Yellow	100%
Green (Low)	90%
Green (High)	100%

Table 9-5: Estimated impact of the various options

Table 9-5 shows that if either the red or green low options were implemented it is assumed there would be a 90% reduction in the average number of landslide related road closures. If the yellow or green high options are implemented then it is assumed there would be no landslide related road closures, and therefore the benefits of these two options are equivalent to the total of the disbenefits of the landslides at the Rest and Be Thankful site.

For the costs of the different options, capital costs, maintenance costs and landslide clear up costs have been taken into account. For the capital costs the mid-point of the estimated range for each option has been used, while high level assumptions have been made with regards to the maintenance costs. The landslide clear up cost is based on actual clear up costs of a previous landslide incident and these costs fall under each option compared to the Do Minimum scenario as they reduce the likelihood of landslide related road closures.

9.6 Results of Economic Assessment

The results of the economic analysis of the various options are set out below. All figures are in standard 2010 discounted market prices.

	Red Option	Yellow Option	Green Low Option	Green High Option
Present Value of Benefits (PVB)	£2.54m	£2.67m	£2.47m	£2.67m
Present Value of Costs (PVC)	£5.86m	£69.67m	£21.37	£66.47m
Net Present Value (NPV)	-£3.32m	-£67.00m	-£18.90	-£63.80m
Benefit to Cost Ratio (BCR)	0.43	0.04	0.12	0.04

Table 9-6: Appraisal indicators for the core economic analysis

The results above show that the BCRs range from 0.04 to 0.43, with the best performing option being the red option. Under this core analysis none of the options provide a level of benefits greater than the present value of costs. Sensitivity analysis has been undertaken which is presented in the section below.

9.6.1 Sensitivity Analysis

Three key assumptions within the analysis relate to the number of trips affected by the landslides, the proportion of the trips that use the diversion route and the number of days the road is closed for per year due to the landslides.

As shown earlier in Figure 9-2, traffic flows in the area are very seasonal with flows ranging from 2,096 (Dec 2011) to 5,460 (August 2010). Therefore the timing of the landslides would have a significant impact on the number of trips affected and, therefore, overall disbenefits.

The proportion of trips diverting is also significant as those trips using the diversion route face the full change in transport costs while the trips that are cancelled, delayed or made to an alternative destination are on average assumed to face half of them. Therefore if the proportion of trips that use the diversion route is high then the overall disbenefits would be greater.

The number of days the A83 is closed at the Rest and Be Thankful site per year due to landslides has been estimated based on 70 months of data (January 2007 – October 2012). The historical data leads to an estimate of just over 5 days per year. However, in the last 12 months there have been 4 separate landslide events, closing the road for a total of 13 days.

A further assumption is the availability of the Old Military Road under the Do Minimum scenario. Under the core analysis it has been assumed that the Old Military Road will be available throughout the 60 year appraisal period. However, it is important to have an idea of the impact on the different options if this was not the case and the current pre-planned diversion route was the only diversion route available for the majority of the 60 year appraisal period. It should be noted that this is purely to facilitate the economic assessment and should not be taken to represent any commitment or otherwise from Transport Scotland regarding the future use of the Old Military Road.

Longer diversion route – for appraisal purposes, it is assumed that the Old Military Road provides the diversion route for the first 5 years of the Do Minimum Scenario before the diversion route reverts back to the route via the A82, A85 and A819. As there is a significant difference in journey distance when travelling via the diversion route both accident costs and environmental costs have been taken into account.

High diversion factor – 100% - assumes all of the traffic diverts onto the Old Military Road.

Low diversion factor – only 51% of traffic diverts onto the Old Military Road, this figure is based on the estimate from the 2008 analysis.

High traffic flows – assumes that the landslides occur during the peak tourist season so the number of people affected is higher. The analysis uses the average daily count data for the summer months in 2010 and 2011.

Low traffic flows – assumes that the landslides occur during the quieter months of the year so fewer people are affected by the road closing. The analysis uses the average daily count data for the winter months of 2010 and 2011.

Larger disruption – assumes that the number of days the A83 is closed at the Rest and Be Thankful site per year due to landslides is equal to the number of days the road has been closed over the last 12 months due to landslides – 13 days.

Sensitivity Test	NPV	BCR
Core Results	-£3.32m	0.43
Longer diversion route	-£0.70m	0.88
High Diversion factor	-£3.08m	0.47
Low Diversion factor	-£3.76m	0.36
High Traffic flows	-£2.80m	0.52
Low Traffic flows	-£3.85m	0.34
Larger disruption	£0.14m	1.02

Table 9-7: Sensitivity analysis – Red Option

Sensitivity Test	NPV	BCR
Core Results	-£67.00m	0.04
Longer diversion route	-£64.06m	0.08
High Diversion factor	-£66.74m	0.04
Low Diversion factor	-£67.45m	0.03
High Traffic flows	-£66.44m	0.05
Low Traffic flows	-£67.55m	0.03
Larger disruption	-£63.36m	0.09

Table 9-8: Sensitivity analysis - Yellow Option

Sensitivity Test	NPV	BCR
Core Results	-£18.90m	0.12
Longer diversion route	-£16.27m	0.24
High Diversion factor	-£18.66m	0.13
Low Diversion factor	-£19.32m	0.10
High Traffic flows	-£18.39m	0.14
Low Traffic flows	-£19.41m	0.09
Larger disruption	-£15.53m	0.27

Table 9-9: Sensitivity analysis - Green Low Option

Sensitivity Test	NPV	BCR
Core Results	-£63.80m	0.04
Longer diversion route	-£60.87m	0.08
High Diversion factor	-£63.54m	0.04
Low Diversion factor	-£64.26m	0.03
High Traffic flows	-£63.25m	0.05
Low Traffic flows	-£64.36m	0.03
Larger disruption	-£60.16m	0.09

Table 9-10: Sensitivity analysis - Green High option

As can be seen from the tables above there is a wide range of BCRs, with the Red Option remaining the best performing option with the BCR ranging from 0.34 to 1.02.

9.7 Other Impacts

As well as the monetised benefits estimated above there are other impacts that should be taken into account, such as landslide related accident costs, journey time reliability, any potential long term reduction in the use of the road and accessibility and social inclusion benefits.

Currently there have been no accidents related to the landslides at the Rest and Be Thankful site and there has also been significant investment in mitigation measures such as debris flow barriers and early monitoring equipment. However, it is important to take into account any increase in the probability of accidents would increase the estimated disbenefits of landslides and therefore increase the benefits of implementing each of the various options.

The risk of a landslide related closure clearly impacts on journey time reliability. Evidence suggests that travellers value changes in excess travel time higher than anticipated travel time, while low levels of journey time reliability or perceived low levels of journey time reliability may impact on the businesses in the area. This impact has not been assessed within this economic appraisal. However the socio-economic impacts of landslide closures with traffic diverted on the A82/A85/A819 are presented in section 2.8 and Appendix F has attempted to take account of these impacts on businesses. It should be noted that the economic impacts identified in section 2.8 cannot be added to the results shown above because this would involve doubling counting of impacts.

A potential additional impact connected to reliability is that the risk of landslide has discouraged people from making trips. A high level analysis of the number of trips on the A83 has been undertaken. This has focussed upon summer peaks, given the importance of tourism and the distorting effects of recent severe winters. This shows that the number of trips has been in decline since 2003 when data are first available and that this has not been the case in similar, more northerly routes to and from the west (A830, A87 and A835). The decline has been particularly marked in the last two summers (2011 and 2012) and some local businesses contend that this has been caused by perceptions of the risk of landslides. However, it has not been possible to establish this with more than anecdotal evidence. The decline predated the 2007 landslide and there may be other economic and social factors affecting traffic flows on the route.

There is also anecdotal evidence of wider impacts, including tourist businesses reporting a loss of business in the days following a closure, but it has not been possible to establish this. Data on traffic flows provide a possible indication of this for the long closure in 2007, i.e. flows did not immediately recover, but since then, closures show a reasonably quick bounce back subsequent to reopening (typically within 6-12 hours).

Accessibility and social inclusion is one of the five key STAG criteria, however, unlike economy, safety and environmental benefits, cannot be monetised. Consequently, the results provided above do not include any accessibility and social inclusion benefits, such as the risk of losing a direct link to local communities.

9.8 Conclusions

Landslides at Rest and Be Thankful clearly impact on travel in the local area. However, the opening of the Old Military Road as the pre-planned diversion route significantly reduces this impact. All of the options perform badly when solely assessing the economic impacts of the option, with the red option performing the best with a core BCR of 0.43. The red option results in a similar level of benefits over the appraisal period as the yellow and green options for significantly less capital costs over the same period.

As highlighted in section 9.7 there are also potential impacts that have not been quantified, or even established, such as potential landslide related accident costs,

journey time reliability, any long term reduction in the use of the road and accessibility and social inclusion benefits. However, it is very unlikely that the conclusions would change as a result of their inclusion.

10 SUMMARY, CONCLUSIONS AND NEXT STEPS

10.1 Summary

The section of the A83 between Ardgartan and the Rest and Be Thankful car park has a history of hillside instability in particular the slopes above Rest and Be Thankful. This has led to road closures on six separate occasions between 1 January 2007 and 31 October 2012, resulting in the road being closed for a total period of 34 days. Other parts of the route have been closed due to landslides but much less frequently.

Following a number of landslides in 2004, Transport Scotland undertook the Scottish Road Network Landslides Study. As part of the Implementation Study a hazard assessment and ranking was undertaken for debris flow. From this assessment the A83 Ardgartan to Rest and Be Thankful is amongst the most highly ranked debris flow hazard sites in Scotland.

As part of the current hazard reduction approach, some preventative measures have already been implemented including upgrading some culverts and the installation of approximately 168m of debris flow barriers and fences. A further 90m of debris flow barrier and a large catch pit will be completed during the early part of 2013. An Emergency Diversion Route has been created along the Old Military Road to provide a short-term alternative route in the event of road closures at Rest and Be Thankful due to landslides.

Consultation undertaken during this study enabled stakeholders to share their views about the issues experienced by road users. This included the wider impacts of road closures due to landslides, based on using the diversion route via the A82/A85/A819. The consultation exercise has informed the identification of the evidence-based transport problems in the study area.

A review has been undertaken on the socio-economic impact of the road closures due to landslides at the Rest and Be Thankful. The outcomes from this review provide evidence in addition to, and not in place of, the standard economic appraisal which has been undertaken.

Using evidence from this review, drawn from several key stakeholders, the additional annual costs to the A83 economy from previous landslide episodes at the Rest and Be Thankful are estimated to be £286,300 (in 2010 prices) for the road being closed for 5½ days over the year (the average duration of the past six events). Sensitivity analysis shows that the additional annual costs to the A83 economy from previous landslide episodes at the Rest and Be Thankful are in the range £130,200 (2½ day closure) to £676,800 (13 day closure).

This study examined a range of potential long-term solutions in the form of alternative routes for access to the A83 study area. Route corridors remote from the Glen Croe valley were rejected at an early stage in the appraisal process since these options did not meet the transport planning objectives of the study. They resulted in increased journey times and the anticipated cost and potential environmental impacts of such routes were considered disproportionate to the identified problems on the existing A83 Rest and Be Thankful.

Six route options in the Glen Croe valley were selected for assessment. These potential options range from new route corridors within the valley, including options which incorporate a debris flow shelter or a multi-span viaduct or a tunnel or less heavily engineered hazard reduction measures on the existing A83 corridor.

The results of the engineering and environmental assessment were collated into a series of Appraisal Summary Tables which provide a mainly qualitative comparison of the potential options.

The Red Option is expected to significantly reduce the frequency of occurrence of landslide debris reaching the A83 Trunk Road at a much lower cost than the other options.

The viaduct option (Yellow) performs better against the appraisal criteria in comparison to the debris shelter or tunnel options (Brown and Purple). The viaduct option has lower cost than both the debris shelter and tunnel options with lower environmental impact than the tunnel option and lower construction impact than the debris shelter option.

The Blue and Green corridor options have comparable estimated costs, in the range £27-91 million excluding VAT. For both of these options the residual risk of road closures due to landslides is considered to be negligible, as the options include appropriate mitigation measures in the form of engineering structures, in particular lengths of viaduct. The Green option however performs better against the safety criteria due to a more desirable route alignment and is therefore taken forward for further consideration.

As a result of this appraisal of options, the Brown, Purple and Blue options were sifted out of the appraisal and the Red, Yellow and Green options were taken forward to a more detailed economic appraisal. The Red option results in a similar level of benefits over the appraisal period as the yellow and green options for significantly less capital costs over the same period.

10.2 Conclusions

At the A83 Rest and Be Thankful, since publication of the Scottish Road Network Landslide Study (2005), appropriate physical hazard reduction measures have been introduced at locations considered to present the greatest hazard. Following the appraisal of the range of permanent options considered in this report, it is concluded that the Red Option offers the best performance against the assessment criteria.

The Red option comprises an additional 440m of debris flow barriers, representing a significant step-change in the landslide hazard reduction for the A83 Rest and Be Thankful. In addition, this option includes measures to improve the hillside drainage adjacent to and under the road. The planting of vegetation may also help contribute to this strategy though the beneficial effects of vegetation would be realised during a period around 15 to 35 years after planting. The cost of these measures is estimated to be in the range £9m-10m (excluding VAT). This represents a cost-effective way of reducing the impact on journey times and the subsequent economic impact as a result of road closures due to landslides at Rest and Be Thankful. The Emergency Diversion Route being brought into use by Transport Scotland would be required until the proposed measures had provided sufficient protection to the A83.

Actions are also recommended to address the ground related hazards at other locations on the A83 Trunk Road, in particular at Glen Kinglas, Cairndow and Loch

Shira to give a comparable level of landslide protection to that proposed at the Rest and Be Thankful.

References

General

Arrochar, Tarbet and Ardlui Heritage Website: [http://www.arrocharheritage.com/HistoryOfRABT.htm]

Jacobs (August, 2012). A83 Trunk Road Route Study – Stakeholder Consultation Workshop: Summary of Discussion. Produced for Transport Scotland. [http://www.transportscotland.gov.uk/road/maintenance/landslides/A83-rest-and-be-thankful]

Winter, M.G., Macgregor, F. and Shackman, L. (Eds). 2005. Scottish Road Network Landslides Study. The Scottish Executive, Edinburgh. [http://www.scotland.gov.uk/Publications/2005/07/08131738/17395]

Galbraith, R.M.,Price, D.J. and Shackman, L. (Eds) 2005 Scottish Road Network Climate Change Study. The Scottish Executive, Edinburgh.

Winter, M.G., Macgregor, F. and Shackman, L. (Eds) 2009. Scottish Road Network Landslides Study: Implementation. Transport Scotland, Edinburgh.Transport Scotland (2009). Scottish Road Network Landslide Hazard Ranking. [http://www.transportscotland.gov.uk/strategy-and-research/publications-and-consultations/j10107-00.htm]

A83 Trunk Road Route Study – Part B Tarbet-Lochgilphead-Kennacraig, Produced by Jacobs for Transport Scotland, December 2012

Winter, M G and Corby, A (2012). A83 Rest and Be Thankful: Ecological and Related Landslide Mitigation Options. Published Project Report PPR 2300. Transport Research Laboratory, Wokingham

Scotland TranServ (2012), Study into Potential Emergency Diversion Routes at the Rest and Be Thankful

Land Use

Forestry Commission Scotland. (2012) Argyll Forest Park Information Leaflet. http://www.forestry.gov.uk/argyllforestpark [Accessed October 2012].

Loch Lomond and the Trossachs National Park. (2011) Adopted Local Plan. http://www.lochlomond-trossachs.org/planning/adopted-local-plan/menu-id-904.html [Accessed October 2012]

Ordnance Survey (2010) Explorer Map 1:25,000, Sheet 364: Loch Lomond North, Tyndrum, Crianlarich and Arrochar.

Royal Commission on the Ancient and Historical Monuments of Scotland (2012) Camore ID 123139. http://canmore.rcahms.gov.uk/en/site/126139/digital_images/laigh+glencroe/ [Accessed October 2012]

The Macaulay Institute for Soil Research (1982) Land Capability for Agriculture 1:250 000, Sheet 4, Western Scotland.

Geology, Land Contamination and Groundwater

BGS (2011) User Guide: Groundwater Vulnerability (Scotland) GIS dataset, Version 2. Groundwater Science Programme, Open Report OR/11/064. British Geological Survey (Ó Dochartaigh B É, Doce D D, Rutter H K and Macdonald A M)

British Geological Survey Geoindex website: http://www.bgs.ac.uk/geoindex (Accessed 08/10/12)

Environment Scotland website: www.environment.scotland.gov.uk (Accessed 08/10/12)

SEPA River Basin Management website: http://gis.sepa.org.uk/rbmp (Accessed 08/10/12)

Water Environment

CIRIA (2007) The SUDS Manual C697, 600pp. Construction Industry Research and Information Association, ISBN: 978-0-86017-697-8.

CIRIA (2010) Culvert design and operation guide C689, 382pp. Construction Industry Research and Information Association, ISBN: 978-0-86017-689-3.

Ordnance Survey (2010) Explorer Map 364: Loch Lomond North, Tyndrum, Crianlarich & Arrochar.

SEPA Pollution Prevention Guidelines. Available at: http://www.sepa.org.uk/about_us/publications/guidance/ppgs.aspx (accessed October 2012).

SEPA (2010) SEPA Indicative River and Coastal Flood Map (Scotland). Available online at: http://www.sepa.org.uk/flooding/flood_extent_maps.aspx (accessed October 2012).

Scottish Environment Protection Agency (2010b). RBMP Waterbody information sheet for waterbody 10217 in Clyde. Accessed October 2012. Available online at: http://apps.sepa.org.uk/rbmp/pdf/10217.pdf.

SEPA (2011a) (accessed May 2012). SEPA River Basin Management Plan (RBMP) Interactive Map. Available online at: http://www.sepa.org.uk/water/river_basin_planning.aspx (accessed October 2012).

SEPA (2011b) SEPA Shellfish Datasheet – Loch Long. Available online at: http://www.sepa.org.uk/water/protected_areas/shellfish_waters/site_reports.aspx (accessed October 2012).

Ecology and Nature Conservation

Argyll Fisheries Trust (2010). South Argyll Rivers Project, Final Report: Survey of fish populations and habitats 2008-10. Argyll Fisheries Trust, Inveraray, Argyll. Available online at: http://www.argyllfisheriestrust.co.uk/pdfs/southargyllrivers.pdf

Davis, A.R. and Gray, D. (2010). The distribution of Scottish wildcats (Felis silvestris) in Scotland (2006-2008). Scottish Natural Heritage Commissioned Report No. 360. Available online at: http://www.snh.org.uk/pdfs/publications/commissioned_reports/360.pdf

Forestry Commission Scotland. Map Viewer.(http://maps.forestry.gov.uk/imf/imf.jsp?site=fcscotland_ext&). Accessed October 2012.

Highland Ecology and Development (HED) Ltd. (2012). A83 Rest and Be Thankful Diversion scheme, Bat survey and report (2 bridges). Unpublished report for Scotland TranServ, August 2012.

Highways Agency et al. (1993). DMRB Volume 11, Environmental Assessment, Section 3, Part 4 (Ecology and Nature Conservation). June 1993. The Highways Agency, Scottish Executive Development Department, The National Assembly for

Wales and The Department of Regional Development Northern Ireland. Available online at: http://www.dft.gov.uk/ha/standards/dmrb/vol11/section3/11s3p04.pdf

Highways Agency et al. (2010). DMRB, Interim Advice Note 130/10. Ecology and Nature Conservation: Criteria for Impact Assessment. The Highways Agency, Scottish Executive Development Department, The National Assembly for Wales and The Department of Regional Development Northern Ireland. Available online at: http://www.dft.gov.uk/ha/standards/ians/pdfs/ian130.pdf

IEEM (2006). Guidelines for Ecological Impact Assessment in the United Kingdom. Available online at: http://www.ieem.net/data/files/Resource_Library/Technical_Guidance_Series/EcIA_Guidelines/TGSEcIA-EcIA_Guidelines-Terestrial_Freshwater_Coastal.pdf

JNCC (1998). Guidelines for Selection of Biological SSSIs. Peterborough, JNCC. Available online at: http://jncc.defra.gov.uk/page-2303#download

JNCC accounts for UK BAP list of priority habitats (http://jncc.defra.gov.uk/page-5706) and UK BAP priority species list (http://jncc.defra.gov.uk/page-5717).

JNCC website (http://jncc.defra.gov.uk/page-0). Joint Nature Conservation Committee. Accessed October 2012.

Loch Lomond & The Trossachs National Park Authority (2009). National Park Biodiversity Action Plan 2008-2011. Accessed October 2012, available online at: http://www.lochlomond-trossachs.org/images/stories/Looking%20After/PDF/NPBAP/NPBAP.pdf

NBN gateway website. The National Biodiversity Network (http://data.nbn.prg.uk/interactive). Accessed October 2012.

Scotland TranServ (2012). Rest and Be Thankful Diversion: Supporting Information for Application for Otter Licence. Unpublished report on behalf of Transport Scotland.

SEPA (2010a). RBMP Water body information sheet for water body 10215 in Clyde. Scottish Environment Protection Agency. Accessed October 2012, available online at: http://apps.sepa.org.uk/rbmp/pdf/10215.pdf

SEPA (2010b). RBMP Water body information sheet for water body 10217 in Clyde. Scottish Environment Protection Agency. Accessed October 2012, available online at: http://apps.sepa.org.uk/rbmp/pdf/10217.pdf

SEPA River Basin Management Plans Interactive Map (http://gis.sepa.org.uk/rbmp/). Scottish Environment Protection Agency. Accessed October 2012.

SNH (2008). Ancient Woodland Inventory. Scottish Natural Heritage. http://www.snh.org.uk/wwo/sharinggoodpractice/eia_home.asp

SNH (2010). Citation for Special Protection Area (SPA) Glen Etive and Glen Fyne (UK9020307). Scottish Natural Heritage. Accessed October 2012, available online at: http://gateway.snh.gov.uk/sitelink/siteinfo.jsp?pa_code=10113

SNH (2011). Citation for Beinn An Lochain Site Of Special Scientific Interest. Scottish Natural Heritage. Accessed October 2012, available online at: http://gateway.snh.gov.uk/sitelink/siteinfo.jsp?pa_code=163

SNH Information Service (www.snh.org.uk/snhi/). Scottish Natural Heritage. Accessed October 2012.

The Multi-Agency Geographical Information for the Countryside website (www.magic.gov.uk). Accessed October 2012.

Transport Scotland (2012). Rest and Be Thankful Diversion Route Record of Determination, v.2. Control Date 30/08/2012. Unpublished report to Transport Scotland and Scotland TranServ.

UK Biodiversity Action Plan (UK BAP) website (www.ukbap.org.uk). Accessed October 2012.

W A Fairhurst & Partners (1999). NVC Community Mapping and Vegetation Condition Assessment of Beinn an Lochain SSSI. Unpublished report to Scottish Natural Heritage, February 1999.

Landscape and Visual

Highways Agency et al., (1993). Design Manual for Roads and Bridges (DMRB), Volume 11, Section 3, Part 5, Landscape and Visual Assessment.

Landscape Institute and the Institute for Environmental Management and Assessment (2002). Guidelines for Landscape and Visual Impact Assessment, 2nd edition. Spon Press.

Scottish Natural Heritage (SNH), (2009). Commissioned Report, Review: Loch Lomond and The Trossachs National Park Landscape Character Assessment. SNH and the Loch Lomond and The Trossachs National Park Authority.

Cultural Heritage

CFA Archaeology Ltd. 2012 Old Military Road, Rest and Be Thankful Diversion Route: Cultural Heritage Assessment.

Highways Agency, 2007, Design Manual for Roads and Bridges, Volume 11, Section 3, Part 2, 'Cultural Heritage', HA 208/07.

Historic Scotland, 2012. Managing Change in the Historic Environment Setting.

Institute for Archaeologists, 2011. Standard and Guidance for historic desk-based assessment.

Transport Scotland, 2012. Rest and Be Thankful Diversion Route Record of Determination.

Air Quality

Air Pollution Information System. www.apis.ac.uk (accessed 3/10/12)

Highways Agency et al. (2007). DMRB Volume 11, Part 1, Section 3 HA207/07. The Highways Agency, Scottish Executive Development Department, The National Assembly for Wales and The Department of Regional Development Northern Ireland.

Transport Scotland (2010) http://www.transportscotland.gov.uk/files/InfoMapper/hot/JTC08338.htm (accessed 22/10/12).

UK Local Air Quality Management Archive (DEFRA) http://laqm.defra.gov.uk/maps/maps2010.html (accessed 3/10/12).

Noise and Vibration

British Standard 5228: 2009 - Code of practice for noise and vibration control on construction and open sites, Part 1: Noise and Part 2: Vibration.

The Highways Agency (November 2011) Design Manual for Roads and Bridges, Volume 11, Section 3, Part 7 – Noise and Vibration (HD 213/11 Revision 1).

Pedestrians, Equestrians, Cyclists and Community Effects

Countryside (Scotland) Act 1967. HMSO.

Design Manual for Roads and Bridges (DMRB) (1993) Vol.11, Section 3, Part 8: Pedestrians, Cyclists, Equestrians and Community Effects.

Land Reform (Scotland) Act 2003. HMSO.

Loch Lomond and The Trossachs National Park (2010) Core Path Plan.

Ordnance Survey (2006) Explorer Map 1:25000, Sheet 364: Loch Lomond North, Tyndrum, Crianlarich & Arrochar.

SNH (2002). The Provision of Paths in Scotland. Scottish Natural Heritage.

Vehicle Travellers

Highways Agency et al., (1993). Design Manual for Roads and Bridges (DMRB), Volume 11, Section 3, Part 9, Vehicle Travellers.

Policies and Plans

Argyll and Bute Council (2002). Argyll and Bute Structure Plan, Argyll and Bute Council

Highways Agency (1994). Design Manual for Roads and Bridges, Volume 11, Section 3, Part 12 “Impact of Roads Schemes on Policies and Plans”, Highways Agency.

Loch Lomond and the Trossachs National Park Authority (2007). National Park Plan 2007-2012, Loch Lomond and the Trossachs National Park Authority.

Loch Lomond and the Trossachs National Park Authority (2011). Loch Lomond and the Trossachs National Park Local Plan, Loch Lomond and the Trossachs National Park Authority.

Scottish Government (2009). National Planning Framework 2, Scottish Government.

Scottish Government (2010). Scottish Planning Policy, Scottish Government.