Stromeferry Options Appraisal

DMRB Stage 2 / STAG Report

The Highland Council

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1. Introduction

1.1 Study Background

The 'Stromeferry Bypass' is an approximately 12km long section of Public Road along the southern shore of Loch Carron, located in Wester Ross, in the western Highlands of Scotland. The road forms part of the A890, between the Strathcarron Junction and the tie in with the A87, Invergarry to Kyle of Lochalsh Trunk road, at Auchtertyre. The road also forms part of the wider road network between Dingwall west to the Isle of Skye via Achnasheen, and provides a popular alternative route from Inverness to Kyle of Lochalsh and Skye.

The public road and a single track railway line are sharing a tight corridor along the southern shores of Loch Carron, which is particularly restricted over an approximately 4.5km long section from Ardnarff to Attadale. The A890 is mainly a single carriageway but reduces frequently to single track with passing places along this section of road.

Figure 1.1 - Southern Shore of Loch Carron from Attadale in the east (top) towards South Strome in the west (bottom)

Up until 1970, when the bypass was opened to the public, the transport link from Kyle of Lochalsh north towards Ullapool was provided by a ferry service crossing the Strome Narrows in between South and North Strome, with minor roads linking the crossing to the local road network at either end.

Since the Stromeferry Bypass was opened, the approximately 4.5km long section of mainly single track road from Ardnarff to Cuddies Point, which is located just west of Attadale, has been subject to landslides and rock fall events, causing the Local Authority to temporarily close the road on several occasions, in order to enable remedial works to the rock slopes to take place.

Figure 1.2 - Northern Shore of Loch Carron looking west towards Lochcarron Village

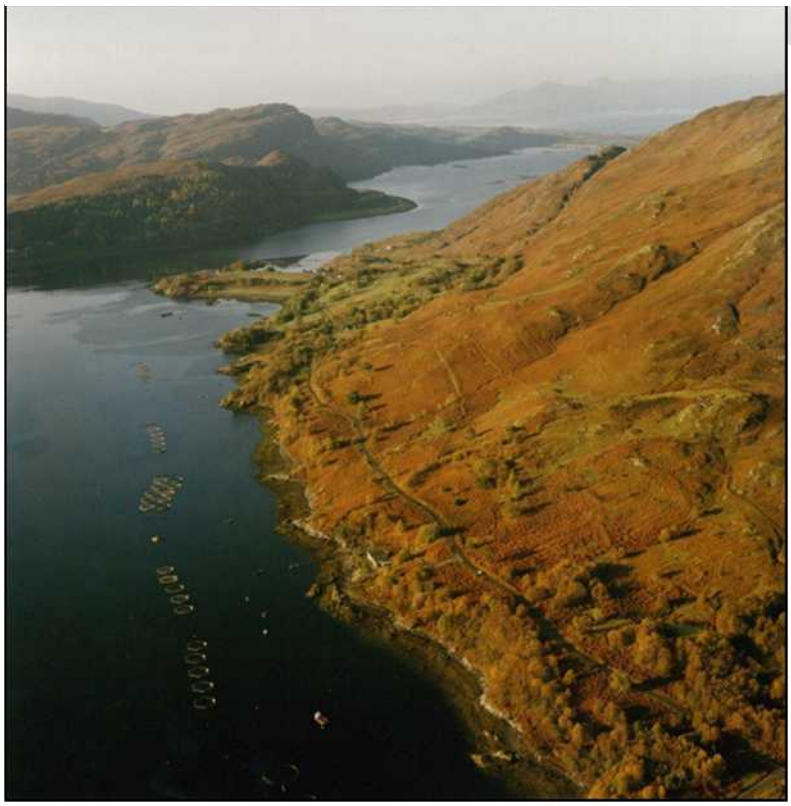

Figure 1.3 - South west end of Loch Carron, looking west towards the Narrows

These events also affected the railway line and forced road and rail users to accept up to 130-mile road diversions during these closures. Other contingency measures, including dual running of road

and rail and a ferry service from South to North Strome, were put in place by The Highland Council to alleviate some of the traffic problems through periods of road closures following more recent rock fall events, particularly those of December 2011. Both the dual running of road and rail and the ferry service were restricted to smaller class of vehicles, and were only available during the day.

Due to the ongoing problems with this section of public road, the Local Authority commissioned several feasibility studies in the 1990s, looking at various possible route options and schemes to bypass the problem areas. However, no final decision was reached on which option to take forward at that stage, and The Highland Council continued to maintain the route and carry out emergency works, as and when required.

Following a rock fall event in December 2011, when the A890 Stromeferry Bypass had to be closed over a period of several months, The Highland Council Committee for Transport, Environmental and Community Services approved the proposal for further options appraisal in connection with the Stromeferry Bypass to be carried out in August 2012. URS Infrastructure and Environment UK Ltd (now AECOM) were appointed by The Highland Council in October 2012.

This report examines the rock fall problem on the A890 and considers options to minimise the effects of road and rail closures on the local communities and road and rail users in the area. It re-formats the previous reports produced by URS (now AECOM) in 2012/13, as set out in Table 1.1 below, to incorporate feedback received from Transport Scotland in September 2015. Other than where necessary to address the specific feedback received from Transport Scotland, this report does not seek to update the quantitative data gathered to inform the original reports. The main emphasis of this report is to focus on the infrastructure required to bypass the rock fall area, previously described as 'Phase 1', the scheme development to bypass the rock fall area as a minimum, as illustrated on Figure 1.4.

Table 1.1 - Stromeferry Reports

Report Name	Date Published
Economic Stakeholder Workshop No 1 Summary	December 2012
Regulatory Stakeholder Workshop No 1 Summary	November 2012
Scottish Transport Appraisal Guidance (STAG) Pre Appraisal Report	March 2013
Stromeferry Options Appraisal STAG Part 1 / DMRB Stage 1 Report	May 2013
Economic Stakeholder Workshop No 1 Summary	December 2012
Regulatory Stakeholder Workshop No 1 Summary	November 2012
Stromeferry Options Appraisal STAG Report (Pre- Appraisal / Part 1)	March 2016

1.2 Description of the Study Area

A plan of the study area is shown within Figure 1.4, below.

The issues with regards to ongoing rock fall events on the A890 between Ardnarff and Cuddies Point affect both the local Loch Carron area from Plockton, Strathcarron and Lochcarron Village up to Applecross, but also significant transport links from East to West, from Skye to Ullapool and Inverness and wider geographical linkages South to North between Fort William and the North West Coast of Scotland.

The Highland Council Local Transport Strategy 2010/11 to 2013/14 identifies the A890 as an 'H2a Regional' road in the context of the Highland roads hierarchy. The route does not feature in the Strategic Transport Projects Review, as it is not a Trunk Road. Although nationally not recognised as a 'strategic' route, locally it provides vital links to health, educational and leisure facilities, as well as places of work, and is a popular tourist route. The West Coast of Scotland is also home to a variety of businesses from renewable energy developments and fish farming, to forestry enterprises, and more local shops and tourism related businesses, all of which rely on the availability of the (local) road network.

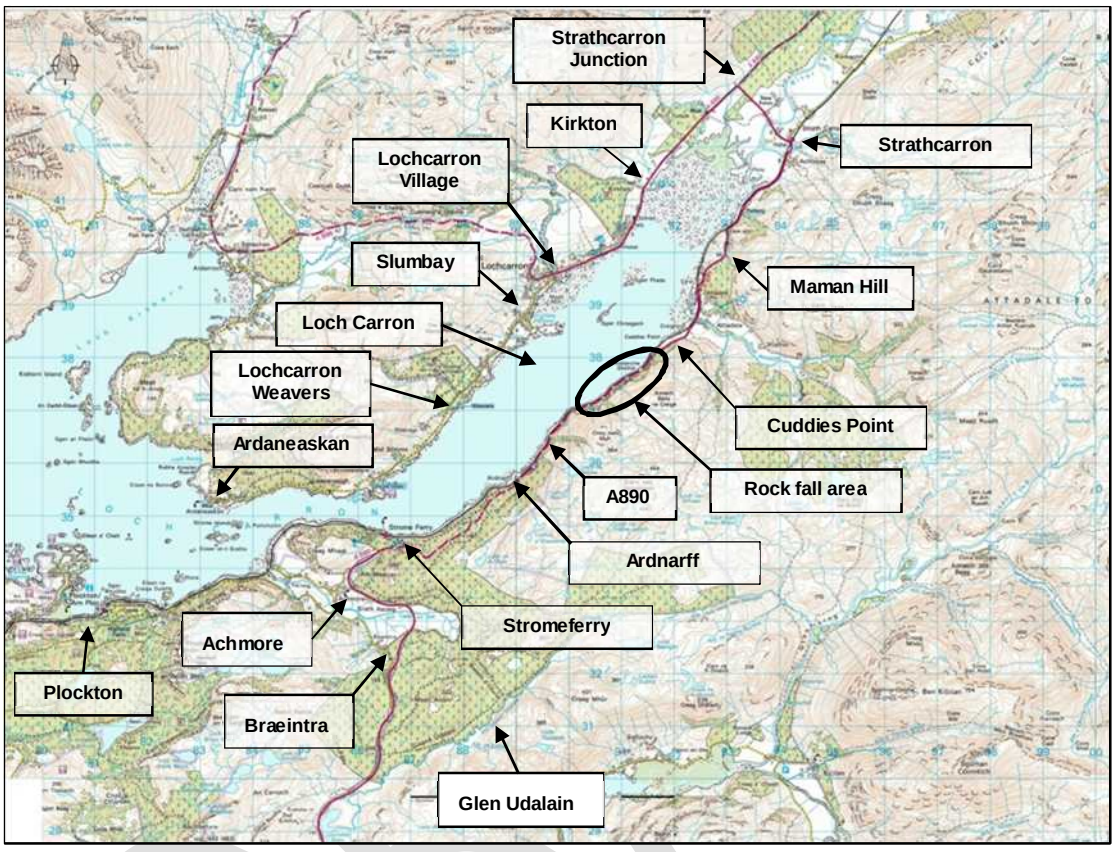

Figure 1.4- Area Plan

Transport reliability and dependency is seen as an important business consideration, with businesses vulnerable to delivery delays, uncertainty regarding connectivity and accessibility. This affects most local businesses in the retail, tourism, haulage and transportation and other sectors.

Closure of the A890 alongside Loch Carron results in diversions via the wider public road network of 130 miles' length, through Achnasheen, Muir of Ord, Loch Ness side and Kintail, as shown in Figure 1.5.

Figure 1.5 - Diversion Route

1.3 Methodology

The methodology agreed with the Client in relation to this study overall is as outlined in the Client's brief (October 2012) and combines the processes of the Scottish Transport Appraisal Guidance (STAG) and Design Manual for Roads and Bridges (DMRB). This methodology adopts a phased approach to scheme delivery involving:

1. Pre-Appraisal stage: active involvement of local 'economic' and 'regulatory' stakeholders through workshop sessions, together with a review of available background information, to develop project (Transport Planning) Objectives, considering identified problems, constraints and opportunities, as well as developing route options and a first step sifting.
2. STAG Part 1 / DMRB Stage 1: high-level appraisal of route options and corridors to fulfil the requirements for the preparation of a Stage 1 Scheme Assessment report in accordance with the DMRB, in combination with an assessment of the route options and corridors against Transport Planning Objectives, STAG Criteria, established policy directives and public acceptability. This is to provide a rationale for the selection or rejection of a route or corridor option.
3. STAG Part 2 / DMRB Stage 2: further in-depth appraisal of emerging route options and corridors in accordance with the requirements of the DMRB Stage 2 Scheme Assessment process, in combination with an appraisal of options against the Transport Planning Objectives and other STAG criteria.

The STAG Pre- Appraisal / STAG Part 1 / DMRB Stage 1 Scheme Assessment Report was published in March 2016.

This report focusses on the STAG Part 2 / DMRB Stage 2 stages only. Further work on developing any option(s) emerging from this study, may be required and is subject to decision by The Highland Council and funding partners.

1.4 Report Structure

Following this Introductory Chapter, the remainder of the report is set out within eight Chapters, as follows:

- Chapter 2 – STAG Pre-Appraisal / STAG Part 1
- Chapter 3 – Options
- Chapter 4 – Engineering Assessment
- Chapter 5 – Environmental Assessment
- Chapter 6 – Traffic and Economic Assessment
- Chapter 7 – STAG Part 2 Appraisal
- Chapter 8 – Conclusions

In addition, there are four supporting Appendices:

- Appendix A – Drawings
- Appendix B – Geotechnical Desk Study Report
- Appendix C – Peat Management Report
- Appendix D – Tunnel Report
- Appendix E – Environmental Assessment
- Appendix F – Buildability Study
- Appendix G – Strome Narrows Crossing Technical Note
- Appendix H – Statutory Processes
- Appendix I – Business Survey Report
- Appendix J – Assessment Summary Tables

2. STAG Pre Appraisal / STAG Part 1

2.1 Analysis of Problems and Opportunities

Stromeferry Bypass is an approximately 12km long section of public road alongside the southern shore of Loch Carron, located in Wester Ross in Western Highlands in Scotland. The road forms part of the A890 between Strathcarron Junction and the tie in with the A87, Invergarry to Kyle of Lochalsh Trunk Road. The road is mainly a single carriageway but reduces frequently to single track with passing places along this section of road.

The existing Stromeferry Bypass shares a narrow corridor with the single track Dingwall to Kyle of Lochalsh railway line along the southern shores of Loch Carron. This is particularly restricted over an approximately 4.5km long section from Ardnarff to Attadale, where the road / rail corridor is restricted by the Loch Carron short to the west and the existing steep rock face to the east. The topography in the study area varies between sea level at Loch Carron up to levels of 490m above Ordinance Survey Datum along the range of hillside south of Loch Carron.

The existing A890 from the Kyle of Lochalsh to Loch Carron passes through undeveloped hill land and areas of forestry, experiencing steep road gradients of up to 14%. The land use within the area is agricultural, comprising mainly rough grazing in large areas of undeveloped heath and moorland, as well as areas of forestry and crofting. Other than the existing road network which includes the A890 Stromeferry Bypass, A896 and other roads, other engineering constraints within the immediate study area include:

- Dingwall to Kyle of Lochalsh railway line, and the existing level crossing at Strathcarron;
- Watercourses including Loch Carron and Strome Narrows, river Attadale, river Carron
- Settlements of Stromeferry, Slumbay, Lochcarron, Strathcarron, Achintee, Achmore, Kirkton and other properties; and
- Local steep topography, including the unstable rock face.

The approximately 4.5km long section of mainly single track road on the A890 from Ardnarff to Cuddies Point, which is located just west of Attadale, has a history of landslides and rock fall events. Between March 1990 and December 2012, there have been ten significant rock fall events, including two closures of the A890 that lasted for extended periods. The March 1990 event lasted eight weeks or approximately 60 days, and affected both the A890 and the adjacent railway line. The rock fall in December 2011 lasted four months or approximately 120 days and affected the A890. Over a period of 21 years and nine months, the A890 has been closed for circa 182 days due to a major rock fall event, and the adjacent railway line for approximately 60 of these days.

The issues with regards to ongoing rock fall events affect both the local Loch Carron area from Plockton, Starthcarron and Lochcarron Village up to Applecross, but also significant transport links from East to West, from Skye to Ullapool and Inverness and wider geographical linkages South to North between Fort William and the North West Coast of Scotland.

When the A890 Stromeferry Bypass road is closed due to a rock fall, there is only one feasible option for undertaking an alternative route. Journeys from north to south, instead of using the A890 Strathcarron junction to A890 Stromeferry junction link, a distance of approximately 8.5 miles (13.6 kilometres) and taking some 15 minutes, would require a trip of circa 130 miles (204 kilometres) and nearly three hours, through Achnasheen, Muir of Ord, Loch Ness side and Kintail. Other contingency measures, including dual running of road and rail and a ferry service from South to North Strome, were put in place by The Highland Council to alleviate some of the traffic problems through periods of road closures following more recent rock fall events. Both the dual running of road and rail and the ferry service were restricted to vehicles limited to 7.5tonnes, and were only available during the day.

Maintenance works carried out on the A890 Stromeferry Bypass over the past years have included emergency works carried out following the rock fall event in December 2011, at a recorded total cost of £2.84M. In addition, The Highland Council estimates that around £250k is required to cover for the maintenance of rock slopes along this route on an annual basis, with future spend for emergency works unknown due to the unpredictable behaviour of the existing rock faces. This was reported to be

the case despite regular inspections carried out by The Highland Council and rigorous contingency planning.

Consultation undertaken during this study enabled stakeholders to share their views about the issues experienced by road and rail users, as well as local business. This included the wider impacts of road and rail closures due to rock fall events, based on using the 130-mile temporary diversion route. The consultation exercise has informed the identification of the evidence-based transport problems and opportunities in the study area.

2.2 Transport Planning Objectives

Transport appraisal in accordance with STAG requires five main areas of impact to be considered: Environment, Economy, Safety, Integration, and Accessibility and Social Inclusion. In addition, specific Transport Planning Objectives (TPOs) were developed to reflect the local situation, as follows:

- Reduce impact on journey times and journey time reliability by reducing the frequency and duration of road and rail closures caused by rock fall events.
- Reduce the negative economic impact to the A890 study area by reducing the frequency and duration of road and rail closures caused by rock fall events.
- Solution reduces, or does not increase, the risk to, and liability of, the railway and maintains suitable access over the life of the scheme.

2.3 Option Generation and Sifting

This study examined a wide range of potential long-term solutions, both roads-based and non-roads-based, to address the rock fall issues on the A890 at Stromeferry, grouped as follows:

2.3.1 Outer North Corridor

The Outer North Corridor (ONC) is an offline corridor with routes leaving the existing A890 near Achmore south-west of Stromeferry, continuing along a western crossing of the Strome Narrows, with some routes heading north towards a tie-in with the A896 near Ardarroch. The ONC encompasses two route options, which vary in the location of the western Strome Narrows crossing. The route ties in to the existing A896 some 2km east of Ardarroch. ONC routes would bypass the section of the A890 from Ardnarff and Cuddies Point which is subject to rock fall events.

The ONC was developed to provide a direct south-north link along the west coast, and also offer easier access to Kishorn Yard. ONC would bypass Stromeferry, the section of the A890 in between Ardnarff and Cuddies Point subject to rock fall events, and all dwellings along the southern shores of Loch Carron, from Stromeferry east to the Strathcarron Junction.

2.3.2 North Shore Corridor

The North Shore Corridor (NSC) is an offline corridor, with routes generally leaving the existing A890 near Achmore, south-west of Stromeferry, then crossing the Strome Narrows, and then tying into the existing road along the north shore of Loch Carron.

The NSC was developed to satisfy the wish for better connectivity of Lochcarron Village, and replicates the original route from Kyle to Lochcarron, before the ferry at Stromeferry was abandoned and the Stromeferry Bypass constructed. NSC routes would bypass the section of the A890 from Ardnarff and Cuddies Point which is subject to rock fall events.

Twelve route options were developed within NSC. These mainly varied with regards to the location and means of crossing the Strome Narrows: options considered include bridge, tunnel and ferry crossings.

2.3.3 Mid-loch Corridor

The Mid Loch Corridor (MLC) is an offline corridor, which includes Loch Carron crossings as an alternative to the Strome Narrows crossings (as included in the ONC and NSC). To cross Loch Carron, MLC routes would require bridge structures of considerable length.

Two route options were developed within MLC. The routes would remain online along the A890 on the south approach to the bridge crossing, and return online at Lochcarron village or at Kirkton. MLC routes would bypass the section of the A890 from Ardnarff and Cuddies Point which is subject to rock fall events.

2.3.4 Online Corridor

The Online Corridor includes routes which follow the existing A890 road corridor. The primary consideration for all online routes is the improvement of the approximately 4.5km long road section in between Ardnarff and Cuddies Point. Six Online route options were developed including carriageway widening, rock face remodelling, bypassing of the rock fall area (via tunnel or viaduct), road / rail share and implementation of an extended rock shelter. Within the Online Corridor, consideration was also given to closure of the railway. In addition, a Do Minimum scenario was established to provide a baseline upon which all other options could be compared.

2.3.5 South Corridor

The South Corridor is an offline corridor which includes routes south of the existing A890 road corridor. South Corridor routes would bypass the section of the A890 from Ardnarff and Cuddies Point which is subject to rock fall events. The corridor includes routes through Glen Udalain, passing Cnoc nam Mult and Loch nam Breac Mora, through Glen Attadale returning to the A890 at Attadale or Strathcarron.

Eight route options were developed within the South Corridor. Some routes provide a high-level route from Stromeferry passing Cnoc nam Mult towards Glen Attadale. Other routes provide alternative tie-ins to the A890 south, from Glen Udalain, Braeintra and Stromeferry.

2.3.6 Outer South Corridor

The Outer South Corridor (OSC) is an offline corridor which includes routes extending from the A87 at Dornie in the south, along Loch Long, north through Glen Ling towards Attadale. The OSC was developed to provide a complete south – north link from the A87 Trunk Road to the A890 at Strathcarron. The OSC would bypass the section of the A890 in between Ardnarff and Cuddies Point which is subject to rock fall events.

Two route options were developed within the OSC.

2.3.7 Non Roads-based options

Three non-roads-based options were considered including routes involving a non-fixed ferry crossing of the Strome Narrows; and air travel.

Individual options within each of these route corridors and groups were subject to an initial sifting process, informed by initial engineering, environmental, and traffic/economic considerations and stakeholder consultations. Fourteen options emerged for appraisal, as set out within Table 2.1, below.

Table 2.1 - Appraisal Options

Route Corridor	Option Name	Option Description
Outer North Corridor	Option ON3	Offline route which provides a direct south to north link, two lane carriageway from Achmore as far north as Ardarroch, including a western crossing of the Strome Narrows
North Corridor	Option N2	Offline route providing a two lane carriageway following a western bridge crossing of the Strome Narrows, and would then tie in to the existing road along the northern shore of Loch Carron
	Option N6	Offline route providing a two lane carriageway, originating at Achmore, following an eastern Strome Narrows bridge crossing and ties in to the existing minor road along the north shore of Loch Carron
	Option N9	Offline route providing a two lane carriageway following a western bridge crossing of the Strome Narrows, continues offline passing north of Stromemore, and then ties in to the existing minor road along the

Route Corridor	Option Name	Option Description
		north shore of Loch Carron
Online Corridor	Option O1	Online improvement of the existing A890 to a two lane carriageway from Ardnarff to Cuddies Point, including major rock excavations
	Option O2	Online improvement of the existing carriageway to a two lane carriageway from Ardnarff to Cuddies Point, including a local 1.8km bypass of the rock fall area west of Cuddies Point by means of a cantilevered structure along the shoreline
	Option O3	Online improvement of the existing carriageway to a two lane carriageway from Ardnarff to Cuddies Point, including a 1.6km bypass of the rock fall area west of Cuddies Point by means of an inland tunnel
	Option O4	The Do Minimum scenario, with no proposed improvements to the existing route, above that which is currently committed
	Option O5	Online improvement of the existing A890 to a two lane carriageway from Ardnarff to Cuddies Point, including a local 1.8km shared road / rail corridor west of Cuddies Point
	Option O7	Online improvement of the existing A890 to a two lane carriageway from Ardnarff to Cuddies Point, including a local 2.0km extended rock shelter west of Cuddies Point
South Corridor	Option S1	Southern offline two lane carriageway bypass from Stromeferry through parts of Glen Udalain and Attadale valley, and ties back in to the existing A890 at Attadale
	Option S3	Southern offline two lane carriageway bypass from Braeintra through parts of Glen Udalain and Attadale valley, and ties back in to the existing A890 at Attadale
	Option S4	Principal southern offline two lane carriageway bypass route from the A890 through Glen Udalain and Attadale valley, and ties back in to the existing A890 at Attadale
	Option 5b	Southern offline two lane carriageway bypass from the A890 through Glen Udalain, with a northern route through Attadale valley and a bypass of Maman Hill, and ties back in to the existing A890 at Achintee

The following section summarises the assessment of these fourteen options. It should be noted that 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 assessment.

2.4 Engineering Assessment

The engineering assessment of the fourteen options under consideration has been carried out in accordance with the requirements of the current guidance provided in DMRB. This has included a broad assessment of engineering issues only at this stage, with a more in-depth assessment required should any option(s) be taken forward for further stages of assessment.

The engineering assessment has considered the existing condition of the A890 carriageway and structures, as well as topography, hydrology and geology of the area in relation to proposed new route alignments.

Assessment of the existing route highlighted the problems with regards to the restricted corridor alongside Loch Carron, as well as the steep road gradients both on the Maman Hill section, as well as in between Stromeferry and Ardnarff.

All routes considered in the appraisal were assessed from starting points which varied from Glen Udalain up to Stromeferry and Ardnarff, extending to endpoints which varied from Ardarroch, Strome

Wood, Cuddie's Point, Attadale and Maman Hill. The proposed new road alignments are to provide an adequate road width to modern standards, with sufficient width to allow safe use by all traffic, including non-motorised users. The assessment of alignments therefore considered a two-lane carriageway, with each lane 3.0m wide, with a 0.65m wide delineated hard strip and 2.5m wide soft verges on either side. This would consider a total corridor width of 12.30m.

Steep gradients were fixed at a maximum of 10% where existing or new road alignments are crossing a steep topography, with the aim to reduce this to 8% maximum at the detailed design stage.

Each of the proposed fourteen route options were appraised in detail, considering both horizontal (plan) and vertical alignments against the currently accepted road standards. All routes were considered to a design speed of 100 kph (60 mph).

The engineering assessment also covered existing and / or new structures, including bridges, tunnels, culverts and retaining walls, and highlighted issues regarding existing dwellings along proposed routes, where these may restrict potential widening of existing roads. Assessment of the existing A890 between Ardnarff and Cuddies Point included developing a variety of possible local bypass measures, as well as considerations to excavate into existing rock slopes to achieve a widened road corridor.

Considerations for feasible crossings of the Strome Narrows, including bridge structures and tunnels at various locations, were also included.

In addition, information on existing Utilities was gathered and reviewed to establish if these may have an implication on any of the route proposals. Outline proposals in relation to the possibility of a renewable energy option were also investigated as part of the engineering assessment. These covered tidal barrages and tidal stream devices.

The Engineering assessment established outline capital costs for each of the options, and these will be subject to refinement should any option(s) be taken forward for further consideration.

2.5 Environmental Assessment

The environmental appraisal of the fourteen options under consideration was conducted drawing guidance provided in DMRB. The key purpose of this stage of the appraisal is to allow a comparison of alternative options, enabling those options which are unsuitable on environmental grounds to be filtered out at an early stage. At this stage the appraisal did not include any detailed on-site survey work, but was conducted using information available for a 'desk based' study. The process also included further consultations with some of the regulatory stakeholders.

The assessment identified environmental advantages, disadvantages and constraints, considering aspects of nature conservation, landscape, road drainage and water environment, noise, air, geology and soils, cultural heritage, effects on travelers and community and private assets. A review of Government policies and plans was also conducted to ensure that none of the route proposals were contradicting these.

The environmental appraisal was conducted using established route corridors (Outer North, North Shore, On-line and Southern), plus an additional corridor covering the Strome Narrows crossings. Nevertheless, where impacts of individual routes within a corridor differed greatly from the assessment of the corridor, this was further assessed and commented on.

Consideration was given to both the magnitude of any impacts, and the sensitivity of the receptor.

2.6 Traffic and Economic Assessment

The economic appraisal has been conducted using standard economic welfare techniques, as set out in 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 rock fall events on the A890 at Stromeferry 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.

Available information on traffic counts were used to establish a traffic pattern on the existing route, confirming the high seasonal dependency with peak flows recorded between May and September, and the busiest month being August. At the time of analysis, no detailed traffic data regarding user groups, origin and destination information, was available. However, assumptions made regarding the usage of the route, considering this to be a 'rural tourist road', suggest that the route is mainly used by cars (over 80%), and 8% of light goods vehicles, with a similar percentage of heavy goods vehicles, and 1% of coaches.

The above was important in order to establish the likely economic impact of road closures of the A890 due to rock fall on the various road users. Ten events of rock fall were recorded since March 1990, with the most significant events closing the road for eight weeks in March 1990, and approximately four months during December 2011 and January 2012.

An economic survey included considerations of likely effects that a new route could have on the local economy. Assessment by corridor looked at the distribution and scale of potential impacts, with the main identified sectors covering tourism, retail and wholesale, agriculture, forestry and fish farming and green energy.

The results of the economic assessment show that the Benefit to Cost Ratios (BCR) are likely to be less than 1.0, with the best performing option being the on-line O5 route option considering road-rail share. The assumed capital costs of the options tend to be high for the traffic on the network, which means that it is unlikely that benefits from this level of analysis would cover the costs.

The high-level analysis suggests that none of the options provide a level of present value of benefits greater than present value of costs. However, with the application of monetised wider economic benefits (WEBs) and other benefits, these results may, of course, change. It should also be noted that no quantification of costs has been undertaken owing to road closure necessitated by option works. This may affect the sifted online route options disproportionately and will be taken account of, if required, at a later date.

2.7 Appraisal Summary

A review of the summary tables established during the appraisal indicated that all new (greenfield) routes score poorly on environmental grounds, with less impact anticipated for the on-line route proposals.

In cost and affordability terms, routes that do not require any major structures are more attractive, and therefore all northern routes, which require a crossing of the Strome Narrows, perform less well than southern routes.

Considering deliverability, the southern routes performed best. All online and northern proposals have higher risks associated with them, based on assumptions made regarding buildability, likely disruptions to both road and rail users, and estimated cost of construction.

Routes identified for further consideration are summarised within Table 2.2, below.

Table 2.2 - Summary of Emerging Route Options for Further Consideration

Corridor	Option	Detail	Description
North Corridor			
	N6	East bridge crossing and online on north shore	Route North N6 is a route option originating at Achmore, considering an eastern Strome Narrows crossing and following the route of the existing minor road along the northern shore of Loch Carron until Strome Wood
	N9	West bridge crossing and offline on north shore	Route N9 is an offline route option considering a western bridge crossing of the Strome Narrows, and then continues offline north of Stromemore, then ties into the existing road on the northern shore of Loch Carron at Strome Wood
Online Corridor			
	O2	Viaduct	Route Online O2 considers online improvement of the existing carriageway and a local 1.8km bypass of the rock fall area west of Cuddies Point by means of a cantilevered structure along the shoreline.

Corridor	Option	Detail	Description
	O3	Tunnel	Route Online O3 considers online improvement of the existing carriageway and a local 1.6km bypass of the rock fall area west of Cuddies Point by means of an inland tunnel structure.
	O4	Do-minimum	Route Online O4 is the Do Minimum scenario, with no proposed improvements to the existing route. This option also includes considerations for suitable contingency measures during (future) road closures.
	O7	Avalanche Shelter	Route Online O7 considers online improvement of the existing carriageway and a local 2.0km extended rock shelter west of Cuddies Point.
South Corridor			
	S4	Glen Udalain	Route South S4 considers a principal southern offline bypass route from the A890 through Glen Udalain and Attadale valley, and ties back into the existing A890 at Attadale.

Performance of each of the options against the appraisal criteria are summarised in Table 2.3, overleaf.

Table 2.3 - Summary of Options Measure against Appraisal Criteria

Appraisal Criteria		Options					
		N6	N9	O2	O3	O7	S4
Transport Planning Objectives	TPO 1: Reduce impact on journey times and journey time reliability by reducing the frequency and duration of road and rail closures caused by rock fall events.	By bypassing the rock fall area, these options would reduce the frequency of occurrence of rock fall debris reaching the A890 at Stromeferry and causing a full road closure, with associated journey time and economic impact. Whilst these options would not directly address rail closures caused by rock fall events, they would provide rail users with an alternative mode of transport during periods of closure. Option O2 has a greater positive impact due to the viaduct structure providing some additional protection to the rail line.			By bypassing the rock fall area by means of an inland tunnel structure, this option has the potential to reduce the frequency of occurrence of rock fall debris reaching the A890 at Stromeferry and causing a full road closure, with associated journey time and economic impact. Whilst it would not directly address rail closures caused by rock fall events, the tunnel structure would provide some protection to the railway and the option as a whole would provide rail users with an alternative mode of transport during periods of closure.	Creation of an extended rock shelter would significantly reduce the frequency of occurrence of rock fall debris reaching the A890 at Stromeferry and causing a full road / rail closure, with associated journey time and economic impact.	Creation of a southern principal off-line bypass route would reduce the frequency of occurrence of rock fall debris reaching the A890 at Stromeferry and causing a full road closure, with associated journey time and economic impact. Whilst these options would not directly address rail closures caused by rock fall events, they would provide rail users with an alternative mode of transport during periods of closure.
	TPO 2: Reduce the negative economic impact to the A890 study area by reducing the frequency and duration of road and rail closures caused by rock fall events.						
	TPO 3: Solution reduces, or does not increase, the risk to, and liability of, the railway and maintains suitable access over the life of the scheme.	Options provide scope for greater protection of the railway from the impact of rock fall events as additional width is available to accommodate protection measures. Options maintain the railway line at its current levels of access.			Option provides scope for greater protection of the railway from the impact of rock fall events as additional width is available to accommodate protection measures. Options maintain the railway line at its current levels of access.	Directly addresses the impact of rock fall events on the railway, and maintains suitable access over the life of the scheme.	Southern option provides scope for greater protection of the railway from the impact of rock fall events as additional width is available to accommodate protection measures. Option maintains the railway line at its current levels of access.
Environment		Major Negative Impact on Loch Carron Marine Consultation Area and setting of Strome Castle. Bridge crossing visual impact. Increase in noise and pollutant concentrations at properties along route corridor.	Major Negative Impact on Loch Carron Marine Consultation Area and setting of Strome Castle. Bridge crossing visual impact. Increase in noise and pollutant concentrations at properties along route corridor.	Moderate Negative Impact on Loch Carron Marine Consultation Area. Landscape impact due to introduction of new structure. Impact on water environment due to viaduct.	Minor Negative Impact on ecology, landscape and, potentially, on groundwater.	Moderate Negative Impact on Loch Carron – especially if bridges/viaducts are part of proposals. Landscape impact due to introduction of additional structures.	Moderate Negative Impact due to offline nature of route – loss of ancient woodland and montane habitat and impacts likely to protected species. Impact on landscape due to new route; crossing of steep slopes which may increase visibility and reduce landscape fit; and visibility from properties in Attadale and local influence on rocky moorland. Moderate negative impact on drainage and water environment due to high numbers of new watercourse crossings required.
Safety		Moderate Positive Impact. Reduced likelihood of rock fall debris reaching the carriageway and causing vehicle accidents. However, increase in length of route and potential impact of increased vehicle kilometres on accident rates. Potential indirect safety issues associated with increased traffic through Lochcarron. No reduced likelihood of rock fall debris reaching the railway line.		Major Positive Impact. Reduced likelihood of rock fall debris reaching the carriageway and railway and causing accidents. Impacts on few residential, community and development areas.		Major Positive Impact. Reduced likelihood of rock fall debris reaching both the carriageway and railway and causing accidents.	Moderate Positive Impact. Reduced likelihood of rock fall debris reaching the carriageway and causing vehicle accidents. However, increase in length of route and potential impact of increased vehicle kilometres on accident rates. No reduced likelihood of rock fall debris reaching the railway line.
Economy		Moderate Positive Impact. Reduces the frequency and duration of road closures caused by rock fall events, with associated reduction in journey time variability, and reduction in the potential loss of, and unreliable, revenue streams. Positive impact on business development and investment. However, may indirectly increase traffic through Lochcarron and impact on several community assets, and shorter journey times and improved accessibility to Lochcarron may disadvantage the small number of retail units in Achmore and Stromeferry.		Moderate Positive Impact. Reduces the frequency and duration of road closures caused by rock fall events and enables vehicles to continue on the A890 without making any changes to their journey. Reduces the variability in journey time due to rock fall events, with associated reduction in the potential loss of, and unreliable, revenue streams. Positive impact on business development and investment. Closures of existing road and railway during construction would be required, with associated negative impact, albeit this would be minimised for O2 through offline working during construction.		Major Positive Impact. Reduces the frequency and duration of road and rail closures caused by rock fall events and enables vehicles to continue on the A890 without making any changes to their journey. Reduces the variability in journey time due to rock fall events, for both road and rail users, with associated reduction in the potential loss of, and unreliable, revenue streams. Positive impact on business development and investment.	Moderate Positive Impact. Reduces the frequency and duration of road closures caused by rock fall events, with associated reduction in journey time variability, and reduction in potential loss of, and unreliable, revenue streams. Positive impact on business development and investment. Option would bypass these Stromeferry and Achmore communities.
Integration		Minor Positive Impact (all options). Limited impact on transport integration. Improving journey times and journey time reliability is in accordance with local and national policies. Compatible with land-use developments, and general policies concerning transport and land use. Align with Government policies beyond transport, particularly those relating to rural affairs.					
Accessibility & Social Inclusion		Major Positive Impact. Bypassing of the rock fall area would improve accessibility for the study area, and these options provide good south-north linkage.		Moderate Positive Impact. Bypassing of the rock fall area would reduce the frequency of occurrence of debris reaching the A890 causing a full road closure and would improve accessibility.		Major Positive Impact. Harnessing of the rock fall area would significantly reduce the frequency of occurrence of debris reaching the A890 causing a full road / rail closure and would improve accessibility.	Moderate Positive Impact. Bypassing of the rock fall area would reduce the frequency of occurrence of debris reaching the A890 causing a full road closure and would improve accessibility for the study area. However, the impact is negated to some degree as the proposed route is remote from existing communities.
Deliverability		Construction of new road alignment, with section of 10% gradient at Stromeferry. Major bridge crossing of Strome Narrows. Corridor availability on northern shore to be investigated due to existing dwellings on roadside. Operationally feasible. Likely to be publicly acceptable.	Green field construction of new road alignment. Major bridge crossing of Strome Narrows. Corridor availability on northern shore to be investigated due to existing dwellings on roadside, but reduced frontage activity compared to other north corridor routes. Strong tidal flow and requirement for marine works. Operationally feasible. Likely to be publicly acceptable.	Complex technical requirements associated with viaduct and embankments. Two railway crossings required. Alignment follows existing road and incorporates substandard geometry. Road closures during construction, but offers some offline working. Some cost and deliverability issues could be mitigated by relocating railway onto viaduct and moving road onto existing railway track bed footprint. Further assessment required. Operationally feasible. Likely to be publicly acceptable.	Includes 1.6km long two-lane tunnel section and associated portal structures, all with inherent engineering and construction difficulty and associated risks. Adequate working space to be generated. 1.0km long rock trap measures to be constructed along existing / abandoned road corridor. Requires road closure during construction which is unlikely to be publicly acceptable.	Adopts existing road alignment with inherent sub-standard sections. Engineering difficulties with regards to excavation in rock, maintaining stability of the railway and maintaining traffic on road and railway to acceptable levels during construction. There are several configurations that could be adopted to provide direct or indirect protection to road and railway long-term. Requires road and railway closure during construction which is unlikely to be publicly acceptable,	Green field construction of new road alignment, including sections of 10% gradient through Glen Udalain and towards Attadale valley. Small to medium structures crossing water courses. Least risk option. Land ownership issues. Operationally feasible. Likely to be publicly acceptable.
Capital Cost (£M)		117	113	129	109	108	37
BCR		<1	<1	<1	<1	<1	<1

3. Options

3.1 Introduction

This chapter summarises the options which were recommended at STAG Part 1, and outlines any option development and then briefly describes the route options. The routes are described in more detail in chapter 4.

3.2 STAG Part 1 Emerging Options

The following options were recommended for further consideration in the STAG Part 1 Appraisal:

Table 3.1 - STAG Part 1 Emerging Route Options

Corridor	Option	Detail	Description
North	N6	East bridge crossing and online on north shore	Route North N6 is a route option originating at Achmore, considering an eastern Strome Narrows crossing and following the route of the existing minor road along the northern shore of Loch Carron until Strome Wood
	N9	West bridge crossing and offline on north shore	Route N9 is an offline route option considering a western bridge crossing of the Strome Narrows, and then continues offline north of Stromemore, then ties into the existing road on the northern shore of Loch Carron at Strome Wood
Online	O2	Viaduct	Route Online O2 considers on-line improvement of the existing carriageway and a local 1.8km bypass of the rock fall area west of Cuddies Point by means of a cantilevered structure along the shoreline.
	O3	Tunnel	Route Online O3 considers online improvement of the existing carriageway and a local 1.6km bypass of the rock fall area west of Cuddies Point by means of an inland tunnel structure.
	O4	Do-minimum	Route Online O4 is the Do Minimum scenario, with no proposed improvements to the existing route. This option also includes considerations for suitable contingency measures during (future) road closures.
	O7	Avalanche Shelter	Route Online O7 considers online improvement of the existing carriageway and a local 2.0km extended rock shelter west of Cuddies Point.
South	S4	Glen Udalain	Route South S4 considers a principal southern offline bypass route from the A890 through Glen Udalain and Attadale valley, and ties back into the existing A890 at Attadale.

3.3 Option Development

3.3.1 Refinement of Option N6

The location of the Strome Narrows bridge crossing has been revised during Stage 2. Several bridge locations were considered for the Strome Narrows crossing, which included bridge structures of different lengths and heights. The crossing location as shown at Stage 2 is approximately one kilometre west of the Stage 1 bridge location, and is considered to be the optimal crossing point.

Option N6 on the south of the Strome Narrows was realigned for the new bridge location, skirting round the west of Craeg Mhaol.

3.3.2 Refinement of Option N9

Option N9 has been realigned along the majority of the route during Stage 2. From Braeintra to the Strome Narrows, Option N9 has been moved southwards to reduce the impact on properties at Achmore, and to minimise the impact of earthworks. The alignment of the Strome Narrows bridge crossing has been realigned at Stage 2 such that the optimal crossing location is now proposed, as described for Option N6 above.

From Leacanasigh to Mid Strome, Option N9 has been realigned moved offline north of Stromemore to avoid impacting on properties which front on to the existing road.

3.3.3 Refinement of Option O2

From Ardnarff to Frenchmans Burn, the online options remain largely unchanged from the Stage 1 alignment.

From Frenchmans Burn to Cuddies Burn, Option O2 (rail viaduct) has been developed during Stage 2 such that the railway would be carried along the viaduct structure. The alignment of the Stage 2 structure is shorter than that proposed during Stage 1.

3.3.4 Refinement of Option O3

From Stromeferry to Frenchmans Burn, the online options remain largely unchanged from the Stage 1 alignment.

From Frenchmans Burn to Cuddies Burn, Option O3 (tunnel) has been realigned slightly with changes made to the west portal location, moved slightly further west to a more suitable location at Frenchman's Burn.

3.3.5 Refinement of Option O7

From Stromeferry to Frenchmans Burn, the online options remain largely unchanged from the Stage 1 alignment.

From Frenchmans Burn to Cuddies Burn, Option O7 (developed avalanche shelter) has a structure approximately 300m shorter than that proposed at Stage 1.

3.3.6 Refinement of Option S4

Through the southern section of the Glen Udalain valley, Option S4 follows a similar alignment to that proposed at Stage 1. However, during Stage 2 Option S4 was realigned further west through the Allt Loch Innis Nan Seangan valley to reduce the earthworks and minimise steep gradients. Similarly, Option S4 was also realigned through the River Attadale valley to reduce the steep gradients and minimise the impact of earthworks.

The Stage 2 alignment ties in to the existing A890 in advance of the River Attadale bridge adopting a tighter horizontal curve on approach to minimise intrusion into the valley.

3.4 STAG Part 2 Options

The following options have been subject to STAG Part 2 Appraisal.

Table 3.2 - STAG Part 2 Route Options

Corridor	Option	Detail	Description
North	N6	Bridge crossing and online on north shore	Route North N6 is a route option originating at Achmore, considering a western Strome Narrows crossing and following the route of the existing minor road along the northern shore of Loch Carron until Strome Wood
	N9	Bridge crossing and offline on north shore	Route N9 is an offline route option considering a western bridge crossing of the Strome Narrows, and then

Corridor	Option	Detail	Description
			continues offline north of Stromemore, then ties into the existing road on the northern shore of Loch Carron at Strome Wood
Online	O2	Viaduct	Route Online O2 considers on-line improvement of the existing carriageway and a local 1.6km bypass of the rock fall area west of Cuddies Point by means of a cantilevered structure along the shoreline.
	O3	Tunnel	Route Online O3 considers online improvement of the existing carriageway and a local 1.5km bypass of the rock fall area west of Cuddies Point by means of an inland tunnel structure.
	O4	Do-minimum	Route Online O4 is the Do Minimum scenario, with no proposed improvements to the existing route. This option also includes considerations for suitable contingency measures during (future) road closures.
	O7	Avalanche Shelter	Route Online O7 considers online improvement of the existing carriageway and a local 1.7km extended rock shelter west of Cuddies Point.
South	S4	Glen Udalain	Route South S4 considers a principal southern offline bypass route from the A890 through Glen Udalain and Attadale valley, and ties back into the existing A890 at Attadale.

3.5 Cost Estimates

3.5.1 Introduction

A Stage 2 Appraisal offers preliminary proposals and therefore only broad-based estimates of cost can be made. Nevertheless, these should allow a meaningful comparison of options. The cost estimates developed are based on typical unit costs for new rural 7.3m wide single carriageway roads, with additions for major earthworks, major structures, service diversions, junctions and any other abnormal elements identified. Costs were derived from a combination of recognised reference material, including the SPONS Civil Engineering and Highway Works Price Book which was used as a comparator reference for consistency throughout the estimating process. Historical information from previous road projects has also been considered. Discussion also took place with a major civil engineering contractor in the Highlands. All costs are presented to the second quarter of 2013.

A further consideration has been phased construction for Stromeferry Bypass. That is initially providing improvements which would bypass the rockfall area as a minimum, with subsequent improvements phased over a further 3 stages ultimately providing improvements from Braeintra/ Achmore / Stromeferry to Strathcarron Junction. This phased approach would assist with affordability and deliverability whilst still satisfying the project objectives. Phasing cost estimates are discussed in section 3.2.13.

3.5.2 Earthworks Costs

Earthworks quantities were derived from the three dimensional MX model used to create the Route Options. It should be noted that these profiles are based on the preliminary ground contour information, supplemented with a local topography survey online from Ardnarff to Cuddies Point. It has been assumed across all routes that an average 50% of all excavated material is reusable as fill, and that 100% of excavated rock is reusable as fill. At this stage, embankment slopes are assumed to be 1 in 2 slopes. Cutting slopes through normal material are assumed to be 1 in 2. Cutting slopes through rock are assumed to be steeper which are stepped bermed slopes as detailed in the Geotechnical Desk Study Report contained in Appendix B. Rock is assumed to be present throughout the majority of the study area. Rock is located at ground surface for online options from

Stromeferry to Attadale; rock is present at 1m below ground surface for North Shore options; rock is present 1m below ground surface for Southern routes from Glen Udalain to Maman Hill; no rock is assumed to be present from Maman Hill to Strathcarron junction.

A higher excavation rate has been assumed for cutting into the rock face from Ardnarff to Cnoc Nam Mult. Estimating the costs associated with remodelling the existing rock face from Cnoc Nam Mult to Cuddie's Point, and throughout the study area offers a challenge as there are many variables, whether the existing slope would be repaired or excavated, whether the rock face would be excavated by drilling and blasting to expose the new face, the height of the slopes, and the geology etc. For this stage in the study, a standard rock cut rate has been assumed throughout which is an average of estimated rates for blasting and breaking out rock, and also includes an allowance for pre-splitting. The area of rock netting which would be replaced or renewed has been estimated and is included in the cost estimates. The lengths of new catch fences which would be installed has been estimated and included in the cost estimates. The requirement for any soil removal at rock slopes for the online options, which is expected to be minimal, has not been included at this stage. Costs associated with tree removal on the upper hillside of the online rock slopes have not been included at this stage.

Rates for rock stabilisation works are based on the costs incurred with the existing ongoing programme of rock slope maintenance works currently being undertaken by URS at Stromeferry on behalf of The Highland Council.

Allowances have also been made for areas of peat which are present in the study area, as detailed in the Peat Management Report contained in Appendix C as depths of peat would not be confirmed until ground investigation is carried out, for the purposes of the cost estimates, peat depths of 3m have been assumed throughout. Costs have been included for removal of peat beneath embankments.

The cost base for the earthworks required by the alignments being considered is detailed in tables 3.3 and 3.4 below.

Table 3.3 - Cost Base for Earthworks

Estimate Rates for Earthworks	
Excavate, deposit & compact normal material	£4.18 / m^3
Excavate, deposit & compact rock	£13.95 / m^3
Import fill & compact	£22.46 / m^3
Excavate & dispose normal material / rock	£38.41 / m^3
Excavate & dispose peat	£115.81 / m^3
Rock netting	£1,000.00 / m
Rock fall catch fence	£5,000.00 / m
Rock fall debris flow barrier	£5,000.00 / m

Table 3.4 - Cost Base for Earthworks

Option	Total Cut (m3)	Total Fill (m3)	Excavate, deposit + compact (m3)	Import fill + compact (m3)	Excavate + dispose (m3)	Rock remodelling fences/barriers (m)	Earthworks Total (£M)
North							
N6 - North bridge online	125,486	174,939	93,844	81,095	39,149	254	6.661
N9 - North bridge Lochcarron	168,948	186,979	133,180	53,800	43,276	449	6.909

bypass							
Online							
O2 – Online Viaduct	47,346	75,986	47,346	28,640	-	356	2.096
O3 – Online Tunnel	114,955	98,120	98,120	-	16,835	937	5.872
O7 – Online Avalanche Shelter	40,905	238,053	40,905	197,148	-	342	5.721
South							
S4 – South Glen Udalain	350,592	551,253	294,052	257,201	77,851	722	16.387

3.5.3 Roadworks Costs

3.5.3.1 Pavement

The lengths of carriageway required were derived from the three dimensional MX model. It has been assumed for the purposes of the cost estimating exercise that new pavement will be provided throughout, therefore allowing for full new road pavement construction along on-line sections. Details of pavement rates adopted are shown in table 3.5.

Table 3.5 - Estimate Rates for Pavement

Estimate Rates for Pavement		
Dense bitumen	30mm surface course	£5.81 / m^2
Dense bitumen	50mm binder course	£7.95 / m^2
Dense bitumen	200mm road base	£22.96 / m^2
Granular sub-base	200mm sub base	£6.91 / m^2
Full pavement construction Total width of new pavement 7.3m		£43.63 / m^2
Cost per linear metre of new carriageway		£318.48 / m

3.5.3.2 Ancillary Costs

The cost of ancillary works required within a road construction project at this stage are most easily expressed as a price per linear metre as shown in table 3.6 below. Site clearance and soiling and seeding are expressed as a rate per metre area.

Table 3.6 - Estimated Rates for Ancillary Items

Estimate Rates for Ancillary items	
Fencing and safety barriers	£69.86 / m
Signs and road markings	£8.21 / m
Kerbs and drainage	£102.68 / m
Cost per linear metre of road	£180.75 / m
Site clearance	£0.13 / m^2
Soiling and seeding	£4.80 / m^2

3.5.3.3 Junctions and Side Roads

At -grade priority junctions are envisaged for the junctions on the proposed new alignment. Further sections of new carriageway may also be required for junctions to tie into the existing road network. At this stage, the costs of these junctions and sideroads have been estimated to be 1% of the pavement and ancillaries cost. The Roadworks cost estimate is detailed in table 3.7.

Table 3.7 - Roadwork Costs

Option	Pavement (£M)	Ancillaries (£M)	Junctions & Side Roads (£M)	Roadworks Total (£M)
North				
N6 - North bridge online	1.750	1.101	0.029	2.880
N9 - North bridge Lochcarron bypass	1.755	1.130	0.029	2.914
Online				
O2 – Online Viaduct	1.319	0.797	0.021	2.137
O3 – Online Tunnel	1.331	0.786	0.021	2.138
O7 – Online Avalanche Shelter	1.319	0.780	0.021	2.120
South				
S4 – South Glen Udalain	4.451	2.901	0.193	7.545

3.5.4 Structures Costs

Cost estimates for structures have been generated using standard rates applied to the structure cross section together with an estimate of the required length to derive the cost of individual structures. For the major structures, these costs have undergone a further level of interrogation to give the necessary levels of confidence. Details of structures rates adopted are shown in table 3.8.

Table 3.8 - Estimated Rates for Structures

Estimate Rates for Structures		
Underbridge, rates vary		£1301.10 / m2 to £2000.00 / m^2
Culverts,	minor (<1m diameter)	£636.70 / m
	small (>1m diameter)	£2690.82 / m
Retaining walls,	1m height	£518.36 / m
	2m height	£1308.00 / m
	3m height	£3266.27 / m
Strome Narrows bridge		£2600.00 / m^2
Rail viaduct		£2646.95 / m^2
Tunnel		£37,978.69 / m
Developed avalanche shelter		£13,430.12 / m

General bridge structure locations have been identified for crossings of large streams and rivers and railway crossings and span sizes estimated to suit. Culvert locations have been identified for small watercourse crossings and an average length assumed.

Allowance has been made for the potential need for retaining walls for online sections North Shore onoine option (N6) within the existing built-up development constraints of Slumbay and Lochcarron. Lengths of retaining walls have also been provided for online routes between Ardnarff and Cuddies Point, provided between the road and railway. A short length of retaining wall has also been provided at Maman Hill for the Online and Southern Route options. Precise requirements will be determined on the development of the Preferred Route Option design during Stage 3 and detailed design. Nominal overall lengths of walls of nominal heights have been allowed for at this stage.

The cost of the major structures as included under the north options (N6 and N9) and online options for the railway viaduct and developed avalanche shelter (O2 and O7), could vary from that assumed as conditions along each route are irregular or not know in detail. A preliminary design based on the parameters of each site/route would be necessary to carry out an accurate costing exercise. At this stage of the study, the cost estimate for the Strome Narrows crossings, North options N6 and N9, has been based on providing a composite steel/concrete box girder deck on reinforced concrete substructure. The cost estimate for the rail viaduct included under Online option O2 has been based on providing a continuous plate girder half-through structure with a reinforced concrete trough supporting the track bed. The cost estimate for the developed avalanche shelter, online option O7, has been based on providing a contiguous precast beam deck slab supported on a retaining wall to the south and reinforced concrete columns with a longitudinal crosshead to the north. These are preliminary estimates as very limited information is available on ground conditions, detailed bathymetric survey or the exact form of construction. The estimated cost for these structures has been based on experience of similar structures, expressed as an indicative rate per square metre of deck area.

The cost estimates included for the tunnel option (O3) are as detailed in the Tunnel Report contained in Appendix D. The preliminary generic costs are based on a DMRB BD 78/99 tunnel option, with elements of Norwegian practice being adopted, i.e. use of targeted rock support rather than providing a fully lined tunnel. Further assessment will be required, but adopting some Norwegian practices would offer some cost savings. At this stage a 20% reduction of the BD 78/99 cost has been assumed.

The estimated structures costs are detailed in table 3.9 below.

Table 3.9 - Estimated Structures Cost

Option	Major structures (£M)	Bridges (£M)	Culverts (£M)	Retaining Walls (£M)	Total Structure Cost (£M)
North					
N6 - North bridge online	28.598	-	0.030	-	28.628
N9 - North bridge Lochcarron bypass	28.598	-	0.030	-	28.628
Online					
O2 – Online Viaduct	29.646	-	0.034	2.276	31.955
O3 – Online Tunnel	58.107	-	0.034	2.328	60.469
O7 – Online Avalanche Shelter	22.831	-	0.034	2.119	24.984
South					
S4 – South Glen Udalain	-	0.865	0.056	-	0.921

3.5.5 Other Cost Considerations

3.5.5.1 On-line/Off-line bias

Costs need to be recognised in the comparative evaluation for construction works at the critical 2km section of rock face and associated ongoing maintenance works which will still be necessary should an off-line option be selected. In this context, all online are deemed to be ‘off-line’ as these solutions all effectively bypass the critical road section.

It is suggested that a figure of £5.0 million is allocated, comprising £1.5 million for road works and £3.5 million for rock face treatment at time of the construction period. The £5.0 million has accordingly been applied to the North Shore and Southern options. Future maintenance costs, such as reactive maintenance costs associated with rock fall events, and ongoing routine maintenance costs, will be included separately in the economic appraisal; Chapter 6 of this report.

3.5.5.2 Do-Minimum

There are no capital costs associated with Option O4 Do-Minimum, all costs are future maintenance costs. Therefore, Option O4 has not been included in the cost summary tables below, instead Option O4 costs are considered separately in the economic appraisal. However it should be recognised a maintenance cost of some £30M is expected to be spent over 60 years, thus being the economic return period.

3.5.6 Landscaping, Accommodation Works, Statutory Undertakers and Land Costs

Land costs, the cost of Accommodation Works and the cost of alterations to Statutory Undertakers equipment are difficult to assess accurately at this stage, and the cost estimates shown in table 3.10 will be updated as more information becomes available during the detailed assessment.

At this stage the land cost has been based on the footprint area of each scheme. All land is assumed to be agricultural, with the land through the built up developed area through Slumbay associated with North Shore online option (N6) assumed to be residential land. Land costs are based on rates taken from the District Valuer Property Management Report 2011.

At this stage, the cost of Accommodation Works has been assumed as a percentage of the civils sub-total, (earthworks, roadworks, structures and other costs) estimated to be 3%. Further allowances have been included for the North Shore Lochcarron bypass (N9) option for three accommodation works bridges to provide access to crofting land.

Landscaping and environmental costs have been estimated as 1.5% of the total civils sub-total, and costs for statutory undertakers works have been derived at 2% of the civils sub-total.

Table 3.10 - Landscape, Accommodation Works, Statutory Undertakers and Land Costs

Option	Landscaping + Environment (£M)	Accommodation Works (£M)	Statutory Undertakers (£M)	Land (£M)
North				
N6 - North bridge online	0.648	1.295	0.863	0.134
N9 - North bridge Lochcarron bypass	0.652	1.304	0.869	0.140
Online				
O2 – Online Viaduct	0.043	0.087	0.058	0.210
O3 – Online Tunnel	0.100	0.200	0.133	0.112
O7 – Online Avalanche Shelter	0.098	0.196	0.130	0.106
South				
S4 – South Glen Udalain	0.289	0.584	0.386	0.380

3.5.7 Civil Engineering (Civils) Costs

It is not the intention that this document be used as the definitive cost estimate for the schemes under consideration, but rather as a guide to allow meaningful alignment comparisons to be made. These costs are for comparative purposes and do not include allowance for inter-alia, traffic management or aggregate tax. A summary of the cost estimates developed for each option is shown in table 3.11.

Table 3.11 - Civil Engineering Costs

Option	Earthworks (£M)	Roadworks (incl. Accwks) (£M)	Structures (£M)	Other costs (£M)	Landscaping Environ (£M)	Statutory Undertakers (£M)	Civils Cost (£M)
North							
N6 - North bridge	6.661	4.175	28.628	5.000	0.648	0.863	45.974

Option	Earthworks (£M)	Roadworks (incl. Accwks) (£M)	Structures (£M)	Other costs (£M)	Landscaping Environ (£M)	Statutory Undertakers (£M)	Civils Cost (£M)
online							
N9 - North bridge offline	6.909	4.217	28.628	5.000	0.652	0.869	46.275
Online							
O2 – Online Viaduct	2.096	2.224	31.955	0.440	0.043	0.058	36.816
O3 – Online Tunnel	5.872	2.338	60.469	0.040	0.100	0.133	68.953
O7 – Online Avalanche Shelter	5.721	2.316	24.984	0.440	0.098	0.130	33.688
South							
S4 – South Glen Udalain	16.387	8.130	0.921	5.000	0.289	0.386	31.113

3.5.8 Construction, Risk & Land Costs

Allowances for preliminaries have been estimated using a cost multiplier applied to the total estimated build cost for each route option. Preliminaries of 30% of the Civils Cost, based on recent tenders and contractor discussions, have been added for these initial estimates to take allowance of interface issues, delays, restrictions, traffic management and general remoteness, particularly when considering on-line options.

An allowance has been included for risk following a review of the risk register and estimated costs. A risk analysis as described in the STAG Manual Database Section 13 was undertaken. Costs associated with individual items were assigned to each option under consideration. Full details of the risk analysis process is included in the STAG Part 2 Report.

Adding the estimated costs for Preliminaries, Land and Risk Allowance to the Civils Cost, gives the 'Construction Cost', as shown in table 3.12.

Table 3.12 - Construction Cost

Option	Preliminaries (£M)	Civils Cost (£M)	Construction Sub-total (incl prelims) (£M)	Risk Allowance (£M)	Construction Cost (incl. Prelims & Risk) (£M)
North					
N6 - North bridge online	13.792	45.974	59.766	5.196	64.961
N9 - North bridge Lochcarron bypass	13.883	46.275	60.158	4.236	64.394
Online					
O2 – Online Viaduct	11.045	36.816	47.861	3.215	51.076
O3 – Online Tunnel	20.656	68.953	89.639	3.330	92.970
O7 – Online Avalanche Shelter	10.106	33.688	43.795	3.806	47.601
South					
S4 – South Glen Udalain	9.334	31.113	40.447	3.157	43.604

3.5.9 Construction & Land Costs

3.5.9.1 Optimism Bias

HM Treasury guidance 'The Green Book – Appraisal and Evaluation in Central Government' recognises that there is a tendency for projects to be overly optimistic. To mitigate optimism in project estimates, the Green Book recommends that uplifts should be applied. Optimism bias of 15% uplift is recommended for Stage 2 road schemes, and 23% for fixed links (major structures and tunnels) to take account of unquantified risks associated with standard civil engineering projects. Applying the Optimism Bias therefore gives the Total Construction and Land Cost, as shown in table 3.13.

Table 3.13 - Total Scheme Cost

Option	Construction Total (£M)	Optimism Bias (construction) (£M)	Land (£M)	Optimism Bias (Land) (£M)	Construction & Land Cost (incl. Prelims, Risk & OB) (£M)
North					
N6 - North bridge online	64.961	11.253	0.134	0.020	76.368
N9 - North bridge Lochcarron bypass	64.394	11.311	0.140	0.021	75.866
Online					
O2 – Online Viaduct	51.076	9.551	0.210	0.031	60.868
O3 – Online Tunnel	92.970	18.094	0.112	0.017	111.193
O7 – Online Avalanche Shelter	47.601	8.396	0.106	0.016	56.118
South					
S4 – South Glen Udalain	43.604	6.067	0.380	0.057	50.108

3.5.10 Total Scheme Costs

3.5.10.1 Professional Fees

An estimate of fees likely to be incurred throughout the whole duration of the project has been included. Industry standard fees of 9% for preparation and design costs and 5% for construction supervision have been added to the Construction & Land Cost to give the total Scheme Cost, as shown in table 3.14.

Table 3.14 - Professional Fees

Option	Construction & Land Cost (£M)	Preparation (£M)	Supervision (£M)	Total Scheme Cost (£M)	Scheme Length (km)
North					
N6 - North bridge online	76.368	6.873	3.818	87.059	5.50
N9 - North bridge offline	75.866	6.828	3.793	86.488	5.51
Online					
O2 – Online Viaduct	60.868	5.478	3.043	69.390	4.14
O3 – Online Tunnel	111.193	10.007	5.560	126.760	4.18
O7 – Online Avalanche Shelter	56.118	5.051	2.806	63.974	4.14
South					
S4 – South Glen Udalain	50.108	4.510	2.505	57.123	13.98

3.5.11 Cost Estimate Summary

A summary of the full cost estimate is detailed in table 3.15.

Table 3.15 - Cost Estimate Summary

Item	N6 – North bridge online (£M)	N9 – North bridge offline (£M)	O2 – Online Viaduct (£M)	O3 – Online Tunnel (£M)	O7 Online Avalanche Shelter (£M)	S4 – South Glen Udalain (£M)
Prelims (30%)	13.792	13.883	11.045	20.686	10.106	9.334
Earthworks	6.661	6.909	2.096	5.872	5.721	16.387
Roadworks & Acc Wks	4.175	4.217	2.224	2.338	2.316	8.130
Structures	28.628	28.628	31.955	60.469	24.984	0.921
Statutory Undertakers	0.863	0.869	0.058	0.133	0.130	0.386
Landscaping & Environment	0.648	0.651	0.043	0.100	0.098	0.289
Other	5.000	5.000	0.440	0.040	0.440	5.000
Risk Allowance (construction)	5.196	4.236	3.215	3.330	3.806	3.157
OB Construction	11.253	11.311	9.551	18.094	8.396	6.067
Construction Total (incl Prelims, Risk & OB)	76.214	75.705	60.627	111.064	55.996	49.671
Land	0.134	0.140	0.210	0.112	0.106	0.380
OB land (15%)	0.020	0.021	0.031	0.017	0.016	0.057
Construction & Land Total (incl Prelims, Risk & OB)	76.368	75.866	60.868	111.193	56.118	50.108
Preparation (9%)	6.873	6.828	5.478	10.007	5.051	4.510
Supervision (5%)	3.818	3.793	3.043	5.560	2.806	2.505
Total Scheme Cost	87.059	86.488	69.390	126.760	63.974	57.123

4. Engineering Assessment

4.1 Introduction

The engineering assessment conducted in relation to the Stromeferry Bypass as outlined in this Chapter has been carried out in accordance with the requirements of TD 37/93, Preparation of the Stage 2 Report.

Only a broad assessment of engineering issues can be made at this stage. The general condition of the existing A890 carriageway and structures, as well as topography, hydrology, geology and geomorphology have all been considered. In addition, problems arising from the existing conditions have been identified and are further outlined below.

Preliminary assessments regarding alignments include considerations for both motorized and non-motorised users.

4.2 Existing Road

The existing public road under consideration in this appraisal is part of the A890 from Auchtertyre on the West Coast of Scotland to Achnasheen, and in particular the section between Stromeferry and the Strathcarron Junction.

4.2.1 Existing Conditions

The Stromeferry Bypass is an approximately 12km long section of the A890 alongside the southern shore of Loch Carron. The road forms part of the local road network between the Lochcarron area and Skye, as well as the wider road network from the Isle of Skye east towards Dingwall, and north along the west coast. It also provides a popular alternative tourist and route from Kyle of Lochalsh and Skye to Inverness.

The public road and a single track railway line are sharing a tight corridor along the southern shores of Loch Carron, which is particularly restricted over an approximately 4.5 km long section from Ardnarff to Attadale. The A890 is mainly a single carriageway but reduces frequently to single track with passing places along the section between Ardnarff and Cuddies Point.

Currently national speed limits would apply on the existing route between Auchtertyre and the Strathcarron Junction. However, steep sections of the A890 with gradients of up to 12% between Stromeferry and Ardnarff, and up to 14% between Attadale and Strathcarron, as well as sections of single track road reduce the average speed of travelling considerably.

4.2.2 Rock Fall Issues

Since the Stromeferry Bypass was opened, the approximately 4.5km long section of mainly single track road from Ardnarff to Cuddies Point, which is located just west of Attadale, has been subject to landslides and rock fall events, causing the Local Authority to temporarily close the road at several occasions, in order to enable remedial works to the rock slopes to take place.

The last major event, which caused closure of the road to through traffic over several months, occurred in December 2011.

Detailed considerations regarding geotechnical issues in relation to the site are given in a separate report by URS (now AECOM) with title ‘Stromeferry Options Appraisal, Geotechnical Desk Study Report, February 2013’.

4.3 Engineering Standards

Roads in Scotland are designed to the requirements set out in the Design Manual for Roads and Bridges (DMRB). These requirements include desirable minimum requirements and absolute requirements. Designs can be below the desirable minimum requirements at the discretion of the Designer, this is known as a Relaxation. If a design does not meet the absolute requirements, a

Departure from Standard is required and this must be approved by the Overseeing Organisation, in this case, The Highland Council.

Road geometry is designed in accordance with DMRB Volume 6, Section 1, Part 1, TD 9/93 'Highway Link Design', which details the standards for horizontal and vertical geometry dependent on the design speed of a road. The existing design speed for Stromeferry Bypass was calculated to be 100 B kph for the section of road between Ardnarff and Cuddie's Point. The national speed limit of 60mph is equivalent to a design speed of 100kph. Therefore, the preliminary route options aim to have geometry appropriate for a design speed of 100kph. However due to the constrained nature of the study area and the local topography, relaxations in both the horizontal and vertical geometry are included to minimise the impact on the local environment. At this preliminary stage, verge widening for forward visibility has not been included for the route option alignments.

DMRB TD 9/93 Highway Link Design states that the desirable maximum gradient for a single carriageway road is 6%, and that gradients steeper than 8% shall be considered a Departure from Standard. TD 9/93 recognises that in hilly terrain steeper gradients will frequently be required, particularly where traffic volumes are low, which is the case for Stromeferry. Therefore, for offline options steep gradients have been fixed at maximum of10% (which would be a Departure from Standard), in an effort to minimise the height of cutting and embankment slopes, and thus reduce the scheme footprint and minimise the impact on the local environment. For on-line options, the existing steep gradients up to a maximum of 10% have been adopted. A further consideration when developing alignments has been the altitude of route options with regards to weather and especially snow, ice and ongoing winter maintenance. The level of route options has been kept below the level of 300m.

During Stage 3 the Preferred Route Option will undergo detailed design, and applications for any Departures from Standard will be sought from the Overseeing Organisation. However, an initial assessment on the mainline geometry standards achieved has been undertaken at Stage 2 and is reported in section 4.11 below.

4.3.1 Design Parameters

4.3.1.1 Cross Section

DMRB Volume 6, Section 1, Part 2 TD 27/05 Cross Sections and Headrooms states that the cross section for an all purpose single carriageway is a 7.3m wide carriageway (2 x 3.65m lanes) with 1.0m hard strips and 2.5m verges. A 6.0m carriageway is permitted in Scotland where the design year flow is 5,000 AADT or less, which is the case for the A890 at Stromeferry. In comparison Highland Council has adopted a cross section consisting of 5.5m carriageway with 0.65m hardstrips for a similar lightly trafficked road in Sutherland. Therefore, the proposed road cross section for Stromeferry Options Appraisal is a single carriageway consisting of two 3.0m lanes, two 0.65m hard strips and 2.5m verges. The typical cross section is detailed on drawing number 5203 in Appendix A.

For on-line route proposals, a cross section with reduced verges as shown on drawing number 5202 in Appendix A has been discussed and agreed with The Highland Council, in order to minimise significant rock cuts and railway re-alignment for the section between Ardnarff and Cuddies' Point.

4.3.1.2 Road Alignment

DMRB TD 37/93 requires the Stage 2 Assessment of road improvements to identify the factors to be taken into account in choosing alternative routes or improvements schemes and to identify the environmental, engineering, economic and traffic advantages, disadvantages and constraints associated with those routes or improvement strategies.

The Stage 2 routes are encompassed within the following corridors:

- North Corridor – crossing of the Strome Narrows, then continue north eastwards, and tying into the existing road on the north shore of Loch Carron;
- Online Corridor – online along the existing A890 corridor from Ardnarff to Cuddies point, and

- South Corridor – offline south of the existing A890, coming offline south of Stromeferry through Glen Udalain heading north eastwards passing east of Loch Nam Breac Mora, then passing through the River Attadale valley and returning online at Attadale.

Three dimensional outline designs have been developed for the options undergoing Stage 2 Assessment using computer software called MX. The options are described below, and drawings showing plan and profiles of each option are contained in the drawing folio Appendix A.

4.3.2 Minor Junctions

Junction locations and sideroads will be considered in more detail at Stage 3, but it is envisaged that at-grade priority junctions would be provided at interfaces with existing roads. Impacts would be low and no engineering difficulties are envisaged.

4.4 Engineering Description of Each Option

The following route options have been assessed as part of this Stage 2 assessment in accordance with the requirements outlined in the DMRB.

The following sections provide an engineering description of the proposed options and should be read in conjunction with and the Plan and Profile and other relevant drawings contained in Appendix A Drawings. It should be noted that the designs for each of the route options described below have been developed to a suitable level for Stage 2. Following selection of the Preferred Route Option, the design of the mainline, junction and sideroads would be subject to further development.

Whilst some consideration has been given to where sideroad junctions and access roads may be required, sideroads and accommodation works design has not been undertaken at this stage. This would be addressed at Stage 3 Assessment design development of the Preferred Route Option.

4.4.1 Option N6

Option N6 has a total length of approximately 5.5km and would leave the existing A896 at Achmore heading westwards passing north of Achmore. Option N6 would mostly be on embankment with slopes no greater than approximately 5.0 metres in height. An at grade priority junction would be provided with the existing A896 providing local access to Stromeferry and to Achmore. Continuing north of Achmore, Option N6 would skirt round the foot of Creag Mhaol, with some embankments of an average height of approximately 5 metres, and maximum embankment heights of approximately 12.5 metres. Option N6 would continue north westwards through a slight cutting approximately 1.0 metre deep before turning eastwards on a 255 metre radius curve. Option N6 would continue through a cutting up to approximately 9.5m deep on approach to the Strome Narrows Crossing. A major structure approximately 830m long would carry Option N6 across the Strome Narrows. The structure would also span the existing railway on the south bank.

At Leacanasigh, Option N6 would pass over the existing road and turn south eastwards on a 360metre radius curve. Option N6 would have a major cutting slope up to approximately 36.0 metres high on the north bound verge. Option N6 continues north eastwards mostly on embankments up to approximately 8.0m in height, and would return online at Stromemore. Lengths of retaining wall would be required adjacent to properties which front on to the existing road, to reduce the impact of the earthworks on adjacent land. This would be considered in more detail at during Stage 3, but the lengths of retaining wall has been estimated and is included in the cost estimate. Option N6 continues and then ties into the existing road at Mid Strome.

4.4.2 Option N9

Option N9 has an approximate length of 5.5km and would leave the existing A896 at Achmore heading westwards passing north of Achmore. Option N9 would mostly be on embankment with slopes no greater than approximately 5.0 metres high. An at grade priority junction would be provided with the existing A896 providing local access to Stromeferry to Achmore. Continuing north of Achmore, Option N9 would skirt round the foot of Creag Mhaol, with some large embankments, with an average height of approximately 5.0 metres with a maximum embankment height of approximately 12.5m. Option N9 would continue north westwards through a slight cutting approximately 1.0 metre

deep before turning eastwards through a 255metre radius curve. Option N6 would continue through a cutting up to approximately 9.5m deep on approach to the Strome Narrows Crossing. A major structure approximately 830m long would carry Option N9 across the Strome Narrows. The structure would also span the existing railway on the south bank.

At Leacanasigh, Option N9 would pass over the existing road and turn south eastwards on a 360metre radius curve. Option N9 would have a major cutting slope up to approximately 36.0 metres in height on the north bound verge. Option N9 continues offline eastwards passing to the north of the Stromemore and would be largely on embankments approximately 8m to 15m in height. Option N9 would then continue on a right hand 400metre radius curve north of Stromemore. Option N9 has gradients of 8% on the approaches to a hill a Stromemore. Option N9 would then return online at Mid Strome with some embankments up to approximately 30m in height on the southbound verge, continuing online from Mid Strome to the Weavers, Option N9 would be on embankments approximately 5 0 metres high.

4.4.3 Option O2 - Viaduct

All online options mainly follow follows the A890 from Ardnarff to Cuddies Burn which is located on the south short of Lochcarron. The existing A890 through this section is largely single track with passing places, providing a two-lane road with standard verges will incur earthworks due to the wider road cross section. The online corridor is especially constrained as the existing A890 is bounded by the steep existing rock face to the south, and the Dingwall to Kyle of Lochalsh railway line and Loch Carron to the north.

The total length of O2 is 4.5 km. From Ardnarff to the Frenchmans Burn, the existing A890 corridor becomes narrow constrained by the railway on the northbound verge, and by the existing steep rockface on the southbound verge. Therefore three lengths of retaining wall are required from Ardnarff to Frenchmans Burn, provided between the railway and the proposed road. Relaxations in horizontal geometry are required, with no transitions provided for horizontal curves. The horizontal geometry through this section is largely below desirable minimum standards, typically curves of radius 200 to 650 metre are provided which is up to four steps below desirable minimum standards. The vertical geometry provided has fewer relaxations, with relaxations in crest curves only up to two steps below desirable minimum. Cuts of varying heights are required on the southbound verge into the existing rock face, with sections of cutting slope typically up to approximately 7.0 metres high, with local sections of cut slopes approximately 18.0 metres, 21.0 metres and 35.0 metres high.

From Frenchmans Burn to Cuddies Burn, Option O2 would realign the railway on to a viaduct structure along the side of the loch. The structure would be approximately 1.6km in length. This would allow a wider corridor to accommodate the two lane road including a wide verge which incorporates a rock trap adjacent to rock face.

4.4.4 Option O3 - Tunnel

Option O3 is 4.5km in length. Option O3 follows the same alignment from Arnarff to Frenchmans Burn. From Frenchmans Burn to Cuddies Burn, Option O3 would provide an inland tunnel. The tunnel would be approximately 1.5km in length. Some rock cut would be required on the south tunnel portal at Frenchmans Burn.

4.4.5 Option O7 – Avalanche Shelter

The length of Option O7 is 4.5km. Option O7 follows the same alignment from Ardnarff to Frenchmans Burn. From Frenchmans Burn to Cuddies Burn, Option O7 would provide a road viaduct which would carry the realigned A890 above the railway. The structure would be approximately 1.7km in length.

4.4.6 Option O4 – Do Minimum

Option O4 is described as the ‘do-minimum’ scenario, with no improvements made to the existing road other than ongoing maintenance. The road would remain as per existing, therefore retaining sections of single track with passing places and existing route alignment and gradients all as described in Section 4.2 of this report.

The ongoing maintenance of this section of the road however is extensive. The Highland Council have a planned programme of reactive maintenance including daily and weekly inspections. In addition, there are planned biennial improvement measures in parallel with any necessary reactive maintenance.

4.4.7 Option S4 – Glen Udalain

Option S4 has an approximate length of 14.0km and would leave the existing A890 south of Braeintra and follow the existing forest track through the Glen Udalain valley, remaining largely to the north of Allt Gleann Udalain. Option S4 would have some earthworks, with cutting and embankment slopes typically no greater than approximately 4.0 metres in height, but with some local embankments approximately 10.0 metres in height. The mainline geometry would largely be at least desirable minimum standards, with no steep gradients required. Option S4 would then cross to the Allt Gleann Udalain via a new bridge and continue to the east side of the river. The horizontal geometry provided would be at least of desirable minimum standards. Relaxations in vertical geometry would be required, including two sections of steep gradient, approximately 220m of 10% grade and a shorter length of 8% grade. Option S4 would be in cutting and on embankment through this section, with cutting slopes approximately 5.0 metres in height, with local cutting slopes up to a maximum of approximately 10.0 metres high. Embankment slopes through this section would be approximately 5.0 to 12.0 metres in height with some slopes up to a maximum of approximately 14.0 metres in height.

Option S4 would then continue northwards heading towards Loch nam Breac Mora. Relaxations in horizontal and vertical geometry are required to more closely follow the existing topography and reduce the impact of earthworks. Two horizontal curves of radius 450metres are required which is below desirable minimum standards. Vertical crest curves through this section are less than the desirable minimum standards, and two short sections of steep gradient are required, both 8% grades of less than 50m in length. Option S4 is both in cutting and on embankments approaching Loch nam Breach Mora, with embankments approximately 8.0 metres high and slopes up to approximately 23.0 metres in high at gulley crossings.

From Loch nam Breach Mora, Option S4 would continue northwards heading towards the River Attadale valley. Option S4 would have horizontal geometry largely to standard, but the vertical geometry provided requires relaxations in crest curves and gradient to allow an alignment which more closely follows the existing topography and therefore minimises earthworks. A steep grade of 10% is required on the approach to the River Attadale valley which is approximately 800m in length. Option S4 passes through sections of both cutting and embankment, each with slopes up to approximately 20.0 metres in height. Option S4 would then continue along the southern side of the River Attadale valley, with some relaxations in horizontal and vertical geometry required to more closely follow the exiting topography. Horizontal curves with a radius of 500 metres are provided which is less than the desirable minimum. Vertical crest curves less than desirable minimum are provided, and two lengths of steep gradient are also required, a 630m length of 8% grade and a 150m length of 10%. Option S4 has sections of both cuttings and embankments through the River Attadale with greater earthworks in the upper valley. Cuttings vary with slopes up to approximately 12.5 metres high in the upper Attadale valley, reducing to approximately 6.5 metres high towards the lower Attadale valley. Embankment slopes are between approximately 6.0 to 9.5 metres high, with a section of high embankment slopes up to approximately 33.0 metres high in the upper valley. The earthworks reduce in height on the approach to returning online at Attadale. A horizontal curve of radius 180 metres is required to allow Option S4 to tie back online in advance of the existing River Attadale bridge, whilst also minimising intrusion into the River Attadale valley. This is four step relaxation below the desirable minimum standards.

4.5 Climate, Topography and Land Use

The effect of the climate on the engineering design will be addressed in detail during Stage 3 work. At this stage allowance has been made to set options below the 300m AOD contour and an assessment of drainage outflows to accommodate increased flows due to climate change issues is discussed in chapter 6.

Considerations regarding the existing topography and land-use within the study area are included in the Environmental Assessment, Volume 2 of this report.

4.6 Geology, Geomorphology and Ground Conditions

A detailed geotechnical desk study has been undertaken to advise this Stage 2 appraisal. The URS, Stromeferry Options Appraisal, Geotechnical Desk Study Report 47065084 GLRP0001, March 2013' is contained in Appendix B. The desk study includes an assessment of underlying geology, hydrology and hydrogeology for each proposed route corridor and provides details of potential constraints for development and recommendations for further detailed intrusive investigation work.

Furthermore, a Peat Management Report which considers options for treatment of peat in the study area has been carried out and is included in Appendix C

A summary of the information presented in this report is provided in the following sections.

4.6.1 Geology

Information regarding the geological conditions at each of the proposed route corridors was obtained from available published geological sheets [1,2] and is summarised in Table 4.1 below.

Table 4.1 - Geological Conditions

Route Name	Geology
Northern Route Corridor	Where mapped, the superficial deposits along the majority of the northern route corridor are recorded to comprise moraine and undifferentiated drift, with the exception of the area between Kirkton and Strathcarron Junction, which is recorded to be underlain by freshwater alluvia. No indication of the depth of the superficial deposits is given; however superficial deposits were not consistently mapped across the site indicating that they are thin or absent. Around Stromeferry and Ardnarff the solid strata is changeable with massive and foliated pyroxenic hornblendic and micaceous gneiss affected by post-Cambrian movement; epidiorite and hornblende-schist affected by post-Cambrian movement; and flaggy quartz-feldspar granulite being recorded. Around Stromemore the routes were recorded to be underlain by massive and foliated pyroxenic hornblendic and micaceous gneiss affected by post-Cambrian movement and epidiorite and hornblende-schist affected by post-Cambrian movement. Beyond that, myolonite was recorded up to, and around, Slumbay Island, with the remainder of the routes being underlain by undifferentiated granulitic schists of the Moine Series. The solid strata were generally recorded to dip east towards Loch Carron at an unspecified angle.
Online Route Corridor	Where superficial deposits are mapped they are generally recorded to comprise moraine and undifferentiated drift of unspecified thickness. No indication of the depth of the superficial deposits is given; however superficial deposits were not consistently mapped across the site indicating that they are thin or absent. The solid strata are noted to vary across the proposed route corridor. Around Stromeferry and Ardnarff the strata is particularly changeable with massive and foliated pyroxenic hornblendic and micaceous gneiss affected by post-Cambrian movement; epidiorite and hornblende-schist affected by post-Cambrian movement; and flaggy quartz-feldspar granulite being noted. Along the remainder of the route, granulitic schists of the Moine series are noted to underlie the route. However, the strata immediately to the south of the routes along Loch Carron are recorded to comprise acid and hornblendic gneiss, amphibolite; and pelitic gneiss. The recorded dip varied from south east, to east, to north east.
Southern Route Corridor	Where mapped, the superficial deposits along the routes were recorded to comprise morainic deposits with some undifferentiated drift and peat. No indication of the depth of the superficial deposits is given; however superficial

[1] British Geological Survey, 1:50,000 Geological Sheets, 82: Lochcarron and 81E: Loch Torridon.
[2] British Geological Survey, 1:10,560 Geological Sheets.

Route Name	Geology
	deposits were not consistently mapped across the site indicating that they are thin or absent. The solid strata were recorded to comprise undifferentiated granulitic schists of the Moine Series, and were noted to dip to the south east.

4.6.2 Seismic Activity

The BGS has recorded several historical earthquake events in the vicinity (approx. 20km radius) of the proposed route corridors. Their location and associated magnitude are listed in Table 4.2 below:

Table 4.2 - Historical Earthquake Events

Date	Location	Magnitude
03/12/1878	Kintail	3.3
06/08/1974	Kintail	4
10/08/1974	Kintail	4.4
27/11/1975	Kintail	4.1
12/02/1975	Loch an Lasaich	2.2
06/04/1978	Lochan Dubha	1.9
28/05/1978	Lochan Dubha	1.9
11/06/1978	Creag Mhor	2.3
11/08/1979	Carn Mor	1.5
30/08/1979	Loch Carron (near avalanche shelter)	2.3
07/02/1988	Criag Mhaol	2.4
08/02/1988	Criag Mhaol	1.9

4.6.3 Mining and Quarrying

Due to the nature of the underlying metamorphic bedrock, it is considered that the risk to the development with respect to mineral stability is very low.

In addition, from a review of historical maps of the area, no quarries have been recorded on, or within 250m, of the proposed route corridors.

4.6.4 Soil Quality

A map showing the soils present within the Stromeferry Bypass study area is shown in drawing number 10.2, Appendix E. The soil types indicated to be present within each route corridor are presented in table 4.3.

Table 4.3 - Soil Types

Route Name	Soil Type
Northern Route Corridor	The majority of the northern route corridor is underlain by Arkaig soils (peaty soils, although they also contain some mineral and mountain soil) in the area around Lochcarron and Kirkton. Lochinver soils (described as brown forest soils and humous-iron podzols), are located in the southern part of the corridor and in the area of the Strome Narrows crossing.

Route Name	Soil Type
Online Route Corridor	The on-line route corridor is underlain by alluvial, organic, corby/boyndie/dinnet and Arkaig soils between Strathcarron Junction and Attadale. From Attadale to Stromeferry, the on-line corridor is underlain by Lochinver soils.
Southern Route Corridor	The southern route corridor is underlain by alluvial, organic, corby/boyndie/dinnet and Arkaig soils between Strathcarron and Attadale. As the route traverses to the south it crosses Lochinver and Arkaig soils and then Lochinver soils only as the route corridor traverses to the west towards Achmore.

Consultation with SEPA has resulted in concerns being raised in relation to the presence of peat within the proposed route corridors. In response to SEPA's concerns, a technical note Constructing Roads over Peat and Peat Management was prepared. This document provides a summary of the geotechnical constraints peat can have on road construction, current guidance / best practice for the construction of roads in areas of peat land to assist in the appraisal of the re-route options, guidance on the management of peat and information on ground investigation works that may be required to investigate peat conditions within the selected road alignment corridors.

4.6.5 Man Made Features

The following existing man-made features (which potentially have associated made ground materials) have been recorded within the study area and include:

- Kyle of Lochalsh to Inverness Railway and its associated infrastructure including bridges and footbridges;
- Bridges;
- Existing road pavement with associated structures and earthworks;
- Side roads, farm tracks and footpaths; and
- Developments within the local area.

4.6.6 Contaminated Land

There is at present no information with regard to the presence of any potentially contaminated land sites within the study area. Given the rural nature of the study area, it is not anticipated that there will be any areas of potential contamination with the exception of the presence of made ground that may be associated with the man-made features referred to in Section 4.5.5. No areas of land have been highlighted during the consultation process.

4.6.7 Peat

A detailed assessment of peak areas likely to be encountered particularly on the Southern Options has been undertaken and is included in the Peat Management Report in Appendix C.

4.7 Hydrology, Hydrogeology and Drainage

Further details on assessments of the proposed scheme options in relation to hydrology and hydrogeology issues can be found the Stage 2 environmental assessment.

4.7.1 Hydrology

The main water bodies in the study area are Loch Carron, Abhainn Cumhang a Ghlinne, River Carron, River Attadale, Allt Cadh an Eas, Allt Gleann Udalain, and Allt Loch Innis nan Seangan. These water bodies are discussed in more detailed in the environmental assessment report contained in Appendix E.

All of the above identified watercourses are potential outfalls for the road drainage system. Proposals for road drainage will be considered in more detail in Stage 3.

Due to the vulnerability of existing groundwater systems in the development area, road design is to include a high level of water treatment prior to discharge of road drainage into the existing systems. Where possible, discharge should be to open water rather than groundwater.

SEPA flood maps of Scotland gave no indication for risk of flooding for any of the proposed schemes.

4.7.2 Hydrogeology

The BGS aquifer maps [3] and accompanying report [4] indicate that:

- Alluvial and drift deposits recorded to underlie the majority of the site are regarded as a non-aquifer due to their low permeability.
- Groundwater flow within bedrock underlying the site is recorded to be through fractures (bedding planes, joints and faults.) These rocks are classified as aquifers with a low to very low productivity.

Groundwater flow directions within aquifer units in the drift deposits will be influenced by the local topography and also by nearby surface waters. A hydraulic connection between groundwater below the site and surface water is unknown.

The Scotland and Northern Ireland Forum for Environmental Research (SNIFFER) groundwater vulnerability map [5] and accompanying report [6] have been consulted and the site has been given a vulnerability classification of 4, based on the assumption of there being approximately 1-3m of superficial deposits overlying bedrock. A vulnerability classification of 4 indicates that groundwater within bedrock beneath the site will be vulnerable to those pollutants not readily absorbed or transformed.

Where bedrock is exposed, or only a thin layer of topsoil is present, a vulnerability classification of 5 would be more appropriate. A vulnerability classification of 5 indicates that groundwater within the bedrock will be vulnerable to most water pollutants with rapid impact in many scenarios.

Groundwater bodies are classified by SEPA, from which the water quality ratings range from Good to Poor. A search of SEPA's River Basin Management Plan (RBMP) database was conducted regarding the groundwater quality beneath the site, and was found to be classified as "good".

4.7.3 Drainage

Consideration has been given to four main elements of drainage design, namely:

- Flooding;
- Sustainable Drainage Systems (SuDS);
- Carriageway drainage; and
- Cross carriageway culverts.

Consultation with SEPA was carried out during the stages of this study and they set out their initial concern. The main issues were related to flood risk, the protection of the natural and water environment and management of waste. Further information relating to the consultation with SEPA is set out in Chapter 13, Road Drainage and the Water Environment, of the DMRB Stage 2 Report, Volume 2 Environmental Assessment which is included in Appendix E.

[3] BGS/SEPA, 2004. *Bedrock Aquifer Map and Superficial Aquifer Map Scale 1:10,000.*
[4] BGS, 2004. *A GIS of aquifer productivity in Scotland: explanatory notes. Commissioned Report CR/04/047N.*
[5] Scotland and Northern Ireland Forum for Environmental Research (SNIFFER), 2004. *Vulnerability of Groundwater in the Uppermost Aquifer, Scale 1:10,000.*
[6] SNIFFER, 2004. *Development of a groundwater vulnerability screening methodology for the Water Framework Directive.*

4.7.3.1 Carriageway Drainage, SUDS & Flooding

Some preliminary design considerations have been undertaken to identify mainline drainage systems for costing purposes only at this stage. Detailed drainage design work would be considered in detailed during Stage 3.

Assumptions based on previous consultation with SEPA, assume two forms of treatment will be required prior to discharge into a water course. It is proposed that treatment will be a combination of carriageway filter drains and detention basins, where appropriate. All carriageway drainage design shall be in accordance with HD 33 – Surface and Sub-surface Drainage Systems for Highways. As detailed in section 3.2.4, the cost estimates include for carriageway filter drains and gullies only, based on the length of the proposed mainlines.

The approximate sizing and costing of SUDs detention basins has not been undertaken at this stage. Further design on the outfalls and detention basis (if required) will be carried out as part of the Stage 3 Assessment. The location of the outfalls and basins will have to carefully consider impacts on the environmental receptors, and approximate areas of land for the basins will need to be identified shaping of the ponds to best fit in with the surrounding topography. Further consultation will be required with SEPA.

As part of the environmental assessment, the flood risk has been assessed based on the SEPA Flood Risk Management Maps (2014), as reported in section 13.4.6 of the Stromeferry Appraisal, DMRB Stage 2 Report, Volume 2 Environmental Assessment (refer Appendix E). This highlights that flood risk from the coast appears to be greater for the North Shore Corridor than for the Online or Southern Corridors. Flood risk from the major watercourses affects all routes, particularly in the Strathcarron Junction area. Should a route option be progressed to a Stage 3 assessment, a flood risk assessment will be required to inform the design of the Scheme. It is not currently known if flood defences will be required or included in any of the proposed options.

4.7.3.2 Culverts

A preliminary assessment of the required cross carriageway culverts has been undertaken, using 1:50,000 scale OS mapping. This has identified drainage structures requirements, as outlined in table 4.8.1 of this report, including both existing and new structures. This is further indicated on drawing numbers 5400 and 5401 in Appendix A of this report.

New drainage structures are proposed to be small bridges or bottomless culverts, where the required span is between 2m and 5m, and single pipe culverts up to approximately 1.0m diameter. The design requirements of the culverts will be confirmed at Stage 3, and are assumed to be required to pass a 1 in 200 year storm plus climate change flow. It will also take into account flood mitigation requirements, minimise geo-morphological impacts and shall consider the need to provide for the passage of migratory fish if required.

4.8 Public Utilities

BT Openreach, Scottish and Southern Energy and Scottish Water are all present within the study area and are affected by the proposals at some degree.

Preliminary information was sourced from utility companies under Appendix C2 of the New Roads and Street Works Act 1991. The information returned indicated apparatus within the study area as discussed in Chapter 2 Existing Conditions. This information has been collated and is shown on drawing numbers 5301 to 5306.

BT Openreach and Scottish Water have underground apparatus located mainly within carriageway and verges in residential areas, with BT apparatus extending along the A890 from Achintee to Ardnarff, from Cuddies' Point to Maman Hill and Achinte to the Strathcarron Junction, as well as the full length of public road from Ardaneaskan to the Strathcarron Junction along the north shore of Loch Carron.

In addition, there is various low voltage overhead SSE apparatus within the study area, generally following the existing road networks. There is also a high voltage overhead SSE line running

alongside the railway line from the north-east, to Strathcarron, Achintee and Attadale, turning south-east through Attadale valley towards Glen Ling and Loch Long.

The diversion or re-routing of the existing utilities are not expected to pose any particular problems to the development of the scheme, considering all route proposals, other than the usual implications affecting cost and programme.

Further consultation and C3 budget estimates for the anticipated diversionary work for the preferred scheme will be required at Stage 3. At the current stage of the assessment assumptions have been made to provide a cost estimate for public utilities for each of the scheme options considered.

4.9 Major Structures

The following chapter describes the preliminary engineering considerations made in relation to the scheme options further developed during the Stage 2 assessment. This includes more detailed structural proposals and considerations regarding buildability, aesthetics, operation, maintenance and inspection, risks and impact during construction. For costs associated with the proposed engineering solutions refer to chapter 3.5.

These will be further refined during Stage 3, when the preferred route will be further developed and a detailed design is carried out.

4.9.1 Structures (General)

Considering the traffic volumes in the study area, it is expected that new junctions and private accesses will be at-grade and there will be no requirement for grade-separated crossings of other roads. Therefore the majority of structures will involve the crossing of watercourses and water bodies - streams, rivers, and the Strome Narrows.

The options being considered also include bridge crossings of the railway and special structures on the On-line corridor comprising a sidelong viaduct, an avalanche shelter and a tunnel.

Several of the options include on-line sections of the existing A896, C1096 and A890 roads where existing structures would be upgraded or replaced. There will also be a need for retaining structures where improvement of on-line sections is constrained by existing development or topography.

Generally, the types of structure comprise;

- Culverts for small streams and large drains;
- Bridges for large streams and rivers, railways;
- Major bridges for crossings of the Strome Narrows;
- Multi-span viaduct - option O2 - Frenchman's Burn to Cuddies Point;
- Avalanche shelter - option O7 - Frenchman's Burn to Cuddies Point;
- Retaining structures for on-line improvement of existing roads.

Significant structures encountered for each of the proposed route options are summarised in Table 4.4 below. Where bridges cross watercourses and rivers, only those named on Ordnance Survey 1:50,000 mapping have been noted. Other smaller watercourses shown on the 1:50,000 mapping have been considered for minor bridges or culverts, and allowances made in the cost estimates for these. Refer to 4.9.2.

With reference to structures for online options O2, O3 and O7, a buildability study has been undertaken giving due consideration to programme and road closures, and is included in Appendix F.

Table 4.4 - Structures

Option	Structure	Crossing	Location
North Shore Option			
N6	830m major bridge or	Strome Narrows	Portchullin –

Option	Structure	Crossing	Location
	2.7km tunnel		Leacanasigh
	Small culvert or bridge, single span 2m to 5m	Various watercourses (8 No.)	New route from Achmore to Midstrome
	Large bridge > 5m	Allt Torr nan Daoine river bridge	Lochcarron Weavers
	Existing small culvert or bridge, single span 2m to 5m, upgraded	Various watercourses (10 No.)	Lochcarron Weavers to A896
	Existing large culvert	Allt nan Carnan	A896 Lochcarron
	Existing small culvert	Various watercourses (8 No.)	A896 Lochcarron
N9	830m major bridge	Strome Narrows	Portchullin – Leacanasigh
	Small culvert or bridge, single span 2m to 5m	Various watercourses (9 No.)	New route from Achmore to Midstrome
	Large bridge > 5m	Allt Torr nan Daoine river bridge	Lochcarron Weavers
	Small culvert or bridge, single span 2m to 5m	Various watercourses (13 No.)	Lochcarron Weavers to A896 along new bypass
Online Options			
O2, O3, O7	Small culvert or bridge, single span 2m to 5m	Various watercourses (18 + 6 No.)	Ardnarff to Cuddies Point
O2	1.6km Railway Viaduct	Sidelong viaduct along Loch Carron	Frenchman's Burn to Cuddies' Point
O3	1.5km Tunnel	Inland tunnel to bypass rock fall area	Frenchman's Burn to Cuddies' Point
O7	1.7km Avalanche Shelter	On-line avalanche shelter	Frenchman's Burn to Cuddies' Point
South Options			
S4	Allt Gleann Udalain bridge, approximately 15m single span	Allt Gleann Udalain	Gleann Udalain
	River bridge, approximately 10m single span	Watercourse	Allt an Lochain Fhuair, waterfalls
	River bridge or large culvert	Allt nan Darach Moire	Attadale Valley
	Small culvert or bridge, single span 2m to 5m	Various watercourses (16 No.)	Gleann Udalain to Attadale

4.9.2 Culverts

Culverts for field drains and small streams would mostly be constructed using precast concrete pipes which are typically available up to 2.4m diameter. Rectangular precast concrete culverts require less depth of excavation to achieve the same discharge rate as circular culverts and can offer cost savings from reduced time and labour on site but are generally more expensive than pipes. At this stage, it is assumed that 1.2m to 1.5m diameter precast concrete pipes would be sufficient to carry the flow from

the small streams that cross the routes. Although it may become apparent that other construction types would be more applicable at some specific sites, this type of construction is fast and economic and is therefore deemed the preferred method.

Large streams could be accommodated with corrugated steel culverts, arches or pipe-arches which are plate structures consisting of various width, curved steel sheets of varying profiles, lengths and thicknesses that are bolted together to form durable structures. These are typically used for diameters of over 3.6m and are available in spans/diameters up to 12m. Bolted plate structures have a high loadbearing capacity and offer some advantages over concrete structures including strength to weight ratio, ease of installation and adaptability to changing conditions.

At present, the Stage 2 cost estimates include for structures as detailed in table 3.9 above, and also include an allowance for minor road drainage and culverts, up to a size of 1.0m diameter approximately.

4.9.3 Bridges

Simple short span bridge crossings would be constructed with decks of in-situ reinforced concrete slab or precast pre-stressed concrete beams on reinforced concrete abutments with appropriate footings. In-situ concrete box structures could be used as underpasses to carry minor access roads or accommodation tracks under the new routes where necessary.

Longer span bridge crossings will be necessary in places to cross a river with a wide floodplain or difficult topography, and to allow structures with an open aspect for aesthetic reasons. This type of crossing could be a multi-span structure consisting of composite pre-stressed precast concrete or structural steel beams and in-situ reinforced concrete slab deck. The potential main span range is quite large and could be in excess of 50m, if required.

The existing bridges on the A896, C1096 and A890 are of a variety of types, including pre-stressed precast concrete beam, reinforced concrete slab and reinforced concrete beam and slab bridges, as well as masonry structures. It is likely to be necessary to refurbish, upgrade or replace some of these structures within the on-line sections of the route improvement options, depending on their condition, load capacity and available road cross section.

Major bridge structures associated with the route options are discussed separately in following subsections of this chapter.

4.9.4 Retaining Structures

Retaining structures will be required within sections of the route options with existing development constraints or difficult topography such as North Shore option N6 through Slumbay and Lochcarron, as well as on-line options on the south side of Loch Carron, where the available room for construction of new embankments required for some of the options considered is very restricted due to the existing topography and adjacent railway line.

Retaining walls can be formed in reinforced concrete and special geotechnical measures such as reinforced soil treatments or soil nails can be used to enable steepened cutting and embankment slopes where there are space constraints.

4.9.5 Strome Narrows Bridge

The North Shore corridor options incorporate a major bridge or tunnel crossing of the Strome Narrows which would allow future traffic to be re-routed to avoid the problem area on the south side of Loch Carron. Furthermore these options can be constructed without being affected by the constraints of the problem area and without significantly affecting the existing A890 road traffic and rail traffic.

Several Strome Narrows crossing were considered as part of the Stage 2 Assessment, and are summarised in the Strome Narrows Crossing Technical Note included in Appendix G. The location considered to cross the Strome Narrows has been narrowed down to one principal location during the Stage 2 assessment, with the choices being determined by the need for southern approaches to a bridge to traverse around the steep sided Creag Mhaol hill. The proposed North Shore route

alignments are to the west of Creag Mhaol and cross from near Portchulliin on the south shore to Leacanasigh on the north of the Narrows.

The following principles have informed this outline design of proposed bridge structures across the Strome Narrows:

- Set finished road level across the bridge and approach roads, to reduce earthworks requirements and to maintain reasonable cut and fill balance;
- Difficult / unknown foundation conditions on the sea bed;
- High tidal range of approximately 6.0m based on admiralty and tidal records for the Strome Narrows;
- Requirements for navigational clearances below the bridge;
- The design, detailing and finishes of the bridge should be of high quality, appropriate to the location of the site;
- Bridge structure to be straight on plan to simplify and facilitate construction techniques, such as launching;
- Aesthetics of the bridge structures, and views of the landscape from the bridge should be maximised;
- A 'simple' structure that frames the landscape and provides a good landscape contrast is preferable to a 'complex' option;
- Retain existing vegetation, minimizing the footprint and hard surfaces where possible to set the new structure within the existing landscape;
- Minimise excavation of hard material and associated environmental issues with disturbance and noise pollution;
- Overall estimated bridge construction costs.

4.9.5.1 Navigational Clearance Requirements

This appraisal included extensive consultations to establish requirements with regards to bridge clearances, both in height and width, for navigational purposes below a proposed bridge structure across the Narrows. Although Loch Carron does not experience a great amount of shipping, there are various user groups (mostly in relation to fishing and leisure), that would be affected by a structure crossing the western end of the loch.

Both historical as well as current requirements received during the consultations were considered. In agreement with The Highland Council Chief Structures Engineer it was concluded, that the consultations to date provide a good indication on a variety of requirements, and that this appraisal should, as a result of this, consider a feasible range of clearances above MHWS, putting forward suitable outline bridge design proposals to suit.

In addition, if a northern route scheme including a bridge structure across the Strome Narrows was emerging as the preferred option after this Stage 2 assessment, an application to Marine Scotland under the Marine (Scotland) Act 2010 will be required. This process, similar to a Planning application process, will involve consultations by Marine Scotland with various user groups and public bodies to confirm that proposed navigational clearance is adequate.

Bridge clearance is considered in relation to a level slightly above recorded MHWS at Plockton, using a tidal range of 6.0m at the bridge location, established using admiralty charts and tidal information. Chart Datum at Plockton is 3.15m below Ordnance Datum, with the reference high water level at the bridge of 2.85m AoD used for the outline bridge design.

Based on the above, proposed bridge design proposals developed during Stage 2 include a cable stay structure, providing a centre span of approximately 700m length, and a height clearance above high water reference level of approximately 35m, and 4 No options for a low level structure, with multiple 40 to 65m spans, providing navigational clearances between approximately 20 and 23.5m

above reference level. The bridge options with a clearance of 20m have been incorporated into the design for costing purposes.

4.9.5.2 Structural form

Examples of bridge solutions developed for the Strome Narrows crossing in the form of a concrete box girder bridge and a cable-stayed bridge are illustrated on drawing numbers 47065084/001 to 004 in Appendix G.

The nautical chart shows the sea bed at the Portchulliin - Leacanasigh location gradually deepening in the southern half to around 10m then markedly steepening to over 29.5m from Chart Datum closer to the north shore. This would lead towards a large main span in the northern half with shorter approach spans in the southern half.

4 no. options for a low level bridge have been developed as part of the appraisal, varying mainly in both horizontal and vertical alignments. End spans of 40m, with 15 to 16 no 50m long spans in the centre of the crossing have been considered, with a final preferred solution developed, providing spans of 40m, 9x48m, 53m, a navigational span of 65m, 53m, 3x48m and 40m, at an overall length of structure of 830m. The finished road level of this bridge has been set at 26mAoD, thus reducing required rock cuts on the north side of the Narrows in comparison to some of the other bridge options considered.

The structural form of a low level bridge would be a precast, pre-stressed concrete, or alternatively composite steel/concrete, box girder bridge deck, supported on reinforced concrete substructures, founded on piles or caissons into bedrock on the sea bed.

In addition, a high level bridge has been considered in the form of a cable stay structure. The advantage of this structure would be a large centre span of 700m length, allowing the main substructure to be located out with the deeper channel of the Narrows. It is anticipated that 3 no. side spans would be required at either side of the centre span of 105m, 85m and 75m length, resulting in an overall structure of 1.23km length. Road levels would be at 37.85mAoD, providing a bridge clearance of approximately 35m above reference high water level.

The structural form of a high level bridge would be cable stay bridge, comprising of a steel box girder deck structure, and reinforced concrete substructures, which are assumed to be founded on bedrock.

With this bridge and road alignment at a much higher level, the requirements for rock cuts in both the southern and northern approaches is reduced considerably.

4.9.5.3 Buildability

Given the nature of the glacially formed loch, it is expected that suitable foundation conditions for a bridge are available at relatively shallow depth however geotechnical investigations are required to confirm this. It is to be expected that bridge foundations and supports will require to be constructed within the loch. Depending on the structural form selected, the superstructure could be erected from floating working platforms or incrementally from the superstructure itself. Launching of the bridge deck from the southern shore has also been considered for the low level options, with the horizontal alignment been kept to a straight line to enable this method of construction.

The nearby former fabrication yard at Kishorn would be a suitable holding place for the delivery and assembly of components combined with local landfall areas created on both shores.

Construction of one of the southern spans over the existing Dingwall to Kyle railway line will also need to be considered, but is not assumed to present a problem.

The close vicinity of existing residential properties on both shores would need further consideration during detailed design of any of the considered bridge options.

An advantage of the north shore crossing would be that the existing route corridor of the A890 along the south side of Loch Carron would remain operational throughout the construction period.

4.9.5.4 Aesthetics

The bridge crossing main structures and associated approach spans would have a major visual impact in the landscape and the seascape and require careful consideration to ensure an elegant design that is fitting for this location.

The high level bridge could provide an 'iconic' statement, whereas a low level bridge is assumed to better blend into the surrounding landscape.

4.9.5.5 Operation/Maintenance/Inspection

The operation, maintenance and inspection requirements of these major bridge structures are not considered to be any different to other structure over water of a similar size and type. It would be important in the design phase to incorporate as many maintenance features as possible.

Routine maintenance and inspection could be carried out from the carriageway above, using underbridge units and roped access inspection. However given the large scale of these bridges, facilities for access for inspection and maintenance should be incorporated into the structure. It is likely that if box structures are adopted, the interior void will be a confined space, requiring special access measures.

4.9.5.6 Risks

There are risks to the construction relating to operations in tidal flow and working from water which would have to be addressed to satisfy the Construction Design and Management (CDM) Regulations' 20015.

There is a residual risk that a high level bridge could be subject to traffic restrictions or closure in high winds which might be expected to occur at the Narrows.

4.9.5.7 Impact during Construction

The nearby settlements of Achmore and Slumbay would experience disruption from construction traffic accessing the site, although bringing materials and components in by sea would help to reduce this as well as ease the impact on the regional road network. There would be more significant disruption to the property holding immediately adjacent to the crossing locations.

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

The proximity of existing residential properties on the north shore has also been recognised and will require further consideration during Stage 3, should a north shore route option be chosen as the preferred route.

4.9.5.8 Selection of Structural Form

URS have undertaken an in depth assessment of bridge options to cross the Strome Narrows. Whilst the high level structure could be designed as an iconic statement structure; giving due consideration to all factors i.e. fitting landscape, community impacts, buildability, operation and maintenance, and cost; the low level bridge has been taken forward to the Assessment Summary Tables. It should be noted however due to the number of intermediate piers, this structure form will impact on the loch bed. Best practice, legislation and guidance would inform mitigation measures. Mitigation would include a combination of minimising direct impacts on the marine environment (e.g. flameshells and various marine mammals) through detailed design as well as habitat creation/restoration where possible. Survey requirements and site specific mitigation measures would be developed at Stage 3 in consultation with statutory consultees where required.

4.9.6 Online Option O2 – Railway Viaduct

Stage 1 considered relocating the road onto a viaduct along the loch side of the railway which was to remove traffic from the hazard area immediately below the hillside and would have allowed construction to take place offline with less disruption to existing road traffic and rail services. The

corridor of the existing road would then have provided a safety margin for future rockfalls impinging on the railway.

However, more detailed consideration of this option, and discussions with Network Rail, have resulted in an amended proposal, where the railway line is moved onto a new viaduct alongside the loch over a length of 1.6km past the rock fall area to west of the Cuddies' Point. This is further detailed on drawing number 5205. The road would be re-aligned on the existing railway corridor, leaving a wide enough separation to the unstable rock faces, which would be further made safe by additional rock fall measures and rock trap ditches. This amendment also omits the requirement for two cross-overs of railway and road, and is therefore considered the more feasible and less expensive alternative.

The construction of the railway tie-ins at each end of the viaduct would require the construction of a spur formed from filling behind a contiguous piled retaining wall.

The railway viaduct would be founded on the sidelong bed of Loch Carron. Some examples of sidelong viaduct construction are the A84 Cruachan viaduct at Loch Awe and the A82 Pulpit Rock viaduct at Loch Lomond, which is to be built in 2014, as well as the A9 Killiecrankie viaduct which is on hillside.

4.9.6.1 Structural form

A rock causeway has been considered as an alternative option to providing a viaduct. The nautical chart for Loch Carron indicates that the loch is 80m - 100m deep which has been confirmed by The Highland Council by sonar and bathymetrical survey. The detail indicates a 1 in 1.5 to 1 in 1.8 scree slope to a depth of 30m - 40m, then a shallower slope out towards the middle of the loch. Widening the shoreline by placing a 2km rock causeway at a 1 in 1.5 slope would take of the order of 2,000,000 m^3 of material plus an additional 800,000 m^3 as the toe would ravel down the slope. There would be an attendant risk of slip failure of this material and/or the underlying slope, and therefore this alternative has been dismissed at this stage of the appraisal.

The multi-span railway viaduct structure would take the form of a contiguous plate girder half-through structure, with a reinforced concrete trough supporting the track bed. The substructure would comprise reinforced concrete columns supported on rock socket mono piled columns.

4.9.6.2 Buildability

It is envisaged that a railway viaduct would be constructed from floating working platforms with barge-mounted piling rigs and cranes and that materials and components would be brought in by sea. The nearby former fabrication yard at Kishorn would be a suitable holding place for the delivery and assembly of components. A local landfall area could be created at Cuddies Point and a temporary bridge constructed over the railway for early access during the construction period until a permanent structure is built.

Deep piled concrete foundations would be required, constructed through the superficial deposits on the sloping loch bed and socketed into the underlying bedrock. Concrete piers would then be constructed from the piles using in-situ construction with a climbing formwork system. Depending on the superstructure adopted, the piers could take the form of individual columns only or columns combined with crossheads.

The superstructure could be formed from a number of material options (reinforced concrete, prestressed concrete or structural steel) however it is envisaged that steel beams would be used rather than concrete for ease of placement by barge-mounted cranes. Deck slab could either be in-situ reinforced concrete on permanent formwork or could make use of a precast deck slab system. As the deck construction progresses, access would also be made along the superstructure for the delivery and placement of materials.

4.9.6.3 Aesthetics

A viaduct would be a visible feature from across the loch. However it should be relatively discreet against the shoreline and the scale of the hillside above. The tidal range would expose varying

appearances of the viaduct and care would be required to ensure an elegant structure particularly at low tide with appropriate attention to structure proportions, materials and finishes.

Railway passengers views of the scenic loch setting would arguably be enhanced from the viaduct while driver views should not be adversely affected.

4.9.6.4 Operation/Maintenance/Inspection

The operation, maintenance and inspection requirements of the viaduct are not considered to be any different to other structures over water of this size and type. It would be important in the design phase to incorporate as many maintenance features as possible e.g. minimising the number of expansion joints and making provision for bearing replacement and access for inspection. Routine maintenance and inspection could be carried out from the cess walkways, using roped access or specialist access plant running on the rails. Choosing suitable steel specifications could help to limit future maintenance requirements.

4.9.6.5 Risks

The main risk associated with the viaduct option is the need for geophysical survey information on the underlying rockhead profile and the definition of the internal structure of the rock to determine the presence any fault zones which would affect the design.

Construction risks such as working from water would be addressed to satisfy the Construction Design and Management (CDM) Regulations' 2007. The residual risk of further rockfalls affecting the road would remain and is allowed for elsewhere in this report.

4.9.6.6 Impacts during Construction

Given that the new railway viaduct is offline from the existing A890, it can be constructed by taking access from the loch and bringing materials by sea, disruption to road and rail traffic should be limited. Railway services would likely be affected by piling operations depending on the method of working. Although the viaduct works would be undertaken from working platforms in the loch there will still be times when short term closures are required, particularly when plant or equipment is being repositioned.

Tie-in of road and railway at each end of the bypass would require careful consideration to minimise disruptions to both road and rail traffic. Works in the proximity to the existing road and railway track would require a certain amount of one-way traffic management. Some full-road and railway closures would have to be considered for short durations and these would be limited to night-time closures where possible.

Bringing materials and components in by sea has the benefit of reducing delivery by road transport and associated impact on the regional road network.

The duration of the railway viaduct works is likely to be over two years. Alterations to the road could not proceed until the rail is realigned to the new viaduct at which stage the new road could then be constructed on the existing track bed.

4.9.7 Online Option O3 – Inland Tunnel

In addition to the other online options, structural proposals considered as part of this appraisal also include an inland tunnel to bypass the rock fall areas locally. A tunnel structure would be of the order of 1.6km in length.

Stage 1 proposals considered a tunnel cross section in accordance with the DMRB, BD 78/99- Design of Road Tunnels, which provides full carriageway width for two-way traffic flows, as well as verges and a narrow pedestrian strip alongside the carriageway in emergency or breakdown situations. In addition, the proposals included a fully segregated area, providing a safe route for Non Motorised Users of the route, as well as a safe exit route for emergency evacuation of the tunnel. This resulted in an overall cross sectional area of approximately 130m^2.

It was recognised during the Stage 1 assessment that cross sectional area of the tunnel is the main influence on construction costs. As a result, reduction of the area required for rock excavations would potentially reduce tunnel costs dramatically.

Norwegian, low cost tunnel construction reduces the cross sectional area, to about 60m^2, providing one or two way carriageways, depending on length of tunnel, and minimal tunnel linings in areas of worst rock conditions, and at carriage way and crown levels, for water and frost protection.

The typical Norwegian tunneling cross-section, as considered offers significant cost benefits but will not totally satisfy the UK design standards and safety regulations. Robust risk analysis and management techniques would have to be applied before it would satisfy the code of practice for risk management of tunnel works in the UK and taken further. Areas to consider include:

- Geology/Hydrogeology
- Drainage/Groundwater
- Pedestrians & Cyclists
- Operation & Maintenance
- Ventilation
- Escape & Refuge

However, from work to date and following a risk analysis it is likely the Norwegian cross section can be developed such that risks are As Low As Reasonably Practicable.

With regard to compliance with the UK standard BD78/99, we would recommend ongoing dialogue and meetings are held with the client; The Highland Council and Transport Scotland as the technical approval authority to set a series of 'Approval Gateways' where the subject is fully explored with the aspiration of final acceptance should the tunnel emerge as a preferred route option.

If an on-line tunnel is to be considered further it is recommended a hybrid solution is developed, taking aspects from the Norwegian design and incorporating them within a design to BD78/99. This solution would offer economies in price whilst conforming to standards. It should also be noted the current standard is some 15 years old. The overseeing authorities are aware of changing technologies for low trafficked roads which may be reflected in expected updates. A 20% reduction has been assumed in the costs for an on-line tunnel to reflect a hybrid solution.

A full report into tunnel options considered as part of this appraisal, including technical details and outline cost estimates has been compiled and can be found in Appendix D of this report.

4.9.8 Online Option O7 - Avalanche Shelter

Debris flow shelters, stone shelters or 'avalanche' shelters are engineered structures that form canopies over a section of road prone to rock fall or debris flows. These structures are usually formed from reinforced concrete and energy is dissipated by placing a depth of granular material on the roof on which the debris flow lands. Where the energy is anticipated to be very high, modifications can be made by shaping the roof so that the material passes over the structure without dissipating much energy.

The existing avalanche shelter built at time of the original road construction covers both the road and the railway for approximately 60m and is formed in reinforced concrete with 'window' openings in the wall between the road and railway and in the external lochside wall. The road is single track with hard strips through the shelter.

The general form of an extended shelter to provide protection for road users would be a prestressed concrete beam deck supported on reinforced concrete columns and a reinforced concrete wall over the full length of the area of concern (approximately 1.7km). It may be possible to provide less coverage by only locating shelters at the high risk locations subject to appropriate slope treatment measures at the intervening sections. This could be considered at the detailed assessment stage of the study.

The shelter would be an 'open' structure towards the lochside to provide light and ventilation, thus avoiding the requirements that apply to a tunnel and reducing the impact on the views experienced by road and rail users.

Several configurations of shelter have been considered:

- Single track carriageway
- Two-way carriageway
- Single width covering road only
- Double width covering road and railway
- Rail above road
- Road above railway.

4.9.9 Avalanche Shelter

Further to consideration of two avalanche structures as reported in the DMRB Stage 2 report, the structure proposed for Option O7 is described below which would avoid excavation of the rock face which would be required for an 'extended shelter'. This preferred structure would re-locate the road on a viaduct above the railway, leaving sufficient width for a rock catch ditch on the line of the existing road. The benefits of this type of solution over an extended avalanche shelter are considered to be:

- less encroachment into the rockface;
- less remediation measures essential to stabilise rockface;
- open aspect;
- less disruption during construction.

An outline of a viaduct-over-rail structure is shown in drawing number 5257.

4.9.9.1 Buildability

Construction activities in relation to this structure arrangement would be extremely constrained in the available working area between the rock face, the existing road and the railway. Construction is likely to require single lane traffic management and full closures of road and railway will also be necessary. In addition, access for construction traffic would be via the existing road corridor, causing further disruptions. The use of precast or pre-fabricated components such as columns, beams and deck slabs would allow some activities to take place offsite and help reduce work activity durations in the constrained site. As the deck construction progresses, access could also be made along the superstructure for the delivery and placement of materials.

In addition, the construction works would also be affected by the close proximity of the railway. All work activities would require to be fail-safe to prevent plant and materials falling or encroaching on the railway. It is envisaged that the structure arrangements would be founded on mono piled footings. It is likely excavation/drilling into rock will be necessary that will impinge on the railway track support zone. This proposal would also require demolition of the existing avalanche shelter. Tie in structures at each end would require special consideration to minimise any delays during construction.

4.9.9.2 Aesthetics

A viaduct above the railway would be visually intrusive within the setting of Loch Carron, although views from the opposite side of the loch would be distant and the structures themselves would be relatively insignificant against the scale of the hillside above.

Driver experience from the elevated road on the developed avalanche shelter would be greatly enhanced by views from the elevated position alongside the loch.

4.9.9.3 Operation/Maintenance/Inspection

There are no specific operational requirements for the extended shelter. Routine maintenance and inspection would be required as for any structure, with specific requirements relating to drainage, lighting and road surface issues. Maintenance would need to include the removal of any debris from the rock fall ditch proposed alongside the new structure, requiring a means of access for small plant. A means for maintenance vehicles to access the railway would also be need to be incorporated. The viaduct option would need a safe method of access to maintain bridge bearings in proximity to the railway.

In addition, provisions for non-motorised users would have to be carefully considered along a 1.6km elevated road way.

4.9.9.4 Risks

Significant risks include the risk to construction personnel from falling debris throughout a lengthy construction period, the stability of the slopes being affected by the shelter works and the risk of both options working in close proximity to railway operations.

4.9.9.5 Impact during Construction

Given the constraints of the narrow corridor it is inevitable that full road closures would be necessary for lengthy durations to allow construction of the piled foundations and columns. Even when construction activities allow traffic to be diverted onto the railway under one-way working, there would be long term traffic management delay and disruption. There would also be disruption and closure of rail services. Although it has its own disruption difficulties, it is assumed that the viaduct option should cause less impact overall than the construction of an extended shelter.

The duration of the works could be over two years.

4.10 Consenting and Statutory Processes

4.10.1 Introduction

Part of the appraisal brief for this Stage 2 assessment of scheme options was to determine statutory processes that are likely to be involved with each of the proposed scheme options in order to assist with determination of likely timescales required during the further stages of this development.

A full report has been compiled detailing all statutory processes determined at this stage of the scheme development, a copy of which can be found in Appendix H of this report.

4.10.2 Summary

A number of statutory processes must be followed at Stage 3 for a preferred scheme. This will include obtaining a number of consents and licences which depending on the route chosen may include the following:

Table 4.5 - Consenting and Statutory Processes

Consent / License and Statutory Process	Applicable to
Planning consent	All options
Marine Licence	N6, N9, O2
Compulsory Purchase	All options
De-crofting of land	All options
Environmental Impact Assessment	All options
Protected species disturbance licence	All options
Habitats Regulations Assessment	All options
Scheduled Monument consent	N6, N9

Consent / License and Statutory Process	Applicable to
Listed Building consent	All options
Tree felling licence	N6, N9, S4
Controlled Activities Regulations Licence	All options
Waste Management Licence	All options
Transport and Works (Scotland) Order	Option O2

It should be noted that a Public Local Inquiry may be required under some of the above processes depending on circumstances/objections and that statutory requirements will be determined at DMRB Stage 3 following further discussions with a number of statutory bodies.

4.11 Potential Departures from Standard

As described in section 4.2 above, roads in Scotland are designed to the requirements set out in the Design Manual for Roads and Bridges (DMRB). These design requirements include desirable minimum and absolute requirements. Designs can be below the desirable minimum requirements at the discretion of the Designer, this is known as a Relaxation. If the design does not meet the absolute requirements, a Departure from Standard is required and this must be approved by the Overseeing Organisation, in this case The Highland Council.

The route options aim to have geometry appropriate for a design speed of 100B kph. However, due to the constrained nature of the study area and the local topography, relaxations in both the horizontal and vertical geometry are included to minimise the impact on the local environment.

An initial review of the proposed mainline geometry has been carried out for the route options. At this preliminary stage, the designs do not include verge widening for stopping sight distance. Therefore the departures and relaxations listed below refer to the horizontal curves and transitions, and vertical curves and gradients only, and do not consider stopping sight distance. Similarly, although the potential location of sideroads junctions has been estimated and considered when assessing potential departures, junctions for private accesses have not been considered as part of this exercise.

A summary of the potential relaxations and departures is detailed in tables 4.6 to 4.11 below. It should be noted that values recorded in the tables below are as the route options currently stand. Further design development will be required on the Preferred Option and therefore the design and geometry will be subject to change.

4.11.1 North Shore Options

4.11.1.1 Option N6 (online)

Option N6 has undergone a preliminary mainline geometry assessment and has found to have 19 mainline departures as summarised in table 4.6. The majority of departures are required where vertical crest curves and gradients have been relaxed near junctions, to more closely follow existing topography and therefore minimise the impact on adjacent land and property. The remaining departures are required at locations where relaxations in horizontal geometry are coincident with relaxations in vertical geometry, therefore these combinations are considered to be Departures from Standard.

4.11.1.2 Option N9 (offline)

Option N9 has undergone a preliminary mainline geometry assessment and has found to have 9 mainline departures, as summarised in table 4.7. Departures are related to the vertical geometry, with relaxations in crest curve and gradient required to more closely follow the existing topography and therefore minimise the impact on adjacent land and property. The remainder are required at locations where relaxations in horizontal geometry geometry are coincident with relaxations in vertical geometry, therefore these combinations are considered to be Departures from Standard.

4.11.2 Online Options

All online options follow the same alignment from Ardnarff to Frenchman's Burn. Other than the section from Frenchmans Burn to Cuddies Point, where special structures are provided to bypass the rockfall area, all online options follow the existing A890. Therefore the online options have a higher number of departures as the alignments aim to follow the existing road alignment which has horizontal and vertical geometry of a lower standard.

4.11.2.1 Option O2 (Viaduct)

Option O2 has undergone a preliminary mainline geometry assessment and has found to have 76 mainline departures. Table 4.8 summarises the departures, but due to the high numbers, the number of departures of similar types have been totalled for sections along the route. The majority of departures are for the non-provision of horizontal transition curves. The remainder are mostly required at locations where relaxations in horizontal geometry are coincident with relaxations in vertical geometry.

4.11.2.2 Option O3 (Tunnel)

Option O3 has undergone a preliminary mainline geometry assessment and has found to have 48 mainline departures. Table 4.9 summarises the departures, but due to the high number of departures, similar types have been totalled for sections along the route. The majority of the departures are for the non-provision of horizontal transition curves. The remainder are mostly required at locations where relaxations in horizontal geometry are coincident with relaxations in vertical geometry.

4.11.2.3 Option O7 (Avalanche Shelter)

Option O7 has undergone a preliminary mainline geometry assessment and has found to have 43 mainline departures. Table 4.10 summarises the departures, but due to the high number of departures, similar types have been totalled for sections along the route. The majority of the departures are for the non-provision of horizontal transition curves. The remainder are mostly required at locations where relaxations in horizontal geometry are coincident with relaxations in vertical geometry.

4.11.3 Southern Corridor

4.11.3.1 Option S4 (Glen Udalain)

Option S4 has undergone a preliminary mainline geometry assessment and has found to have 11 departures, as summarised in table 4.11. From Glen Udalain to Attadale Point, three departures are required for steep gradients, provided to more closely follow the existing topography and therefore minimise the impact on adjacent land. The remainder of Departures are mostly required for locations where relaxations in horizontal geometry are coincident with relaxations in vertical geometry.

Table 4.6 - Potential Departures from Standards - Option N6

OPTION N6 ROAD GEOMETRY REQUIRING DEPARTURES FROM STANDARD

Ref No.	Chainage	Type	Description	Standard Required	Standard Achieved	Route Location
N6/D001	121 - 310	vertical curve	vertical crest - 1 step below des min, at junction	100K	55K	Achmore to Leacanasigh
N6/D002	348 - 468	vertical curve	vertical crest - 2 steps below des min, at junction	100K	30K	Achmore to Leacanasigh
N6/D003	637 - 937	vertical curve	vertical crest - 2 steps below des min, at junction	100K	30K	Achmore to Leacanasigh
N6/D004	1256 - 1702	vertical gradient	gradient greater than desirable maximum	6%	8%	Achmore to Leacanasigh
N6/D005	3334 - 3709	vertical curve	vertical crest - 2 steps below des min, at junction	100K	30K	Achmore to Leacanasigh
N6/D006-D008	various, 4274 -4514	horizontal	length of transition curve	q=0.6	no provision	Leacanasigh to Strome Wood
N6/D009-D014	various, 4614 -5209	horizontal	length of transition curve	q=0.6	no provision	Leacanasigh to Strome Wood
N6/D065	901 - 937	combination	combination - horizontal & vertical relaxation			Achmore to Leacanasigh
N6/D066	1853 - 1989	combination	combination - horizontal & vertical relaxation			Achmore to Leacanasigh
N6/D067	3954 - 4024	combination	combination - horizontal & vertical relaxation			Leacanasigh to Strome Wood
N6/D068	4417 - 4514	combination	combination - horizontal & vertical relaxation			Leacanasigh to Strome Wood
N6/D069	4782 - 4851	combination	combination - horizontal & vertical relaxation			Leacanasigh to Strome Wood

Table 4.7 - Potential Departures from Standards - Option N9

OPTION N9 ROAD GEOMETRY REQUIRING DEPARTURES FROM STANDARD

Ref No.	Chainage	Type	Description	Standard Required	Standard Achieved	Route Location
N9/D001	121 - 310	vertical curve	vertical crest - 1 step below des min, at junction	55K		Achmore to Leacanasigh
N9/D002	348 - 468	vertical curve	vertical crest - 2 steps below des min, at junction	30K		Achmore to Leacanasigh
N9/D003	637 - 937	vertical curve	vertical crest - 2 steps below des min, at junction	30K		Achmore to Leacanasigh
N9/D004	1256 - 1702	vertical gradient	gradient greater than desirable maximum	8%		Achmore to Leacanasigh
N9/D005	3334 - 3675	vertical curve	vertical crest - 2 steps below des min, at junction	30K		Achmore to Leacanasigh
N9/D006	5378 - 5427	vertical curve	vertical crest - 1 step below des min, at junction	55K		Leacanasigh to Strome Wood
N9/D012	901 - 937	combination	combination - horizontal & vertical curve			Achmore to Leacanasigh
N9/D013	1853 - 1989	combination	combination - horizontal & vertical curve			Achmore to Leacanasigh
N9/D014	4374 - 4558	combination	combination - horizontal & vertical curve			Leacanasigh to Strome Wood

Table 4.8 - Potential Departures from Standards - Option O2

OPTION O2 ROAD GEOMETRY REQUIRING DEPARTURES FROM STANDARD

Ref No.	Chainage	Type	Description	Standard Required	Standard Achieved	Route Location
O2/D049 - D081	various, 3291 - 5008	horizontal	length of transition curve	q=0.6	No Provision	Ardnarff to Cnoc Nam Mult
O2/D082 - D111	various, 5174 - 6935	horizontal	length of transition curve	q=0.6	No Provision	Cnoc Nam Mult to Cuddies Point
O2/D112	7009 - 7194	vertical curve	vertical crest - 2 steps below desirable minimum, at junction	100K	40K	Cnoc Nam Mult to Cuddies Point
O2/D113 - D114	7147	horizontal	length of transition curve	q=0.6	No Provision	Cnoc Nam Mult to Cuddies Point
O2/D115	7283 - 7638	vertical curve	vertical crest - 2 steps below desirable minimum, at junction	100K	30K	Cnoc Nam Mult to Cuddies Point
O2/D116 - D117	various, 7321	horizontal	length of transition curve	q=0.6	No Provision	Cnoc Nam Mult to Cuddies Point
O2/D146	4480 - 4555	combination	combination - horizontal curve and vertical curve relaxation			Ardnarff to Cnoc Nam Mult
O2/D147	5477 - 5527	combination	combination - horizontal curve and vertical curve relaxation			Cnoc Nam Mult to Cuddies Point
O2/D148	6098 - 6179	combination	combination - horizontal curve and vertical curve relaxation			Cnoc Nam Mult to Cuddies Point
O2/D149	6212 - 6271	combination	combination - horizontal curve and vertical curve relaxation			Cnoc Nam Mult to Cuddies Point
O2/D150	7147 - 7194	combination	combination - horizontal curve and vertical curve relaxation			Cnoc Nam Mult to Cuddies Point
O2/D151	7283 - 7321	combination	combination - horizontal curve and vertical curve relaxation			Cnoc Nam Mult to Cuddies Point
O2/D152	7321 - 7481	combination	combination - horizontal curve and vertical curve relaxation			Cnoc Nam Mult to Cuddies Point

Table 4.9 - Potential Departures from Standard - Option O3

OPTION O3 ROAD GEOMETRY REQUIRING DEPARTURES FROM STANDARD

Ref No.	Chainage	Type	Description	Standard Required	Standard Achieved	Route Location
O3/D049 - D081	various, 3291 - 5008	horizontal	length of transition curve	q=0.6	No Provision	Ardnarff to Cnoc Nam Mult
O3/D082 - D093	various, 5174 - 5615	horizontal	length of transition curve	q=0.6	No Provision	Cnoc Nam Mult to Cuddies Point
O3/D122	4480 - 4555	combination	combination - horizontal curve and vertical curve relaxation			Ardnarff to Cnoc Nam Mult
O3/D123	5523 - 5546	combination	combination - horizontal curve and vertical curve relaxation			Cnoc Nam Mult to Cuddies Point
O3/D124	7367 - 7520	combination	combination - horizontal curve and vertical curve relaxation			Cnoc Nam Mult to Cuddies Point

Table 4.10 - Potential Departures from Standard - Option O7

OPTION O7 ROAD GEOMETRY REQUIRING DEPARTURES FROM STANDARD

Ref No.	Chainage	Type	Description	Standard Required	Standard Achieved	Route Location
O7/D049 - D081	various, 3291 - 5008	horizontal	length of transition curve	q=0.6	No Provision	Ardnarff to Cnoc Nam Mult
O7/D142	4480 - 4555	combination	combination - horizontal curve and vertical curve relaxation			Ardnarff to Cnoc Nam Mult
O7/D143	5227 - 5340	combination	combination - horizontal curve and vertical curve relaxation			Cnoc Nam Mult to Cuddies Point
O7/D144	5526 - 5619	combination	combination - horizontal curve and vertical curve relaxation			Cnoc Nam Mult to Cuddies Point
O7/D145	5748 - 5762	combination	combination - horizontal curve and vertical curve relaxation			Cnoc Nam Mult to Cuddies Point
O7/D146	6078 - 6197	combination	combination - horizontal curve and vertical curve relaxation			Cnoc Nam Mult to Cuddies Point
O7/D147	6197 - 6274	combination	combination - horizontal curve and vertical curve relaxation			Cnoc Nam Mult to Cuddies Point
O7/D148	6589 - 6671	combination	combination - horizontal curve and vertical curve relaxation			Cnoc Nam Mult to Cuddies Point
O7/D149	7117 - 7147	combination	combination - horizontal curve and vertical curve relaxation			Cnoc Nam Mult to Cuddies Point
O7/D150	7147 - 7196	combination	combination - horizontal curve and vertical curve relaxation			Cnoc Nam Mult to Cuddies Point
O7/D151	7285 - 7323	combination	combination - horizontal curve and vertical curve relaxation			Cnoc Nam Mult to Cuddies Point

Table 4.11 - Potential Departures from Standard - Option S4

OPTION S4 ROAD GEOMETRY REQUIRING DEPARTURES FROM STANDARD

Ref No.	Chainage	Type	Description	Standard Required	Standard Achieved	Route Location
S4/D001	4140 - 4361	vertical gradient	gradient greater than des max	6%	10%	Glen Udalain Valley
S4/D002	10910 - 11722	vertical gradient	gradient greater than des max	6%	10%	Glen Udalain Valley
S4/D003	12942 - 13101	vertical gradient	gradient greater than des max	6%	10%	Glen Udalain Valley
S4/D004	13416 - 13665	vertical curve	vertical crest - 2 steps below des min, at junction	100K	30K	Glen Udalain Valley
S4/D005	13940	horizontal	Length of Transition Curve - 180mR	q=0.6; 198m	No Provision	Glen Udalain Valley
S4/D018	6987 - 7193	combination	combination - horizontal & vertical relaxation			Glen Udalain Valley
S4/D019	8320 - 8383	combination	combination - horizontal & vertical relaxation			Glen Udalain Valley
S4/D020	9076 - 9209	combination	combination - horizontal & vertical relaxation			Glen Udalain Valley
S4/D021	12705 - 12796	combination	combination - horizontal & vertical relaxation			Glen Udalain Valley
S4/D022	13416 - 13444	combination	combination - horizontal & vertical relaxation			Glen Udalain Valley
S4/D023	16363 - 16539	combination	combination - horizontal & vertical relaxation			Maman to Achintee

5. Environmental Assessment

A STAG Part 2 environmental appraisal, which draws on guidance provided in the DMRB, was carried out on the full route options and was reported in the Stromeferry Appraisal, DMRB Stage 2 Report issued in October 2014. These assessments are contained in Appendix E.

As described in section 1.1, the main emphasis of this Stromeferry Options Appraisal STAG Part 2 Report is to focus on the infrastructure required to bypass the rock fall area, previously described as Phase 1 options. This report does not seek to update the quantative data gathered to inform the original report.

5.1 Environmental Summary Topics

5.1.1 This chapter summarises each of the environmental assessment topics, as included below. Noise & Vibration

An appraisal of the potential noise and vibration impacts associated with the set of route options has been undertaken by the counting of sensitive properties within 300 metres of the alignments. The number of sensitive properties has been compared with the baseline (Online Route O4) in order to determine the potential change in the number of properties affected by road traffic noise and vibration.

This is as a result of no significant change in the number of noise sensitive properties neighbouring the alignment in comparison with the baseline case.

5.1.2 Air Quality

The Air Quality chapter considered the impact of the proposed route options and their effects on local and regional air quality, and on Sites of Importance for Nature Conservation.

The chapter found that existing and future baseline air quality in the do-minimum scenario is of a good standard, with the pollutant concentrations of concern to this assessment being well below their respective national air quality objective values.

With the proposed North Shore Route options in operation, there would be a neutral to slight adverse impact on local air quality at some receptors, although due to the good standard of air quality within the study area, the overall effect on local air quality would be negligible. With the Online Route options and Southern Route options in operation, there would be a neutral impact on local air quality. The effect of any of these impacts is not considered to be significant.

Because baseline air quality in the study area is so good, none of the proposed route options would lead to an impact that would have a significant effect on regional air quality. However, the North Shore and Southern Route options would lead to an increase in the number of vehicle kilometres travelled, and therefore the amount of pollutants emitted on a regional scale, due to the construction of new highway.

5.1.3 Water Quality, Drainage and Flood Defence

The water features in the study area include Loch Carron and River Attadale which is divided by the Route Options, other minor watercourses and the groundwater beneath the Scheme.

During construction, a number of standard control measures should be put in place to reduce the potential for significant quantities of sediment or other typical construction pollutants being discharged into the surrounding water bodies. These measures are considered to be current best practice within the construction industry. There may a significant effect on River Attadale and Loch Carron for some of the Online Route options and for the River Attadale for the Southern Route, related to changes in water quality, geomorphology and hydrology due to their high sensitivity.

Once the Scheme is constructed, road run off from the A890/A896 would be collected and passed to two levels of Sustainable Drainage Systems (SUDS) for treatment before being discharged, as is required for schemes of this nature. Again, there may a significant effect on the major watercourses and Loch Carron for some of the Online Corridor Route options, and for River Attadale for the

Southern Corridor, related to changes in water quality, geomorphology and hydrology due to their high sensitivity.

The preferred option for the Scheme with regards to Road Drainage and the Water Environment would be the Online Route O7, with the avalanche shelter extension option. The least preferred option is the Southern Corridor route due to the large number of new crossings required and earthworks related to building on undeveloped land.

5.1.4 Geology

The Geology assessment identifies the study area baseline in terms of geology, including superficial geology, solid geology, hydrogeology, man-made features, contaminated land, site history and geohazard potential including landslide / rockfall history. The impacts identified in the assessment primarily include impact to the Attadale SSSI and impact upon existing bedrock from cutting / tunnelling.

The assessment identifies that the preferred route option would be Route Option S4 (South Glen Udalain) within the Southern route corridor. Although the proposed route primarily comprises the construction of a new road, it is considered that it could be designed and constructed to minimise impact to geology if the mitigation measures are adopted. The route option would by-pass the existing rockfall problem area on the A890 whilst avoiding the construction of tunnels/bridges and the requirement for undertaking significant slope stability remedial works.

The second best routes are considered to be the Online Routes; O2 and O7. These routes would primarily utilise the existing road network, which would have a reduced impact upon the underlying geology and soil. Both of these route options would require slope stability remedial work, which would be costly but would have an overall long term beneficial impact.

The least preferred options would be the Northern routes. N6 and N9 utilise the existing road network and include the construction of new stretches of road. However, the corridor would by-pass the area of slope instability along the existing A890 and would avoid the requirement for significant slope stability remedial works. These options also require the construction of a crossing over the Strome Narrows (via a bridge), which would have a greater impact upon the geology.

5.1.5 Biodiversity & Habitats

The nature conservation chapter identifies the ecological receptors (sites, species and habitats) of high (national or international – for definitions see chapter) value which are likely to be directly or indirectly affected by the proposed scheme options. These are:

Internationally designated sites (including their qualifying features):

- Rassal SSSI & SAC Biological features: Mixed woodland on base-rich soils associated with rocky slopes; Base-rich fens; Hard-water springs depositing lime; Plants in crevices on base-rich rocks; Limestone pavements; Alpine and subalpine calcareous grasslands; and Mountain willow scrub.
- Coille Mhor SSSI & SAC Biological features: Western acidic oak woodland.
- Nationally designated sites (including their qualifying features):
- Rassal National Nature reserve Biological features: Upland mixed ash woodland.
- Slumbay Island SSSI Geological features: Structural and metamorphic geology: Moine.
- Attadale SSSI Geological features: Structural and metamorphic geology: Moine.
- Allt nan Carnan SSSI Biological features: Upland birch woodland.
- Carn a' Bhealaich Mhoir SSSI Geological features: Structural and metamorphic geology: Moine.
- Loch Carron Nature Conservation Marine Protection Area (MPA) designated for the protection of flameshell beds on the northern side of the narrows. Other features: burrowed mud, horse mussel beds, kelp and seaweed communities on sublittoral sediments and tide-swept algal communities. Common skate and ocean quahog have also been recorded. It was also noted that there are aggregations of flameshell beds on the northern side of the narrows.

- Habitats of national importance likely to be affected by the proposed scheme include:
- Semi-natural ancient broadleaf woodland; this habitat type occurs in discrete locations throughout the study area and is likely to contain plant and animal communities of significant conservation interest and
- Loch Carron marine water body, described above (Loch Carron MPA).

Species of national importance possibly affected by the proposed scheme include: Otter, bats, wild cat, breeding birds, golden eagle, hen harrier, and black-throated diver.

Other sites, habitats and species of importance at a regional or local scale are also likely to be affected by the proposed routes options, details of these can be found in the main chapter.

The design of the main carriageway is similar for each scheme option (and sub-options) with the exception of parts of the Online Routes. Online route O2 incorporate a 1.8km long embankment / viaduct, Online route option 3 includes construction of a tunnel and Online route option O7 requires the extension of an existing avalanche shelter. These extra required structures result in construction impacts of varying degree but are not necessarily more adverse than other routes. Predicted construction and operational impacts common to all options include:

- Water quality: Potential impacts include direct disturbance or destruction of freshwater and marine substrates and degradation through siltation and other pollution. This may directly or indirectly affect fresh water / marine species including bivalve molluscs.
- Sediment deposition: Potential impacts include modifications to current sediment deposition patterns. This may directly or indirectly affect a number of fresh water, marine and intertidal species.
- Effects on a range of terrestrial habitats will occur within the route corridors; though the extent and location will vary with each route option. Principal habitats affected will include the loss and fragmentation of damp Calluna heath, acid grassland, coniferous planation woodland, with broadleaved plantation and semi-natural woodland also affected.
- Direct impacts upon intertidal habitats are only likely to occur with the Northern Route Options (Strome Narrows Crossing), Online Route Option O2 (Viaduct) and possibly Online Route Options O7 (Developed Avalanche Shelter), all are likely to involve construction activities within the intertidal zone.
- Potential impacts upon breeding birds; these include destruction of nests, nesting/foraging habitats.
- Increased risk of wildlife road fatalities particularly within off-line sections, and because the road will be wider (upgraded to single carriageway) with a higher average traffic speed.

In respect of ecology and nature conservation, Online route 07 (Developed avalanche shelter) has the lowest overall impact and Southern route S4 the highest overall impact. Three critical conservation issues, potentially affected to varying degree by all options, have been identified: disturbance of protected sites, destruction of broadleaf semi-natural ancient woodland and negative impacts on Schedule1/Annexe 1 birds. Protected sites most at risk include the Attadale SSSI and Loch Carron Marine Protection Area (MPA). Ancient woodland comprises part of these sites but is also present out with these areas. Schedule/Annex 1 bird species potentially affected by the scheme include black-throated and red-throated divers and golden eagle.

The North Shore Routes involve the construction of a bridge over the Strome Narrows which will have a major impact on the Loch Carron MPA. The North Shore Routes will also result in the loss of the woodland habitat and is likely to have a negative effect on a number of protected species. Although the alternative North Shore Route N9 would not impact upon the SSSI, the other impacts associated with the main route would remain.

Further investigations are required before the impacts of the current options can be fully analysed as part of a Stage 3 assessment. In particular further survey is required regarding the impact all options may have on protected sites (the MPA and SSSIs), habitats of high conservation interest (including semi-natural ancient woodland) and protected species. Work near watercourses and water bodies must be avoided or minimised and must adhere to all SEPA regulations and guidance, with all measures developed through consultation with SNH. SNH should also be consulted specifically concerning impacts to designated sites.

5.1.6 Landscape

None of the route options are anticipated to result in significant impacts on the landscape designations identified within the study area.

The North Shore Route Options (N6 and N9) are anticipated to result in locally significant, impacts on parts of three LCTs and the Strome Narrows area. Impacts on the remaining LCTs are not anticipated to be significant.

The Online Route Options are anticipated to result in localised significant impacts on one LCT, with Option O7 also anticipated to result in significant impacts on parts of a second LCT. No significant impacts are anticipated on the remaining Landscape Character Types (LCTs) and the landscape character of the study area as a whole.

The Southern Route Option (S4) is anticipated to result in locally significant impacts on five LCTs. There are likely to be no significant impacts on the character of the remaining LCTs.

It is therefore considered that, from a landscape character perspective, Online Route Option 4 is likely to have the least impact, followed by Online Route Options 3. The Southern Route Option is likely to result in the greatest impacts on landscape character and is therefore the least favoured option.

5.1.7 Visual Amenity

The North Shore Route Options are anticipated to result in significant impacts on receptors at Stromemore, Stromeferry, Ardaneaskan, Portchullin, Achmore, the south side of Loch Carron (including the railway, A890 and residential properties between Ardnaff and Cam-allt), and users of the loch. Visual receptors at other locations within the study area are not anticipated to receive significant impacts.

Online Route Options 2 and 7 are anticipated to result in significant impacts on receptors at Lochcarron and users of Loch Carron. Visual receptors at other locations within the study area are not anticipated to receive significant impacts. Online Route Options 3 and S4 are not anticipated to result in significant impacts on visual receptors within the study area.

Visual receptors at other locations within the study area are not anticipated to receive significant impacts. There is also potential for positive impacts on receptors at a number of locations, such as those in Lochcarron and along the north side of the loch, at Achmore and Braeintra, railway passengers and loch users.

It is therefore considered that, from a visual amenity perspective, Online Route Option 4 is likely to have the least negative impact, followed by the Southern Route and Online Route Options 3. North Shore Option N6 represents the least favoured option, largely due to impacts associated with the crossing at Strome Narrows and on receptors in Lochcarron.

5.1.8 Agriculture & Soils

The Soils assessment identifies the study area baseline in terms of soil quality and agricultural land use. The impacts identified in the assessment primarily include impact to compressible soils (peat / alluvial soil) and impact from soil erosion and compaction.

The assessment identifies that the preferred route options would be the Online Routes; O2 and O7. These routes would primarily utilise the existing road network, which would have a reduced impact upon the underlying soil and are along existing routes avoiding agricultural land. All route options would require slope stability remedial work, which would be costly but would have an overall long term beneficial impact. These options would also avoid potential issues in relation to peat, and would negate any potential environmental effects that this may have.

The Northern routes, N6 and N9, utilise the existing road network and include the construction of new stretches of road where peat soils may be encountered.

The least preferred option is Route Option S4 (South Glen Udalain) within the Southern route corridor as it comprises the construction of a new road that will traverse areas of peat land (which will have an

impact upon road design and the surrounding environment), it is considered that it could be designed and constructed to minimise impact to soils if the mitigation measures are adopted. Although the agricultural land take is more extensive for Option S4 it is considered of moderate quality and crofting land.

5.1.9 Cultural Heritage

The cultural heritage chapter has presented the potential impacts and residual effects from the scheme options for the Stromeferry Appraisal. Seven route options were considered, including a 'do nothing' option and two options require the construction of a bridge across the Strome Narrows. A total of one scheduled monument and seven listed buildings are located within the study area. There are approximately 80 non-designated assets within the study area of all options.

The scheduled monument of Strome Castle has the potential to have its setting impacted by the construction of a bridge across the Strome Narrows and recommendations have been made for the highest quality design principles for the structure to reduce the visual impact (applicable to Route options N6 and N9).

The earliest archaeology located within the study area dates from the prehistoric period. There is evidence for raised beach sites along the loch edge which are sea-cut platforms formed when the sea-level dropped which then became raised beaches and were often used as lithic working sites. There is the potential for further lithic working sites to be recovered within all options which run adjacent to the shoreline.

5.2 Assessment Summary Tables

A summary of each environmental topics has also been included in Table 5.1 below.

Options have been assessed using the seven point scale identified as described in Chapter 2 of the DMRB Stage 2 Environmental Assessment contained in Appendix E, summarised below.

Summary Table Key:

Major positive impact	ü ü ü
Moderate positive impact	ü ü
Minor positive impact	ü
Negligible/No benefit or impact	o
Minor negative impact	û
Moderate Negative Impact	ûû
Major negative impact	ûûû

Table 5.1 - Summary of Environmental Assessment

	Option N6 – North Online	Option N9 – North Offline	Option O2 – Online Viaduct	Option O3 – Online Tunnel	Option O4 – 'Do Minimum'	Option O7 – Online Avalanche Shelter	Option S4 – South Glen Udalain
Noise and Vibration	O No benefit or impact when compared to baseline	O No benefit or impact when compared to baseline	O No benefit or impact when compared to baseline	O No benefit or impact when compared to baseline	Baseline – Case not assessed, other routes assessed against the scenario.	O No benefit or impact when compared to baseline	O No benefit or impact when compared to baseline
Air Quality	O No benefit or impact when compared to baseline	O No benefit or impact when compared to baseline	O No benefit or impact when compared to baseline	O No benefit or impact when compared to baseline	O No benefit or impact when compared to baseline.	O No benefit or impact when compared to baseline	O No benefit or impact when compared to baseline
Water Quality, Drainage and Flood Defence	O No benefit or impact when compared to baseline	O No benefit or impact when compared to baseline	X Minor negative impact as may be slight change in water quality, geomorphology, hydrology and groundwater movement.	X Minor negative impact as may be slight change in water quality, geomorphology, hydrology and groundwater movement.	O No benefit or impact when compared to baseline	O No benefit or impact when compared to baseline	X X Moderate negative impact as may be moderate change in water quality, geomorphology, hydrology and groundwater movement.
Geology	O No benefit or impact when compared to baseline – utilises existing road, minimising impact to geology and soils.	X Minor negative impact – Road utilises existing road and construction of new stretches of road, which pass through potential peat land areas.	O Negligible impact – utilises existing road, minimising impact to geology and soils but will include construction of a rail viaduct and will require remedial works to be undertaken on unstable rock slope.	X X Moderate negative impact – utilises existing road, although includes construction of a tunnel which will have greater impact on geology. Will require remedial works to be undertaken on unstable rock slope.	✓ Minor positive impact – utilises existing road, which will minimise impact to geology but will require remedial works to be undertaken on unstable rock slopes.	O Negligible impact – utilises existing road, minimising impact to geology and soils but will include construction of an avalanche shelter and will require remedial works to be undertaken on unstable rock slope.	O No benefit or impact when compared to baseline
Biodiversity and Habitats	X X Moderate negative impact due to habitat loss/ fragmentation and disturbance/ mortality of protected species. Degradation of benthic/ intertidal habitats.	X X Moderate negative impact due to habitat loss/ fragmentation and disturbance/ mortality of protected species. Degradation of benthic/ intertidal habitats.	X X Moderate negative impact due to habitat loss/ fragmentation and disturbance/ mortality of protected species. Degradation of benthic/ intertidal habitats.	X X Moderate negative impact due to habitat loss/ fragmentation and disturbance/ mortality of protected species. Degradation of benthic/ intertidal habitats.	X Minor negative impact during road repairs due to localised disturbance.	X Minor negative impact during road repairs due to localised disturbance.	X X Moderate negative impact due to habitat loss/ fragmentation and disturbance/ mortality of protected species. Degradation of benthic/ intertidal habitats.
Landscape	X X X Major negative impact due to introduction of bridge at Strome Narrows	X X X Major negative impact due to introduction of bridge at Strome Narrows	X Minor negative landscape impact	O No Landscape impacts.	O No Landscape impacts.	X X Moderate negative impact due to introduction of new large structure.	X X Moderate negative landscape impact due to introduction of road and traffic into otherwise undeveloped landscape.
Visual Amenity	X X Moderate negative impact due to introduction of bridge at Strome Narrows	X X Moderate negative impact due to introduction of bridge at Strome Narrows	X X Moderate negative visual impact due to widening of the road/ rail corridor and introduction of a new structure along the loch edge.	O No significant visual impacts	O No visual impacts.	X X Moderate negative impact due to introduction of new large structure.	X Minor negative visual impact
Agricultural and Soils	O No benefit or impact when compared to baseline – utilises existing road, minimising impact to geology and soils.	O No benefit or impact when compared to baseline – utilises existing road, minimising impact to geology and soils.	O Negligible impact – utilises existing road, minimising impact to geology and soils but will include construction of a rail viaduct and will require remedial works to be undertaken on unstable rock slope.	X Minor negative impact due to construction on new road through potential peatland.	O No agriculture or soils impact.	O Negligible impact – utilises existing road, minimising impact to geology and soils but will include construction of an avalanche shelter and will require remedial works to be undertaken on unstable rock slope.	X Minor negative impact due to minimal land-take of agricultural/ crofting areas and sizable land-take required within woodland areas.
Cultural Heritage	X Minor negative impact on cultural heritage due to negative impact on the setting of Strome Castle	X Minor negative impact on cultural heritage due to negative impact on the setting of Strome Castle	X Minor negative impact – Possible impact upon loch bed deposits, paleo-environmental remains, lithic scatters.	X Minor negative impact – Possible impacts upon lithic scatters, setting impacts.	O No change to existing baseline	X Minor negative impact – Possible impacts upon lithic scatters, setting impacts.	X Minor negative impact – Possible impacts upon unknown archaeological assets.

6. Traffic and Economic Assessment

6.1 Introduction

A detailed economics assessment was undertaken as part of this appraisal. The STAG Part 2 Appraisal involved a detailed appraisal against three sub-criteria:

- Transport Economic Efficiency (TEE);
- Wider Economic Benefits (WEBs); and
- Economic Activity and Location Impact (EALIs).

This information is presented below.

6.2 Economy

6.2.1 Introduction

The STAG 1 Appraisal recommended that several route options are taken forward to STAG 2. During the STAG 1 Appraisal, sifting of route options was conducted, with the number of route options being reduced to six. The remaining six route options have undergone a more refined economic assessment and this is summarised in this chapter.

For the purpose of the economic assessment it is necessary to define a 'Do-Minimum' scenario. This is the scenario that is most likely to occur without the intervention and which is used to test the sifted options against.

The Do-Minimum scenario is the existing condition of the A890 Stromeferry Bypass, with a diversion route undertaken by vehicles during future road closures due to rock falls. The effect of this is to increase journey times and vehicle operating costs which would be expected to have negative economic impacts compared with the route options.

Recorded rock fall events are detailed in Table 6.1.

Table 6.1 - Rock Fall Events

Closure Events since 1990 due to significant rock face failure on the A890 Stromeferry Bypass

Date of Event	Rock Displacement on Road (tonnes / m^3)	Length of Closure	Comments
March 1990	200t	8 Weeks	Blocked both road and railway
October 2001	500m^3	Not stated	Blocked both road and railway
October 2004	5 m^3	Not stated	
January 2007	20 m^3	Not stated	Road and railway unaffected
May 2007	0.5 – 1.0m^3	Not stated	Affected both road and railway
August 2008	Not stated	Not stated	Required traffic closure
September 2009	Not stated	Not stated	Affected Road
November 2011	Not stated	Not stated	No road closure
December 2011	Not stated	Approximately 4 months	Road closed late December 2011 to late April 2012
December 2012	Not stated	2 days	

The six route options being assessed at are summarised below:

Northern Corridor -

- N6 route Off-line from A890; and
- N9 route Off-line from A890.

On-line Corridor -

- 02 viaduct option;
- 03 tunnel option;
- 07 avalanche shelter option.

Southern Corridor -

- S4 Glen Udalain option.

6.2.2 Traffic Assessment

6.2.2.1 Traffic Surveys

The values for mean traffic flows, vehicle speeds and vehicle composition were derived from a set of traffic surveys undertaken from the 12th to the 18th of March 2013. These consisted of:

- Manual Classified Turning Counts (MCC);
- Automatic Traffic Counts (ATC); and
- Journey Time Surveys (JTS).

Additional data on trip user purpose, trip origins and destinations and trip behaviour following a rock fall event were obtained from:

- Roadside Interview Surveys (RSI)

The RSIs were undertaken over two weekdays on the 27th and 28th August 2013.

6.2.2.2 Mean Vehicle Flows

The ATC data from the March 2013 surveys was used to determine 24 hour and peak hour traffic flows.

Table 6.2 gives the 7-day 24 hour average one-way vehicle traffic flows for two sites, one at Attadale Gardens on the A890 close to the section of road vulnerable to rock fall and the other on the C1096 west of Lochcarron.

Table 6.2 - 7-day Average 24 Hour One-way Vehicle Flows

7-Day Average 24 Hour One-Way Vehicle Traffic Flows, A890 Attadale Gardens & C1096 Lochcarron, March 2013

Year	Direction	A890 Attadale Gardens	C1096 Lochcarron
2013	Eastbound	338	63
	Westbound	357	61
	Two – way	695	124

Note: Friday data was taken as an average of the weekday values as this had not been recorded in the ATC data.

The traffic flows from the survey data gave 7-day average 24 hour 2-way volumes of 695 vehicles at Attadale and 124 vehicles at Lochcarron. These traffic volumes do not present road capacity problems on the A890 in March. However it is noted that Government data sources show traffic volumes on the A890 increase significantly in the peak summer months, reflecting an appreciably higher level of demand for the route at that time of year.

Using ATC 7-day data from the March 2013 surveys, Table 6.3 indicates the AM and PM Peak Hour weekday traffic flows. The AM Peak is an average hourly flow for the peak period 0800hrs – 1000hrs and the PM peak is an average hourly flow for the peak period 16:00hrs – 18:00hrs. This gives a better representation of the flows during the peak period.

Table 6.3 - Average Peak Hour Weekday Traffic Flows

Average Peak Hour Weekday Traffic Flows, A890 Attadale Gardens & C1096 Lochcarron, March 2013

Year	Direction		Attadale Gardens	C1096 Lochcarron
2013	Eastbound	AM	25	4
		PM	34	5
	Westbound	AM	32	4
		PM	36	5

At between 25 and 36 vehicles on the A890 and between 4 and 5 vehicles on the C1096, peak hour traffic flows are easily accommodated within the current road capacity. The surveys indicated that there was no significant daily tidal flow direction and traffic volumes remained fairly consistent throughout the day.

6.2.2.3 Vehicle Composition

The values for vehicle composition have been derived from the actual values reported from the ATC data. Table 6.4 shows this recorded 7-day average vehicle composition.

Table 6.4 - 7-day Average Vehicle Composition

7-DAY AVERAGE VEHICLE COMPOSITION, A890 ATTADALE, AUGUST 2013

Direction	Eastbound	Westbound	Two-way
Cars	79.2%	83.7%	81.5%
LGVs	16.9%	13.8%	15.3%
OGV-1s	1.8%	0.8%	1.3%
OGV-2s	1.8%	1.4%	1.6%
PSVs	0.3%	0.3%	0.3%

Table 6.5 indicates that cars contributed nearly 82% to the overall vehicle mix depending on traffic direction. Cars, which together with light goods vehicles (LGVs) are classified as “lights”, account for nearly 97% of all vehicles on the A890. However, heavy goods vehicles (HGVs) and public service vehicles (PSVs) contributed to less than 4% of the traffic mix on this route.

The percentage of cars recorded by the surveys is comparable to Government values for the equivalent road classification, which the NESA manual defines as 84.1% for a Rural Tourist Route (Table 5/2/7). However, as the surveys were conducted during the non-tourist season, the proportion of cars is likely to increase during summer months. Table 6.5 summarises the vehicle composition between recorded values and NESA values.

Table 6.5 - Comparison of Vehicle Composition

Comparison Of Vehicle Composition On A Rural Tourist Route, Survey Data Verses Nesa Data

Vehicle Type	Survey	NESA
Cars	81.5%	84.1%
LGVs	15.3%	7.6%
OGV-1s	1.3%	4.5%
OGV-2s	1.6%	2.8%
PSVs	0.3%	1.0%

The percentage of LGVs recorded in the surveys is higher than the equivalent Government values, and the percentage of HGVs recorded in the surveys is considerably lower than defined in NESA.

6.2.2.4 Vehicle Speeds

For the STAG 1 Appraisal, there was no reliable data available within the study area for traffic speeds across the local road network. Therefore, for the purposes of the STAG 2 Appraisal, Government values were adopted based on road classification and default link speeds.

Journey time surveys were undertaken in August 2013 to establish actual link speeds on the A890 between the A890 Strathcarron junction at the northern end of the route and the A87/A890 junction at the southern end. The average speed between timing points are shown in Figure 6.1.

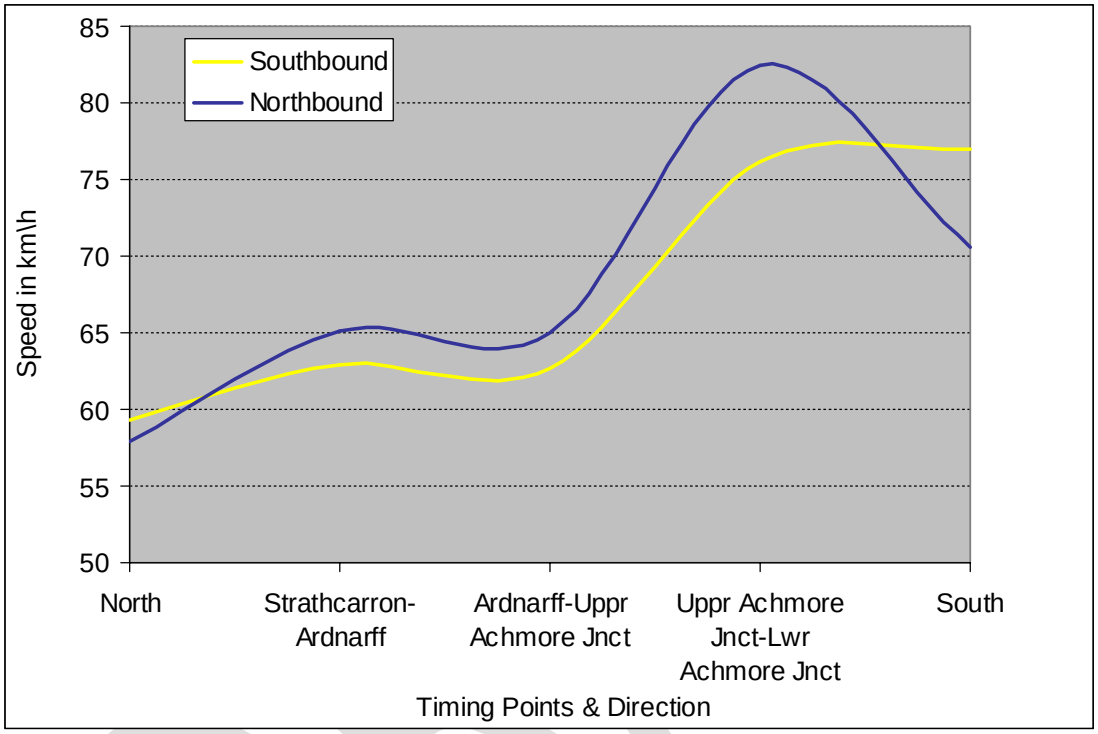

Figure 6.1 - Average Speeds, August 2013

The speeds recorded from the journey time surveys vary according to road quality. In general, recorded journey time speeds are higher than the Government default speeds for the equivalent road classification.

It should be noted that the surveys were undertaken in August when the A890 experiences the greatest demand from peak tourist traffic. Journey speeds would therefore be expected to be higher for other times of the year with reduced traffic volumes on the road.

6.2.2.5 Trip User Purpose

As detailed in the STAG 1 Appraisal, there was no information available to define trip user purpose. This was important with regards to the significant contribution to overall traffic volumes made by tourists, especially in the summer months.

The RSI survey results shown in Figure 6.2 indicated that the percentage of tourist traffic on the A890 was approximately 45% of all traffic. As the survey was undertaken in August, the peak tourist season, this percentage would be expected to reduce at other times of the year.

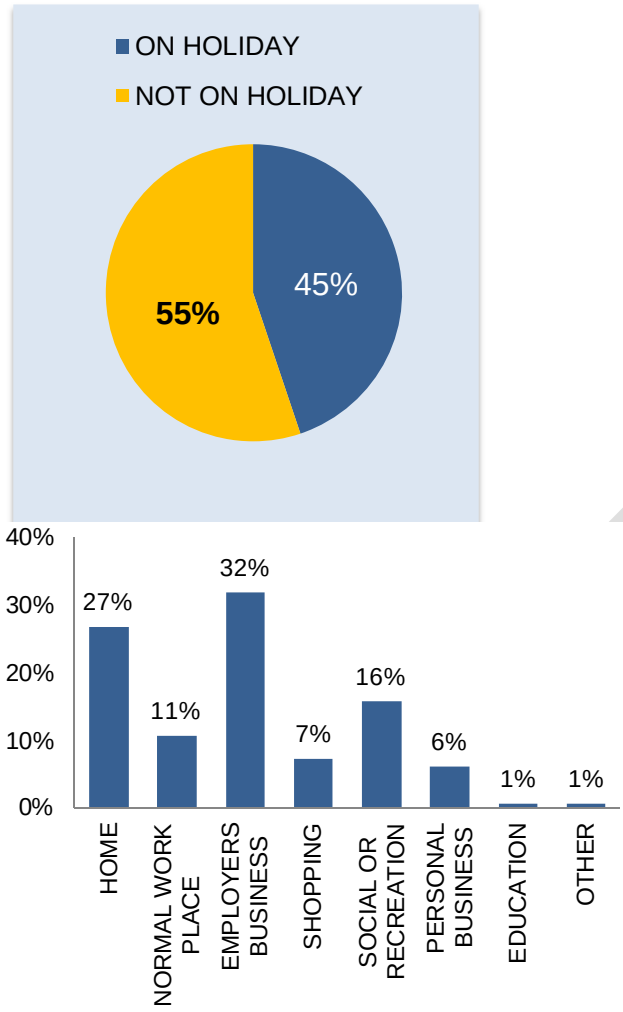

Figure 6.2 - Trip Purpose, Holiday Traffic versus Non-Holiday Traffic and Trip Purpose at Destination for Non-Holiday Traffic, August 2013

Stripping out holiday traffic, the remaining most dominant trip purposes for traffic interviewed on the A890 were:

- Travelling on employers business;
- Travelling home, and
- Social or recreational trips.

6.2.2.6 Origin and Destination Data

There was no information available that indicated trip origin and destination data for the STAG 1 Appraisal. Actual origin and destination data was therefore gathered from the RSI surveys undertaken during the DMRB Stage 2 assessment.

The survey results indicate that a significant proportion of trips have a regional origin defined as the rest of the Scottish Parliamentary Constituency of Skye, Lochaber and Badenoch. The survey results also indicated that a substantial proportion of trips had a local destination defined as a destination on the north or south shore of Loch Carron.

This pattern would be expected where a significant proportion of vehicles were tourists visiting the area as part of a holiday trip chain involving the wider region.

A summary of key findings are:

- 56% of respondents stated they were travelling to local destinations, 41% of which were travelling to destinations on the north shore of Loch Carron and 15% of which were travelling to destinations on the south shore of Loch Carron;
- 52% of respondents surveyed were regional in origin; and
- 24% of respondents were going to either Inverness or Moray.

6.2.2.7 Road Capacity

The vehicle capacity for the A890 was estimated using the DMRB (Volume 15). This sets out highway capacities for various road types, based on numbers of lanes and speed limits.

Road capacity of the A890 Stromeferry Bypass is determined by its width and condition. For part of the route between the Attadale Estate and the Stromeferry junction the route is classified as 4.0 metre width and is in poor condition. It is this section of the road that is most vulnerable to rock fall.

For a Rural Poor 4.0 metre single lane road, road capacity is 140 vehicles per hour per direction. For other sectors of the A890, which comprise a mix of 5.5 metre and 6 metre links, road capacity is 800 to 900 vehicles per hour per direction.

All route options are designed to a 6.0 metre wide carriageway and so would have a road capacity of 900 vehicles per hour per direction.

By comparing the Design Flows with the network capacities on each link, the level of congestion was estimated. This is based on the ratio of flow to capacity (RFC). The RFC is the standard network indicator used to show the level of utilisation of capacity. An RFC of greater than 85% represents conditions of significant congestion, when safety and delay issues can be expected. An RFC of greater than 100% represents complete saturation.

Peak hour flows from Table 6.6 indicates that the RFCs at Attadale are significantly less than 85% for all sections of the route. This suggests that in March, when the surveys were conducted, the 4 metre links on the A890 do not present a vehicle capacity constraint. The same is true of the C1096 west of Lochcarron. None of the new alignment options would be expected to experience capacity problems.

6.2.3 NESA Economic Appraisal

As more information became available during the DMRB Stage 2 assessment, and to meet the requirements for this level of assessment, the economic appraisal was developed and refined using the standard Scottish Government economic modelling software, NESA.

NESA is consistent with STAG and provides an accurate comparison of the performance of the Do-Something options against the Do-Minimum scenario.

Based on the scheme costs defined previously, and the application of the NRTF (1997) central traffic growth projections, the economic appraisal of the Scheme options defined in the NESA model are summarised in Table 6.6.

Table 6.6 - NESA Appraisal Summary

NESA APPRAISAL SUMMARY in £m, 2010 prices

Economic Indicator/ Option	Present Value of Benefits (PVBs)	Present Value of Costs (PVCs)	Net Present Value (NPV)	Benefit to Cost Ratio (BCR)
N6 route On-line	33.92	73.85	-39.93	0.46
N9 route Off-line	34.05	73.62	-39.57	0.46
02 viaduct	1.66	58.21	-56.54	0.03
03 tunnel	1.89	106.33	-104.44	0.02
07 avalanche shelter	1.67	53.66	-51.99	0.03
S4 Glen Udalain	-1.95	50.94	-52.89	-0.04

It should be noted that the economic assessment above is based on the application of default accident rates defined in NESA for the local road types.

The results presented above require adjustment for the particular circumstances of the scheme options which will have an impact on the relevant Do Something option performance. These circumstances are as follows:

- Effects of Diversion;
- Rock fall Journey Response;
- Construction Delays; and
- Remedial Rock Face Maintenance.

6.2.3.1 Effects of Diversion

The primary objective of the proposed improvement was to eliminate the threat from and disruption caused by rock fall events on the A890.

Although relatively rare occurrences, rock falls can result in the closure of the road, and less frequently the railway line, for up to several weeks at a time. Details of the significant rock fall events since March 1990 are shown in Table 6.1 of this report.

Between March 1990 and December 2012, there have been 10 significant rock fall events, of which at least two required road closure for two months or more. Although the lengths of road closures are not stated, inspections required after each of the other events would also require road closure for short periods of time.

There have been road closures for both extended and shorter periods of time. The latter allows opportunities for the authorities to carry out both emergency and planned inspections. For appraisal purposes, as noted in the DMRB Stage 1 report, the combined effect of these has been considered as an annualised closure period of approximately 9 days. This has necessitated the use of a diversion route for the duration of road closure.

In order to accommodate displaced traffic from the A890 Stromeferry Bypass onto the wider road network, there is only one feasible diversion route available. This would involve the use of all or part of the following road sections:

- Between the A890/A896 Strathcarron junction and the A832/A835 junction (53.9 km);
- Between the A832/A835 junction and the A835/A834 junction at Contin (13.6 km);
- Between the A835/A834 junction and the A82/A831 junction at Drumnadrochit (33.2km);
- Between the A82/A831 junction and the A87/A887 junction (44.6 km); and
- Between the A87/A887 junction and the A87/A890 junction near Dornie (49.4 km).

Use of the diversion route identified above would be required, for example, for trips between Kyle of Lochalsh / Skye and Lochcarron and would involve an additional distance of approximately 170 kilometers. However for trips between Plockton, Achmore or Stromeferry and Lochcarron the additional trip distance would be close to 200 kilometers and involve an extra 3 hours travel time.

With prior notice given to motorists of a rock fall event, it would be expected that only a proportion of these motorists planning to use the A890 would continue to complete the planned journey, so incurring the cost of the diversion.

6.2.3.2 Rock Fall Journey Responsiveness

To estimate the proportion of vehicles that would make the journey using the diversion route in the event of a rock fall, the RSIs included the question:

If you had planned to use the A890 and it was closed due to a landslip would you:

1. Take an alternative route;

2. Choose an alternative destination, or
3. Cancel the trip?

The proportion of respondents selecting option 1 to the question above would be needed in order to estimate the percentage of vehicles that would use the diversion route. Drivers who responded that they would either have chosen an alternative destination or would have cancelled the trip altogether would not have used the diversion route.

The results, shown in Table 6.7, indicate that approximately 30% of vehicles would either have chosen an alternative destination or would have cancelled the trip, and so would not have used the diversion route.

Table 6.7 - Rock Fall Responsiveness

ESTIMATED ROCK FALL JOURNEY RESPONSIVENESS

Rock fall journey diversion responsiveness on the A890	Cars and LGVs	33%	Don't make the original trip
	HGVs & PSVs	31%	Don't make the original trip

The corollary of Table 6.7 suggests that approximately 70% of vehicles would undertake the diversion trip. This proportion of vehicles was used in the economic analysis to compare traffic volumes between the Do-Minimum and Do-Something scenarios.

The impact of the diversion on the present value of discounted PVBs for each of the Do Something options is detailed in Table 6.8 with both the scenario of 100% of vehicles undertaking the diversion and the more robust scenario estimate of 70% of vehicles undertaking the diversion.

Table 6.8 - Impact of Diversion

Diversion Impact On Present Value Of Benefits In £M, 2010 Prices

OPTION	**Present Value of Benefits**	
	100% of Vehicles using diversion route	70% of Vehicles using diversion route
N6 route On-line	10.92	7.64
N9 route Off-line	10.92	7.64
02 viaduct	10.92	7.64
03 tunnel	10.92	7.64
07 avalanche shelter	10.92	7.64
S4 Glen Udalain	10.92	7.64

Reducing the number of vehicles undertaking the diversion will reduce the benefits of the scheme options from £10.92m to £7.64m. Fewer vehicles are making the diversion, therefore fewer vehicles are incurring time and vehicle operating cost penalties.

6.2.3.3 Construction Diversion Delays

As detailed in the Engineering Assessment, the On-line options would incur significant delays associated with vehicle diversions during the construction period. Therefore, the DMRB Stage 2 economic appraisal accounts for these construction period diversion delays in more detail.

The duration of road closures and the impact this has on PVBs are shown in Table 6.9. The table indicates the adjustments made to the PVBs resulting from these additional costs. It should be noted that diversion delays during construction represent a cost to users and therefore a reduction in PVBs. This is shown in Table 6.9.

Table 6.9 - Impact of Construction Delays and Diversions

IMPACT OF CONSTRUCTION DELAYS AND DIVERSIONS ON PRESENT VALUE OF BENEFITS IN £M, 2010 PRICES

OPTION	Road Closure	Impact on PVB
N6 route On-line	0 months	0.00
N9 route Off-line	0 months	0.00
02 viaduct	3 months	-2.70
03 tunnel	6 months	-5.40
07 avalanche shelter	15 months	-13.49
S4 Glen Udalain	0 months	0.00

6.2.3.4 Remedial Rock Face Maintenance

There will be significant savings associated with the reduction in on-going rock fall remedial maintenance work with the implementation of the Do-Something options identified above.

However, advice taken from The Highland Council suggests this cost will not be eliminated entirely. There will be a permanent requirement to maintain the rock face for the railway line and for residual users of the existing road. A lower cost saving will reduce the overall benefit associated with rock face remedial maintenance that had been assumed in the DMRB Stage 1 appraisal.

The base cost savings of remedial rock face maintenance associated with the Do-Minimum scenario and the design costs associated with on-going remedial maintenance costs required for each of the Do Something scenarios are shown in Table 6.10.

Table 6.10 - Impact of Remedial Rock Face Maintenance

IMPACT OF REMEDIAL ROCK FACE MAINTENANCE ON PRESENT VALUE OF BENEFITS In £M, 2002 PRICES

OPTION	Base Cost Savings	Design Costs
N6 route On-line	-5.25	1.83
N9 route Off-line	-5.25	1.83
02 viaduct	-5.25	0.75
03 tunnel	-5.25	0.75
05 shared use	-5.25	0.75
07 avalanche shelter	-5.25	0.75
S4 Glen Udalain	-5.25	1.83

6.2.4 NESA Economic Appraisal Adjusted

Based on the scheme costs defined previously, the application of the NRTF (1997) central traffic growth projects and the adjustments noted above, the economic appraisal of the route options defined in the NESA model are summarised in Table 6.11.

Table 6.11 - NESA Appraisal Summary Adjusted

NESA APPRAISAL SUMMARY ADJUSTED in £m, 2010 PRICES

Economic Indicator/ Option	Adjusted PVB	Adjusted PVC	Adjusted NPV	Adjusted BCR
N6 route On-line	41.56	70.43	-28.87	0.59
N9 route Off-line	41.69	70.20	-28.51	0.59
02 viaduct	6.61	53.71	-47.10	0.12

NESA APPRAISAL SUMMARY ADJUSTED in £m, 2010 PRICES

03 tunnel	4.14	101.83	-97.69	0.04
07 avalanche shelter	-4.17	49.16	-53.33	-0.08
S4 Glen Udalain	5.69	47.52	-41.83	0.12

6.2.5 Safety Appraisal

The Safety objective identified within STAG is concerned with reducing the loss of life, injuries and damage to property resulting from transport accidents and crime.

6.2.5.1 Local Accident Data

The Highland Council provided Transport Scotland accident data in the Strathcarron area. No additional information has been made available.

Accidents were classified into one of four categories namely, fatal, serious injury, slight injury or damage only. This is summarised in Table 6.12 for the A890 and for both the A890 and A896 combined. The values and percentages shown in the table indicate accidents by severity for the 5 years, commencing 1st August 2007 to 31st July 2012.

Table 6.12 - Record of Accidents by Severity

Recorded Accidents By Severity, August 2007 To July 2012

Severity	A890	A890 & A896
Fatal	1 (5%)	1 (3%)
Serious injury	1 (5%)	2 (6%)
Slight injury	4 (18%)	7 (22%)
Damage only	16 (73%)	22 (69%)

6.2.5.2 Local Accident Risks

Table 6.13 shows the recorded accident rate in accidents per 100m vehicle-kilometres for the A890 for the 5 years, 1st August 2007 to 31st July 2012.

Table 6.13 - Recorded Accident Rates by Severity

Recorded Accident Rates For The A890 By Severity, August 2007 To July 2012

Severity	A890
Fatal	2.3 accidents per 100m vehicle - kilometres
Serious injury	2.3 accidents per 100m vehicle - kilometres
Slight injury	9.1 accidents per 100m vehicle - kilometres
Personal Injury Accident	13.6 accidents per 100m vehicle - kilometres
Damage only	36.3 accidents per 100m vehicle - kilometres

Table 6.13 shows the average fatal accident rate was 2.3 accidents per 100m vehicle – kilometres for the A890 for the period 2007 to 2012.

In contrast, the latest data available for the Northern Region defined by police force area shows that the average fatal accident rates for local authority A roads fell from 2.4 to 0.7 accidents per 100m vehicle kilometres between the periods 2004 – 2008 and 2008 – 2012 respectively.

Therefore the fatal accident rate on the A890 between 2007 and 2012 is comparable to the 2004 - 2008 5-year value for the Northern Region as a whole, but is considerably higher than the 2008 – 2012 5-year value for this region, although it is acknowledged that this rate is based on 1 fatal accident.

The results for serious injury accident rates for local authority A roads for the years 2008 - 2012 in the Northern Region are 3.4 serious injury accidents per 100 million vehicle kilometres. The equivalent value for the A890 is substantially lower at 2.3 accidents per 100 million vehicle kilometres.

In terms of Personal Injury Accidents (PIA) the rate for the A890 is approximately 13.6 accidents per 100 million vehicle-kilometres. The comparable default accident rates defined in NESA varies from 22.6 for a rural typical single 6.0 metre road to 29.7 for a rural poor single 4.0 metre road. This suggests that local accident rates are substantially lower than national rates.

It is reasonable to assume that upgrading the current alignment or establishing a new alternative road alignment would help reduce the fatal accident rate to a rate closer to the most recent recorded Northern Region average rate and further reduce the number of serious injury accidents on the local road network.

Another key issue is the impact the route options may have on the ability to minimise response times to emergencies and access times to key local and regional facilities such as hospitals and clinics in Dingwall and Inverness.

There is little doubt that all the options under consideration, would, by removing the problem with rock fall, potentially improve both emergency response time and access to key facilities.

6.2.5.3 Removal of Other Accident Risks

In addition to the reduction of the accident rates described above, there are also safety benefits associated with road network improvements. This includes the removal of the threat from falling rock material onto the road and adjacent railway providing a safer transport environment.

There will be a residual threat element of falling rock, but this should be mitigated by continuing remedial maintenance work carried out on vulnerable sections of the rock face.

6.2.6 Public Transport

6.2.6.1 Rail

There is some separation between road and railway, which for minor rock failure provides a measure of safety for the railway. However on at least three occasions over the last twenty two years both the road and railway have been blocked by rock fall in the Attadale – Ardnarff area. It is only because the rail line is further from the rock face than the road that the rail line has been spared more frequent obstruction.

Nevertheless, rail services are subject to a 30mph speed limit to counter the risk of rock fall debris on the track giving time for the train to stop if necessary. Network Rail's policy is to minimise operational risk and manage the residual risk.

The rail line between Inverness and Kyle of Lochalsh is a passenger only line operated by 2 car class 155 trains. It operates Mondays to Saturdays with four services a day in each direction spaced out every two to three hours. Total journey time between Inverness and Kyle of Lochalsh is approximately two and half hours. Table 6.14 shows passenger patronage between Inverness and Kyle of Lochalsh in terms of total station entries and exits. The data was sourced from the Office of Rail Regulator (ORR).

Table 6.14 - Passenger Patronage

PASSENGER PATRONAGE, INVERNESS – KYLE OF LOCHALSH BY STATION, '000

	2006/07	2007/08	2008/09	2009/10	2010/11	2011/12	2012/13
Beauly	35.9	41.9	52.4	51.1	49.9	54.5	55.2
Muir of Ord	32.6	39.2	51.1	57.4	62.4	74.5	74.1
Dingwall	55.0	64.4	72.1	80.3	84.9	101.7	104.7
Garve	9.7	9.8	8.5	6.9	5.8	5.0	5.4
Lochluichart	0.3	0.4	0.2	0.4	0.3	0.4	0.4
Achanalt	0.2	0.2	0.2	0.2	0.2	0.2	0.2
Achnasheen	2.7	3.0	3.2	3.6	3.7	4.0	3.6
Achnashellach	0.5	0.7	0.6	0.8	0.7	1.1	1.1
Strathcarron	7.9	8.6	8.3	8.2	8.1	11.0	9.3
Attadale	0.4	0.5	0.5	0.5	0.5	1.0	0.7
Stromeferry	1.1	1.0	1.0	1.1	1.4	2.2	2.1
Duncraig	0.3	0.5	0.4	0.4	0.6	0.7	0.8
Plockton	8.3	8.6	9.2	10.7	11.2	13.0	12.9
Duirinish	0.8	0.8	0.7	0.6	0.8	0.7	0.8
Kyle of Lochalsh	46.7	48.3	52.7	60.2	60.5	66.3	66.8

The stops within the study area are:

- Strathcarron;
- Attadale; and
- Stromeferry.

For most of the year passenger traffic using the rail service is relatively light. At each end of the day the service is used by commuters to Inverness. However, in the peak summer period rail patronage on this line can become heavy coinciding with the tourist season.

It can be seen from the table that incidents of rock fall would have a serious impact on rail passengers travelling between Kyle of Lochalsh and stations east of Strathcarron, by virtue of the numbers involved. In such an event Scot Rail would put on a substitute bus service, usually between Strathcarron and Kyle of Lochalsh.

The STAG 1 Appraisal outlined in some detail the appraisal of the impacts from rock fall events on the Inverness – Kyle of Lochalsh rail service. However, the measures put in place by Scot Rail noted above and information that has been made available since the submission of that report, would effectively remove these impacts on the service.

6.2.6.2 Bus Services

From October 2012, Lochcarron Garage began operating the 702 bus service between Lochcarron and Inverness twice a week. This is a flexible service calling in and dropping off passengers at their place of residence. DMK Motors also provides a bus service, service 704, which operates a minibus connection between Lochcarron and Strathcarron Station for the early morning Kyle train. However, this service is only provided on request.

Both the council and private operators run daily school bus services which use the A890 route. School bus services are poorly publicised. Many tourists and local residents are not aware that the services are also available for use by the general public. This is always subject to space permitting, but seating is usually available, especially for school bus runs using larger coaches. There is normally also space available when empty school buses return to their point of origin after dropping off children at their schools.

There is an acute concern amongst the local community of the direct danger rock falls present to school bus services and there is also unease over the potential amount of time schoolchildren would have to spend on the bus to and from school in the event of a substantial rock fall and subsequent closure of the A890 Stromeferry Bypass. By eliminating the threat from rock fall and potentially speeding up bus services, these concerns are addressed by all the route options being considered to address the rock fall issue.

6.3 Wider Economic Benefits (WEBs) Appraisal

6.3.1 Introduction

To capture the wider economic benefits (WEBs) that result from investment to improve transport infrastructure, the UK Department for Transport (DfT) published in 2005 a set of WEBs transport impacts covering a range of welfare and Gross Domestic Product (GDP) benefits, a principal measure of national income. These are as follows;

- WB1 Agglomeration economies;
- WB2 Increased competition as a result of better transport;
- WB3 Increased output in imperfectly competitive markets; and
- WB4 Wider benefits arising from improved labour supply.

6.3.2 Agglomeration Economies (WB1)

These are some of the most important of the wider economic benefits resulting from the impact of transport on agglomeration. This describes the productivity benefits that some firms derive from being located close to other firms.

Closer proximity of firms to one another facilitates a greater sharing of knowledge and enables access to more suppliers, larger labour markets, a greater amount of raw materials and an increase in available expertise.

Government guidance points out those more rural areas such as the Lochcarron district would be likely to benefit as much as heavily populated regions with changes in transport costs that improve levels of agglomeration.

The economic benefits from agglomeration can be quantified. Benefits are calculated through the use of a Government spreadsheet model, the Agglomeration Productivity Aggregate Response Calculator (APARC). This software allows the calculation of agglomeration benefits of transport improvements.

User benefit data is used as a proxy for the change in generalised cost. Therefore, only travel time, vehicle operating costs and user charges data are included in the assessment and these are entered in discounted present values.

6.3.3 Increased Competition as a Result of Better Transport (WB2)

The current view of Transport Scotland is that owing to its geography, there may be evidence in certain parts of Scotland for a relationship between transport and competition. However in the absence of further information, the present Transport Scotland position is that WB2 should be treated as neutral. Therefore the WB2 benefits have not been quantified in the appraisal.

6.3.4 Increased Output in Imperfectly Competitive Markets (WB3)

The Government recommends that an appropriate “uprate factor” to business user benefits is applied to reflect the direct cost savings to firms as a result of business time savings and reliability gains from improved transport links.

At present this uplift is 10% in almost all cases, but research by Transport Scotland has indicated that because price cost margins are higher in rural areas, it is reasonable to apply a higher uplift, 20%, in these areas.

As the Lochcarron Civil Parish meets the Scottish Government definition of a very remote rural area in accordance with the Government's 8-fold urban rural classification, an uplift of 20% is applied as recommended by the Government.

6.3.5 Wider Benefits Arising from Improved Labour Supply (WB4)

Government guidance notes three labour market effects which could have consequences for GDP. These include more people choosing to work as a result of commuting time savings, some people choosing to work longer hours because of reduced commuting time and the relocation of jobs to higher productive areas because improved transport links makes the area more attractive to firms and workers.

However, as the data requirements are extensive, Transport Scotland will provide further guidance on the application within Scotland in due course. Therefore, this element has not been quantified in this analysis.

6.3.6 Presentation of the WEBs Results

In line with current Scottish Government advice, the results from the WEBs appraisal are presented as an additional sensitivity to the TEE results for each of the Do-Something options. Only WEB1 and WEB3 are quantifiable and quantified in the results. An opening year of 2019 and a horizon year of 2078 are assumed, giving a 60 year appraisal period. The WEBs benefits are also presented in £million and in 2002 prices.

It should be noted that, in line with current STAG advice, WEBs benefits are not included in the standard calculation of NPV and BCR. Instead a second NPV and BCR, termed NPV web and BCR web respectively present the sum of the standard TEE benefits together with the WEB benefits. These are shown for each Do-Something option in Table 6.15.

Table 6.15 - Estimated Wider Economic Benefits

Estimated Wider Economic Benefits, 60 Year Appraisal, £M In 2010 Prices

	NPV	BCR	Agglomeration Impacts WB1	Imperfect competition impacts WB3	NPV web	BCR web
N6 route On-line	-28.87	0.59	4.42	1.11	-23.34	0.67
N9 route Off-line	-28.51	0.59	4.44	1.11	-22.95	0.67
02 viaduct	-47.10	0.12	0.14	0.05	-46.92	0.13
03 tunnel	-97.69	0.04	0.14	0.06	-97.49	0.04
07 avalanche shelter	-53.33	-0.08	0.14	0.05	-53.15	-0.08
S4 Glen Udalain	-41.83	0.12	-0.45	-0.03	-42.31	0.11

In terms of the WEBs benefits, the Northern Corridor routes, N6 and N9 show WB1 agglomeration benefits of £4.42 million and £4.44 million respectively and WB3 imperfect competition benefits of £1.11 million. This adjusts the NPV to -£23.34 million and -£22.95 million respectively and the BCR to 0.67 for each of these options. However, the WEBs benefits for the other options are negligible.

6.4 Economic Activity and Location Impacts (EALIs) Appraisal

6.4.1 Introduction

The net impact of a transport option on the Scottish Economy is captured by the TEE and WEB analysis. The EALI analysis assesses the distribution of the impacts captured through the TEE and WEB, identifying these impacts on different areas and/or for different groups.

The EALI does not generally identify additional economic impacts that could be added to the TEE or WEB results, but provides an assessment of the impact in terms of changes to employment and/or income (GDP or GVA) in these different areas and/or for different groups.

6.4.2 Local Economic Activity

The Lochcarron – Stromeferry region of Wester Ross is relatively remote and unpopulated. The beauty of the region encourages significant tourist activity to the area and tourism remains an important part of the local economy.

There is significant tourist accommodation between the settlements of Lochcarron, Strathcarron Stromeferry and Plockton, and there are a number of restaurants. The local tourist attractions include, but are not restricted to:

- Attadale Estate and Gardens;
- Balmacara Estate and Lochalsh Woodland Garden;
- Applecross Heritage Centre;
- Kirkton and Woodland Heritage Group;
- Balnacra Arts;
- Carron Craft Shop & Gallery; and
- Lochcarron Weavers.

There are a wide range of tourist activities available in the area. These include walking and mountaineering in the nearby Torridon Mountains, bird-watching, fishing, cycling and deer stalking in the Udalain valley.

Tourism however is only one of a number of important economic sectors in the region. Others include agriculture, forestry, fish farming and transportation. For example, approximately 10,000 tonnes of timber is harvested annually in the area and shipped out of Kishorn to processing plants in Ayrshire and further afield. Kishorn is also the conduit for significant amounts of fish feed, chemicals and an important point of transfer for fish eggs and immature fish to and from local fish farms. A substantial proportion of these are moved by road between the harbour at Kishorn and the local region, which includes the use of the A890.

Green energy is an increasingly important source of income, especially true in terms of local on-shore wind farms that assist in supplementing farming revenues. In addition, there is considerable potential business interest in the development of large scale offshore wind farms located off the west coast of the Scottish mainland. These may in future be served by Kishorn harbour for the transhipment of materials and supplies and might also be served by Broadford airfield for transporting personnel and staff.

6.4.3 Business Surveys

To gather the data required for the EALI a business survey was undertaken in October and November 2013. 257 surveys were distributed by post with 106 usable returns. This sample response, at 41%, is consistent with a high rate of questionnaire return for a survey of this kind.

For the business survey it was possible to identify:

- The potential gainers and losers grouped by sector and by corridor;
- The potential distribution and scale of potential impacts;
- The distribution of potential employment impacts by sector;
- The distribution of potential employment impacts by location; and
- An overview of the scale of local expenditure impacts.

The Business Survey Report submitted to The Highland Council in February 2014 details the results of the business survey and is contained in Appendix I. Details relating to the distribution of business impacts spatially and by group are further described and analysed, both qualitatively and quantitatively, in this report.

6.4.4 Potential Gainers and Losers

Table 6.16 summarises the potential impacts by sector.

The Agriculture, Forestry and Fish-farming sector and the Transport and Manufacturing sector would benefit significantly from the N9 direct route south across the Strome Narrows as this is the quickest route option to supplies and markets in other parts of Scotland, whether transporting produce to the south by road or by ship using Kishorn harbour.

On-line Corridor options should see benefits to tourism businesses and accommodation located on the South Shore, and benefits to the agriculture, forestry and fisheries industries with quicker journey times between Kishorn and routes south out of the region.

However the scale of benefits experienced by the tourism and retail sectors located in and around Lochcarron using the North Shore route options would be reduced with option N6 if this option results in excessive local congestion in Lochcarron especially during the summer months.

Commuters and those accessing services would also benefit from quicker journey times to Lochcarron offered by the North Shore options.

Table 6.16 - Potential Impact by Sector

Potential Impacts by Sector

North Shore Route Options	Major Sector	Gainers	Losers
N6 Online N9 Offline	Tourism	Accommodation and small tourist businesses on North Shore with significantly quicker access	There may be some losers if severe congestion results in Lochcarron especially with the N6 On-line route and some of the accommodation on the south shore may lose customers to competitive accommodation on the north shore
	Retail & Wholesale	Small shops and retail /wholesale businesses on North Shore with significantly quicker access	There may be some losers if severe congestion results in Lochcarron especially with the N6 On-line route, and other competing retail sectors on the south shore
	Agriculture, Forestry & Fish-farming	Timber operators accessing timber stands, fish farms with improved access to markets south of the region	Fish farms and agricultural producers transporting perishable and time-sensitive supplies if congestion is significant in Lochcarron with the N6 On-line route
	Public Sector	Commuters between the Lochcarron area and areas to the south of Loch Carron	None
	Finance & Property Services	Commuters and those accessing services in the Lochcarron area	None

Potential Impacts by Sector

	Transport, Manufacturing & Other	Those using the A890 to transport materials between centres of activity on the North Shore such as at Kishorn Harbour and the region to the south of Loch Carron	None, unless congestion, especially in the summer months becomes a severe problem for the N6 route option
Online Route Options	**Major Sector**	**Gainers**	**Losers**
02 viaduct, 03 tunnel, 07 avalanche shelter	Tourism	Owners of tourist businesses, tourist accommodation and the larger tourist attractions based on the south shore of Loch Carron	None
	Retail & Wholesale	Retail especially in Lochcarron would be likely to benefit from quicker access	The few retail units based in Stromeferry and Achmore may lose out on passing trade
	Agriculture, Forestry & Fish-farming	Timber operators with improved access to timber stands in south of area, faster delivery times of supplies to businesses and produce to market	None
	Public Sector	Commuters with faster journey times	None
	Finance & Property Services	Commuters and those accessing services in the Lochcarron area	None
	Transport, Manufacturing & Other	Those using the A890 to transport materials between centres of activity on the North Shore such as at Kishorn Harbour and the region to the south of Loch Carron	None
South Route Options	**Major Sector**	**Gainers**	**Losers**
	Tourism	Owners of tourist businesses, tourist accommodation and larger tourist attractions, especially in Lochcarron / Strathcarron with quicker access	Competing tourist business owners and accommodation in Achmore and Stromeferry by-passed
	Retail & Wholesale	Shops and other retail units especially in Lochcarron	Retail sector in Stromeferry, losing passing trade
	Agriculture, Forestry & Fish-farming	Timber operators with increased accessibility to forestry stands in	None

		south of area, faster more reliable route for timber extraction for processing, Fish farm operators with an alternative reliable route south to potential markets and sources of supplies	
	Public Sector	Commuters from Kyle of Lochalsh and Skye with faster journey times	None
	Finance & Property Services	Commuters from Kyle of Lochalsh and Skye with faster journey times	None
	Transport, Manufacturing & Other	Those using the A890 to transport materials between centres of activity on the North Shore such as at Kishorn Harbour and the region to the south of Loch Carron	None

The online options would be expected to contribute benefits to businesses in Lochcarron and elsewhere on the North Shore in terms of business access including commuting, but not to the same extent as the North Shore route options. This would be true for most businesses regardless of sector. Shorter journey times and improved accessibility to Lochcarron may disadvantage the small number of retail units in Achmore and Stromeferry.

The S4 Glen Udalain route would be expected to provide some benefits to timber operators with increased accessibility to forestry stands in the south of area and a faster more reliable route for timber extraction for processing. This route also provides fish farm operators with an alternative reliable route south to potential markets and sources of supplies.

However, in terms of the retail and tourism sectors, the southern route option by-passes Achmore and Stromeferry and these sectors would clearly risk missing out on potential passing trade.

6.4.5 Distribution of Employment Impacts by Sector

Businesses were asked if improvements to the A890 road network would encourage them to hire more staff. Table 6.17 shows a summary of the estimated average value reported by businesses, which have been grouped by sector. The table shows first round impacts, those relating to direct employment rather than indirect and induced employment impacts.

Although as many businesses as possible were interviewed, not all businesses in the study area would have received nor responded to questionnaires sent out. Therefore, values in the table are indicative of the additional employment impacts.

Table 6.17 - Average Additional Employment by Sector

SUMMARY OF ADDITIONAL EMPLOYMENT BY SECTOR

Sector	Average Additional Employees	Percentage
Tourism	7.6	18%
Agriculture, Forestry & Fish-farming	3.7	9%

SUMMARY OF ADDITIONAL EMPLOYMENT BY SECTOR		
Retail and Wholesale	4.6	11%
Public Sector	0.4	1%
Finance and Property Services	0.7	2%
Transport, Manufacturing & Other	24.9	59%
Total	41.9	100%

Businesses in the Transport, Manufacturing and Other sector account for the greatest increase in employment, with 25 or 59% of the additional employment reported. This result is likely to have been influenced by the existing forestry and fisheries transport operations at Kishorn harbour, where significant quantities of timber and fish feed are loaded and unloaded, some of which is transported using the A890.

The Public Sector and the Finance and Property Services sector state that they would see the least increase in employment terms. This is unsurprising as the performance of these sectors is probably less sensitive in terms of changes in the cost of accessibility that improvements to the A890 would represent than is the case for the transport, tourism and retail sectors.

6.4.6 Distribution of Employment Impacts by Locality

Table 6.18 summarises the distribution of potential average direct employment impacts noted in the previous section as reported by businesses grouped by locality.

Table 6.18 - Distribution of Employment Impacts by Locality

SUMMARY OF ADDITIONAL EMPLOYMENT BY LOCALITY		
Locality	**Average Additional Employees**	**Percentage**
Shieldaig / Applecross	1.0	2%
Kishorn	9.2	22%
Lochcarron / North Strome / Ardaneaskan	10.1	24%
Attadale / Achintee / Strathcarron	8.0	19%
Achmore / Stromeferry / Plockton	2.8	7%
Other Skye and Wester Ross	10.7	26%
Total	41.9	100%

The table indicates that businesses located in the Lochcarron area and in Kishorn on the North Shore, with 10.1 and 9.2 additional jobs respectively, and those located in other parts of Skye and Wester Ross, with 10.7 additional jobs, report the biggest potential increase in employment. The comparatively large increases in potential employment reported in Lochcarron and surrounding area is likely to be the result of the relatively large concentration of tourist businesses and retail facilities located in Lochcarron and neighbouring area.

Businesses based in Kishorn and in other parts of Skye and Wester Ross use the A890 as a route for the transport of goods and supplies both to local areas and through to other areas nationally. This potential increase in employment related to improvements to the A890 may indicate the degree to which eliminating the necessity of undertaking a costly diversion route on a periodic basis may have on businesses located in these areas.

6.4.7 Potential Employment Gain by Sector

Recognising that the overall increase in direct employment is relatively modest, Table 6.19 shows the proportion of the potential increase in employment by locality and by sector with improvements to the A890 Stromeferry Bypass.

Table 6.19 - Distribution of Additional Employment by Locality and Sector

DISTRIBUTION OF ADDITIONAL EMPLOYMENT BY LOCALITY AND SECTOR

Locality	Tourism	Agriculture forestry & Fish-farming	Retail and Wholesale	Public Sector	Finance & Property Services	Transport Manufacturing & Other	Total by Locality
Shieldaig /Applecross	0.6	0.4	0.0	0.0	0.0	0.0	1.0
Kishorn	0.3	1.2	0.4	0.0	0.1	7.1	9.2
Lochcarron/North Strome/Ardaneaskan	3.6	0.4	2.1	0.1	0.3	3.6	10.1
Attadale/Achintee/ Strathcarron	0.5	0.4	0.0	0.0	0.0	7.1	8.0
Achmore/Stromeferry/ Plockton	1.3	0.8	0.4	0.1	0.3	0.0	2.8
Other Skye and Wester Ross	1.3	0.4	1.7	0.2	0.1	7.1	10.7
Total by Sector	7.6	3.7	4.6	0.4	0.7	24.9	41.9

Regarding the potential increase in employment by locality, the largest increases for Kishorn, Attadale / Achintee / Strathcarron and Other Skye and Wester Ross are in the Transport, Manufacturing and Other sector. This is in contrast to Shieldaig / Applecross and Achmore / Stromeferry / Plockton where no employment increase is expected in this sector in these localities. However, Attadale, Achintee and Strathcarron show no expected increase in Retail / Wholesale, Public Sector no in Finance and Property Services, reflecting the low number of businesses in these sectors.

However, in terms of the potential increase in employment by sector, the information supports the finding that increases in employment in Tourism tends to be concentrated in the Lochcarron area, and increases in potential employment in the Transport, Manufacturing and Other is concentrated in Kishorn, Attadale and other parts of Skye and Wester Ross.

6.4.8 National Impacts

Table 6.20 shows the number of businesses, grouped by sector that indicated their suppliers were primarily based locally, regionally or nationally. In terms of the regional suppliers, these are based in rest of the Highland area, and national suppliers are based in the rest of Scotland or the rest of the UK. The table also shows the businesses reporting suppliers based regionally or nationally as a percentage of the business survey sample.

Table 6.20 - Distribution of Business Suppliers by Sector

DISTRIBUTION OF BUSINESS SUPPLIERS BY SECTOR

Sector	Tourism	Agriculture, Forestry & Fish-farming	Retail & Wholesale	Public Sector	Finance & Property Services	Transport, Manufacturing & Other
Number of Business in Sample	48	9	11	12	8	7
Local Suppliers	21	7	7	2	2	4
Regional Suppliers – Rest of Highland	8	-	1	5	3	0
National Suppliers – Rest of	6	1	2	0	2	0

DISTRIBUTION OF BUSINESS SUPPLIERS BY SECTOR

Scotland & Rest of UK						
Not specified	13	1	1	5	1	3
Percentage Primarily Sourcing from Regional Suppliers	17%	0%	9%	42%	38%	0%
Percentage Primarily Sourcing from National Suppliers	13%	11%	18%	0%	25%	0%

The Table indicates that the overall numbers of businesses reporting that their suppliers were principally regionally or nationally based was comparatively small at 28 compared to the business sample of 95. The results of the survey suggest that most businesses obtained their supplies from local suppliers or did specify the location of their suppliers.

The largest overall numbers of businesses that source supplies regionally and nationally are in the Tourism sector. However, this is unsurprising as the largest proportion of the sample was made up of tourism businesses. On a relative basis, regional suppliers are most important for the Public Sector and for the Finance and Property Services sector, and national suppliers are most important for the Finance and Property sector and the Retail and Wholesale sector.

Examining the number, size and expected increase in turnover resulting from improvements to the A890, and comparing this information with those businesses whose suppliers are based outside the local area, this would give a high level qualitative assessment of the importance of road improvements to supplier linkages.

Table 6.20 identifies Tourism as the sector that has the greatest number of businesses that source their supplies nationally and regionally. However, Table 6.21 shows that the size of businesses in this sector is small in terms of turnover, with 11 of them having an annual turnover of £50k or less. Only just over half of these businesses predict that their turnover will increase by 5% or more as a result of improvements to the A890. It is unlikely therefore that regional or national employment and income impacts from these improvements would be significant based on existing supplier linkages.

Table 6.21 - Distribution of Businesses by Size and Predicted Increase in Turnover

DISTRIBUTON OF RESPONSES BY BUSINESSES BY SIZE AND LEVEL OF PREDICTED TURNOVER WHO PRIMARILY OBTAIN SUPPLIES NATIONALLY OR REGIONALLY

Number of Businesses		Tourism	Agriculture Forestry & Fish-farming	Retail and Wholesale	Public Sector	Finance & Property Services	Transport, Manufacturing & Other
Size of Business	£250k – £500k	1	-	-	1	-	-
	£50k – £250k	2	1	1	-	2	-
	Less than £50k	11	-	1	3	3	-
	Not Specified	-	-	1	1	-	-
Predicted Change in Turnover	Up 40%-60%	-	-	1	1	-	-
	Up 20%-40%	1	-	-	-	-	-
	Up 5%-20%	7	-	-	-	1	-
	Up 0%-5%	1	-	1	2	-	-
	Not Specified	5	1	1	2	4	-

Although 5 organisations in the Public Sector source supplies regionally and nationally, only a single organisation in this sector has a reported annual turnover of greater than £250k. Therefore

employment and income impacts on a regional and national basis resulting from supplier linkages with this sector are also likely to be negligible.

6.4.9 Distribution of Local Expenditure Impacts by Size of Business

Businesses were asked the extent to which improvements to the A890 or its replacement by an equivalent route would have in terms of total increase in their turnover. Table 6.22 shows the number and percentage of businesses in the sample grouped by size based on turnover.

The table also shows the estimated average increase in turnover of businesses resulting from improvements to the A890 and the proportion of suppliers and materials source locally. This indicates the potential scale of expenditure that would be spent by businesses locally.

Table 6.22 - Increase in Business Turnover and Potential Local Expenditure Impacts

SUMMARY OF BUSINESSES SOURCING OF LOCAL SUPPLIES AND MATERIALS AND THOSE REPORTING AN INCREASE IN TURNOVER, BY SIZE OF BUSINESS

Size of business	Number of Businesses	Percentage of survey sample	Average increase in turnover	% Local source of supplies & materials
>£3m	1	1%	n/a	n/a
£1m – £3m	5	5%	£320k	65%
£500k – £1m	5	5%	£113k	23%
£250k – £500k	8	8%	£117k	33%
£50k – £250k	23	24%	£35k	31%
Less than £50k	44	46%	£4k	11%
Not available	9	9%	-	-

Amongst the largest businesses, those with a turnover of between £1 million and £3 million in aggregate reported the largest total impacts on turnover of approximately £320k. This is a relatively large impact, in spite of the fact that these businesses represented less than only 5% of the sample. Moreover, these businesses state that they source 65% of their supplies and materials locally, suggesting that the impact on local supply linkages is relatively large.

However, small businesses, those with a turnover of less than £50k, represent nearly half of the business survey sample but reported an aggregate increase of only £4k in turnover as a result of improvements to the A890. The proportion of supplies and materials locally sourced is relatively modest at only 11%.

These results imply that improvements to the A890 road network would have a relatively larger impact on the biggest businesses in the area in terms of turnover, and it is these businesses which source the majority of their supplies and materials locally. Therefore, this indicates that there may be a relatively significant increase in local expenditure, and through local multiplier effects, on local income from these improvements.

7. STAG Part 2 Appraisal

7.1 Introduction

This appraisal of route options developed in connection with the Stromeferry Bypass has been carried out using mainly qualitative descriptions supplemented and supported with quantitative data where available.

Appraisal Summary Tables (ASTs), outlining the findings of this, assessment, are included within Appendix J, and a summary of the appraisal is outlined within this Chapter of the report.

It should be noted that the approach of undertaking the DMRB assessment and STAG appraisal in parallel results in areas of overlap, and, as such, this Chapter seeks to provide a summary of the option appraisal whilst avoiding duplication of reporting from earlier Chapters of this report.

7.2 Summary of Appraisal Criteria

The options have been appraised in accordance with STAG, against the following criteria:

- Transport Planning Objectives:
- STAG Appraisal Criteria:
- Cost to Government:
- Risk and Uncertainty

7.2.1 Transport Planning Objectives (TPOs)

As noted in section 2.2 above the TPOs developed for Stromeferry Options Appraisal are as follows:

- TPO 1 - Reduce impact on journey times and journey time reliability by reducing the frequency and duration of road and rail closures caused by rock fall events.
- TPO 2 - Reduce the negative economic impact to the A890 study area by reducing the frequency and duration of road and rail closures caused by rock fall events.
- TPO 3 - Solution reduces, or does not increase, the risk to, and liability of, the railway and maintains suitable access over the life of the scheme.

7.2.2 STAG Appraisal Criteria

- Environment – maximising the quality of the built and natural environment for enjoyment by all.
- Safety – reducing the risk and incidence of accidents and improving the security of all transport users.
- Economy – saving people's and business's time and money and facilitating desired economic development
- Integration – fitting the transport network together and ensuring a rational relationship between transport and land-use and wider policy
- Accessibility and Social Inclusion – providing everyone, not just users, but also non-users the means to travel to opportunities of all kinds.

7.2.3 Cost to Government

A detailed analysis of the total public sector cost of options, including investment costs, operating and maintenance costs and grant/subsidy payments.

7.2.4 Risk and Uncertainty

A detailed analysis of the risk and uncertainty associated with each option.

7.2.5 'Implementability' Appraisal

In addition to the five main Government objectives, STAG also recommends that the capability of delivering an option should be considered. This can highlight any potential "implementabilty" problems with any proposal. Implementability criteria include Technical, Operational, Public (Public Acceptability), and also Financial.

7.3 Summary of Appraisal Methodology

Options were appraised against the TPOs and STAG criteria using the standard seven point scale as shown below:

Major benefit	ü ü ü
Moderate benefit	ü ü
Minor benefit	ü
No benefit or impact	o
Minor negative impact	û
Moderate negative Impact	û û
Major negative impact	û û û

Engineering, environmental, and traffic and economic assessments have informed the appraisals.

The engineering assessment, including option cost estimates, is detailed in Chapter Four. Findings have informed appraisal of the TPOs, STAG Criteria, and the 'implementability' assessments.

The environmental appraisal was undertaken in accordance with the requirements of the DMRB Chapter 11, which sets out the various subject disciplines to be considered and assessed. Further details are contained within Chapter Five. Findings have informed appraisal of the TPOs and the STAG criteria.

The traffic and economic appraisal undertaken was done using standard economic welfare techniques consistent with STAG. Further details are contained within Chapter Six. Findings have informed appraisal of the STAG criteria, 'implementability' assessments and also the 'Cost to Government' criteria.

The output from the assessment, is summarised within table 7.1. Associated ASTs have been developed for each option, and are included within Appendix J.

Table 7.1 provides an overall summary of the performance of options following the DMRB Stage 2 / STAG Part 2 appraisal, and summarises the rationale for selecting or setting aside each option at this stage.

Table 7.1 - Assessment Summary Tables

Assessed Options	Objectives			Government Criteria					Summary
	TPO1	TPO2	TPO3	Environment	Safety	Economy	Integration	Accessibility Accessibility & Social Inclusion	
North Shore 6 (Including Bridge Crossing)	ü ü	ü ü	ü ü	ûûû	ü ü	ü ü	ü	ü ü ü	**General:** Route option provides good north-south linkage. Includes bridge crossing of Strome Narrows. All northern routes bypass the rock fall area, steep gradients at Maman Hill and railway interface issues. Some difficult route development due to existing frontage activity. **Environment:** Route utilises the existing road minimising impacts on the environment. Moderate negative impact on Loch Carron Marine Protection Area. Major negative impact on landscape due to bridge crossing of Narrows. Moderate impact on setting of Strome Castle. Minor negative impact on landscape character. Minor negative visual impact on receptors. **Safety:** Route alignment would reduce the likelihood of rock fall debris reaching the carriageway and causing vehicle accidents, however this may be negated to some degree due to the increase in length of route and potential impact of increased vehicle kilometres on accident rates. There may be indirect safety issues associated with increased traffic through Lochcarron. **Economy:** This option would reduce the frequency and duration of road closures caused by rock fall events. Compared to the Do Minimum situation, the variability in journey time due to rock fall events would be reduced. This would reduce the potential loss of, and unreliable, revenue streams, with positive impact on business development and investment. However, the route proposal may indirectly increase traffic through Lochcarron and impact on several community assets, and shorter journey times and improved accessibility to Lochcarron may disadvantage the small number of retail units in Achmore and Stromeferry. **Integration:** Limited impact on transport integration. Improving journey times and journey time reliability is in accordance with local and national policies. Compatible with land-use developments, and general policies concerning transport and land use. Aligns with Government policies beyond transport, particularly those relating to rural affairs. **Accessibility & Social Inclusion:** Bypassing of the rock fall area would improve accessibility for the study area and option provides good south-north linkage. **Deliverability:** Construction of new road alignment, with a section of 10% gradient at Stromeferry. Involves major bridge crossing of the Narrows. Corridor availability on northern shore to be investigated due to existing dwellings on roadside at Stomemore. In terms of costs, it is comparable to the cheapest northern option N9. **Overall Assessment:** As a northern route option, provides good north linkage. However, compared to N9, has potential impact on properties at Stromemore. **Therefore, this option will be set aside from further consideration.**

Assessed Options	Objectives			Government Criteria					Summary
	TPO1	TPO2	TPO3	Environment	Safety	Economy	Integration	Accessibility Accessibility & Social Inclusion	
North Shore 9 (Including bridge crossing)	ü ü	ü ü	ü ü	û û û	ü ü	ü ü	ü	ü ü ü	**General**: Route option provides good linkage. Includes bridge crossing of Strome Narrows. All northern routes bypass the rock fall area, steep gradients at Maman Hill and railway interface issues. Offline at Stromemore, therefore has reduced frontage activity compared to other north corridor route. Cheapest northern options. **Environment:** Moderate negative impact on Loch Carron Marine Protection Area. Major negative impact on landscape due to bridge crossing of Narrows. Moderate impact on setting of Strome Castle. Minor negative impact on potential peat lands due to construction of new stretches of road. Minor negative impact on landscape character. Minor negative visual impact on receptors. **Safety:** Route alignment would reduce the likelihood of rock fall debris reaching the carriageway and causing vehicle accidents, however this may be negated to some degree due to the increase in length of route and potential impact of increased vehicle kilometres on accident rates. There may be indirect issues associated with increased traffic through Lochcarron. **Economy:** This option would reduce the frequency and duration of road closures caused by rock fall events. Compared to the Do Minimum situation, the variability in journey time due to rock fall events would be reduced. This would reduce the potential loss of, and unreliable, revenue streams, with positive impact on business development and investment. However, the route proposal may indirectly increase traffic through Lochcarron and impact on several community assets, and shorter journey times and improved accessibility to Lochcarron may disadvantage the small number of retail units in Achmore and Stromeferry. **Integration:** Limited impact on transport integration. Improving journey times and journey time reliability is in accordance with local and national policies. Compatible with land-use developments, and general policies concerning transport and land use. Aligns with Government policies beyond transport, particularly those relating to rural affairs. **Accessibility and Social Inclusion:** Bypassing of the rock fall area would improve accessibility for the study area and option provides good south-north linkage. **Deliverability:** Green field construction of new road alignment. Involves major bridge crossing of the Narrows. In terms of cost, it is the cheapest northern option. **Overall Assessment:** Route option performs well against objectives and reasonably well against appraisal criteria, including deliverability. Option N9 is the most affordable and least intrusive northern option, having reduced frontage activity compared to N6. **Therefore, this option will be taken forward for further appraisal.**

Assessed Options	Objectives			Government Criteria					Summary
	TPO1	TPO2	TPO3	Environment	Safety	Economy	Integration	Accessibility Accessibility & Social Inclusion	
Online 2 (Viaduct)	ü ü ü	ü ü ü	ü ü	ûû	ü ü ü	ü ü	ü	ü ü	**General:** This route option bypasses the rock fall area by means of a build-out viaduct, but there are potential railway interface and buildability issues. Limited road closures during construction will be required. **Environment:** Route utilises the existing road minimising impacts on the environment. Moderate negative impact on Loch Carron Marine Protection Area. Minor negative impact on landscape and moderate visual impact due to introduction of new structure. Moderate negative impacts on biodiversity and habitats. Minor negative impact on water environment due to viaduct. **Safety:** Route alignment would reduce the likelihood of rock fall debris reaching the carriageway and railway and causing accidents. Option impacts on few residential, community and development areas. **Economy:** This option would reduce the frequency and duration of closures caused by rock fall events. It would enable vehicles to continue on the A890 without making any changes to their journey. Compared to the Do Minimum situation, the variability in journey time due to rock fall events would be reduced. This would reduce the potential loss of, and unreliable, revenue streams, with positive impact on business development and investment. Disruption to road and rail should be limited as construction is offline and from barges on Loch. **Integration:** Limited impact on transport integration. Improving journey times and journey time reliability is in accordance with local and national policies. Compatible with land-use developments, and general policies concerning transport and land use. Aligns with Government policies beyond transport, particularly those relating to rural affairs. **Accessibility and Social Inclusion:** Bypassing of the rock fall area would reduce the frequency of occurrence of debris reaching the A890 causing a full road closure. This would improve accessibility for the study area. **Deliverability:** 1.6km viaduct founded in potentially deep water, resulting in difficult construction and access and buildability issues. Alignment follows existing road and therefore incorporates substandard geometry. Road closures during construction will be required, but solution does offer some offline working from barges. It is comparable to the cheapest online option O7. **Overall Assessment:** Due to some offline construction this option provides least disruption during construction. The main disadvantages are associated with constructing sub-structure within the shores of Loch Carron where deep water is expected and ground conditions are unknown. Further assessment to better assess these issues is required, and so **this option will be taken forward for further appraisal.**

Assessed Options	Objectives			Government Criteria					Summary
	TPO1	TPO2	TPO3	Environment	Safety	Economy	Integration	Accessibility Accessibility & Social Inclusion	
Online 3 (Tunnel)	ü ü ü	ü ü ü	ü ü	û û	ü ü ü	ü ü	ü	ü ü	**General:** Route option incorporates tunnel section to bypass the rock fall area. Challenging construction method, but offline tunnel route offers distinct advantages. Most expensive online option. **Environment:** Moderate negative impacts on Loch Carron Marine Protection Area. Moderate negative impact on biodiversity and habitats. Potential minor negative impact on groundwater. **Safety:** Route alignment would reduce the likelihood of rock fall debris reaching the carriageway and railway and causing accidents. Option impacts on few residential, community and development areas. Adequate working space will have to be generated during construction. **Economy:** This option would reduce the frequency and duration of road closures caused by rock fall events. It would enable vehicles to continue on the A890 without making any changes to their journey. Compared to the Do Minimum situation, the variability in journey time due to rock fall events would be reduced for road and rail users. This would reduce the potential loss of, and unreliable, revenue streams, with positive impact on business development and investment. Closures of existing road and railway during construction would be required, though temporary measures may be possible. **Integration:** Limited impact on transport integration. Improving journey times and journey time reliability is in accordance with local and national policies. Compatible with land-use developments, and general policies concerning transport and land use. Aligns with Government policies beyond transport, particularly those relating to rural affairs. **Accessibility and Social Inclusion:** Bypassing of the rock fall area would reduce the frequency of occurrence of debris reaching the A890 causing a full road closure. This would improve accessibility for the study area. **Deliverability:** Includes 1.6km long two-lane tunnel section and associated portal structures, all with inherent engineering and construction difficulty and associated risks. Adequate working space will have to be generated. Delays to road and railway traffic during the construction period are to be expected. 1.0km long rock trap measures to be constructed along existing /abandoned road corridor. Most expensive option overall. It is the most expensive option overall. **Overall Assessment:** The tunnel offers benefits with regard to buildability/rail interface issues and the environment and possibly least disruption to the existing road during construction. However, O3 is the most expensive option, almost double the cost of other online options, and it performs poorly due to high scheme costs. **Therefore, this option will be set aside from further consideration.**

Assessed Options	Objectives			Government Criteria					Summary
	TPO1	TPO2	TPO3	Environment	Safety	Economy	Integration	Accessibility Accessibility & Social Inclusion	
Online 4 (Do Minimum)	o	o	o	o	o	o	o	o	**General:** Do Minimum low cost option, no improvements to carriageway or alignments. Ongoing rock slope maintenance to existing programme and reactive measures, as and when required. Option retains status quo and does not satisfy local requirements. **Environment:** Neutral impact on environment due to continuation of status quo. **Safety:** Does not reduce the likelihood of rock fall debris reaching the carriageway / railway and causing accidents. **Economy:** Does not reduce the frequency and duration of road closures caused by rock fall events. Does not enable vehicles to continue on the A890 without making any changes to their journey when rock fall events occur. Lengthy detours (and other mitigation measures) required during rock fall events. **Integration:** Neutral impact on transport integration and policy integration through continuation of status quo. **Accessibility and Social Inclusion:** Option does not seek to reduce the frequency of occurrence of debris reaching the A890 causing a full road / rail closure. There would be no impact on accessibility for the study area. **Deliverability:** Least expensive, base-line option. Would not be publically acceptable. **Overall Assessment:** Does not satisfy TPOs or STAG criteria, and results in an overall neutral score, but required as the base-line case for comparison. **This option will be taken forward for further appraisal.**

Assessed Options	Objectives			Government Criteria					Summary
	TPO1	TPO2	TPO3	Environment	Safety	Economy	Integration	Accessibility Accessibility & Social Inclusion	
Online 7 (Extension to Avalanche Shelter)	ü ü ü	ü ü ü	ü ü ü	û û	ü ü ü	ü ü ü	ü	ü ü ü	**General:** Extended avalanche shelter provides protection to road and rail long term and delivers a safe and reliable route, but significant disruption during construction with railway interface issues. Cheapest online option. **Environment:** Route utilises the existing road minimising impacts on the environment. Moderate negative impact on Loch Carron Marine Protection Area. Moderate negative impact of landscape and visual amenity due to the introduction of a new large avalanche shelter structure. **Safety:** This option would reduce the likelihood of rock fall debris reaching both the carriageway / railway and causing accidents. Option impacts on few residential, community and development areas. Adequate working space will have to be generated during construction. **Economy:** This option would reduce the frequency and duration of road and rail closures caused by rock fall events. It would enable vehicles to continue on the A890 without making any changes to their journey. Compared to the Do Minimum situation, the variability in journey time due to rock fall events would be reduced, for both road and rail users. This would reduce the potential loss of, and unreliable, revenue streams, with positive impact on business development and investment. However, construction would require single lane traffic management and full closures of road and rail would be necessary. **Integration:** Limited impact on transport integration. Improving journey times and journey time reliability is in accordance with local and national policies. Compatible with land-use developments, and general policies concerning transport and land use. Aligns with Government policies beyond transport, particularly those relating to rural affairs. **Accessibility and Social Inclusion:** Harnessing of the rock fall area would significantly reduce the frequency of occurrence of debris reaching the A890 causing a full road / rail closure. This would improve accessibility for the study area. **Deliverability:** Includes 1.7km extended shelter, complex engineering structures and rock treatment will require closures of road and railway during construction. Does offer some element of offline working. Adopts existing road alignment with inherent sub-standard sections. Cheapest online option. **Overall Assessment:** This appears to be a cost effective online option, with potential to provide long-term protection to the most difficult rock fall area. However, it has engineering difficulties with regards to excavation in rock, maintaining stability of the railway and maintaining traffic on road and railway to acceptable levels during construction. **Therefore, this option will be set aside from further consideration.**

Assessed Options	Objectives			Government Criteria					Summary
	TPO1	TPO2	TPO3	Environment	Safety	Economy	Integration	Accessibility Accessibility & Social Inclusion	
South 4	ü ü	ü ü	ü ü	û û	ü ü	ü ü	ü	ü ü	**General:** South Offline route option to consider long-term liability regarding existing route. Potential environmental impacts from new green field route and extended journey time due to longer route alignment. Promotes remote route alignment, with no direct link to communities. Cheapest option overall. **Environment:** Negative impacts due to offline nature of route – loss of ancient woodland and montane habitat and impacts likely to protected species. Minor negative impact on landscape due to visibility from properties in Attadale and local influence on rocky moorland. Moderate negative impact on drainage and water environment due to high numbers of new watercourse crossings required. **Safety:** Route alignment would reduce the likelihood of rock fall debris reaching the carriageway and causing vehicle accidents, however this may be negated to some degree due to the increase in length of route and potential impact of increased vehicle kilometres on accident rates. **Economy:** This option would reduce the frequency and duration of road closures caused by rock fall events. Compared to the Do Minimum situation, the variability in journey time due to rock fall events would be reduced. This would reduce the potential loss of, and unreliable, revenue streams, with positive impact on business development and investment. However, would bypass communities of Stromeferry and Achmore. **Integration:** Limited impact on transport integration. Improving journey time reliability is in accordance with local and national policies. Compatible with land-use developments, and general policies concerning transport and land use, albeit route is remote. Aligns with Government policies beyond transport, particularly those relating to rural affairs. **Accessibility and Social Inclusion:** Bypassing of the rock fall area would significantly reduce the frequency of occurrence of debris reaching the A890 causing a full road closure. This would improve accessibility for the study area. However, the impact is negated to some degree as the proposed route is remote from existing communities, with no direct linkage. **Deliverability:** Green field construction of new road alignment, including sections of 10% gradient through Glen Udalain and towards Attadale valley. Small to medium structures crossing water courses. Cheapest option overall. **Overall Assessment:** The assessment indicates that S4 is the most advantageous route, and performs well in relation to risk, deliverability and safety. **This option will then be taken forward for further appraisal.**

7.4 Risk and Uncertainty

Following the appraisal process detailed above, an initial high level review of potential project delivery risks has been considered with regards to significant technical, economic, environmental or statutory risks. Funding issues are not considered at this stage. Table 7.2, below, summarises the initial risk review findings. This list is not exhaustive and will be reviewed as the preferred option(s) are further developed.

Table 7.2 - Risks and Uncertainty

Options	Risks & Uncertainty
All Options	Engineering assessment. Ground Investigations, topographical, bathymetrical and traffic surveys have not been fully carried out. The results of these may affect the cost, ranking and construction periods. As all of the options other than the south option involve significant structures, current outcomes may be affected by the results of these investigations and surveys.
All Options	Environmental assessment. Work detailed in this report has been desk-based, limited survey information is available. Impacts on international & national designations, scheduled monuments and listed buildings may be more severe than anticipated. The results of these may affect ranking and cost. As all of the options other than the online options involve construction through 'green field' areas impacts on protected species, birds and woodlands may be more significant than anticipated.
All Options (apart from Do Minimum)	An assumption has been made that simple drainage outfalls will suffice. Problems may be encountered with SEPA over discharge requirements and obtaining CAR licences. This may affect programme particularly construction start dates.
All Options	The frequency of future rock falls along the existing road is uncertain. A closure period of nine days per annum has been assumed. This is not a prediction of future events, these may cause more or less disruption than this.
All Options	Key Stakeholders and Landowners may contest outcomes. Statutory processes will be required as all of the options involve work outside the existing highway boundary and will require land acquisition or land owner agreements and this could result in the need for a Public Local Inquiry and project delays. Objections are expected from Statutory and Non-Statutory objectors.
All Options	Appropriate standards have resulted in relaxations and departures from standard. If these are not granted costs, land take and environmental impacts will increase.
All Options	An initial assessment of PU apparatus has been undertaken and the information provided is limited. Services may impact on the works and dealing with PUs could be problematic and time consuming.
All Options	Traffic and economic modelling is based on limited information and assumptions have been made that may downgrade BCR. Sensitivity testing should be carried out on preferred option(s).
All Options	Traffic Management and Network Rail supervision costs have been recognised. These costs could be very significant particularly in summer months.
Online Options	Rock slope stability has not been fully assessed at this stage
Online Options	Discussions with Network Rail are at an early stage, outcomes could affect costs and route selection particularly maintenance liability if online route selected.
Online Options	All online solutions require co-operation with Network Rail. Discussions

Options	Risks & Uncertainty
	are at an early stage. The demands placed by them to create a 'fail safe' operation during construction may make online solutions unviable.
Online Options	Limited road corridor to allow safe working areas, compounds, lay-down, storage during construction.
Online Options	Options require mitigation measures during construction to maintain free-flow traffic. Acceptable negotiated measures are likely to affect construction programme, cost and possibly route selection.
Online Options	An economic design requires cut-fill balance: disposal of surplus material from O3 likely to be a problem.
Offline Options	A cost premium is required for offline options to compensate for ongoing maintenance liability for existing road and railway. This may not be sufficient.
South Option	Likely to be strong landowner objections leading to lengthy statutory processes and delays, mitigation costs to ensure road/railway remain operational will increase.
South Option	Mainly 'greenfield' solutions with unknown ground conditions and environmental sensitivities.
North Options	Mainly 'greenfield' solution with unknown ground conditions and environmental sensitivities.
North Options	Significant bridge crossing across Narrows. Construction and cost uncertainty, strong tidal flow and requirement for marine works.
Online 2	The build out of a viaduct (or causeway) requires foundation bearing at a reasonable level. This has not been confirmed. Buildability issues require to be explored further.
Online 2	Option requires expensive marine works and unknown down-time.
Online 3	Construction of tunnels has inherent and unknown risk due to unforeseen ground conditions that are likely to affect programme and or cost. Material disposal problem to create cut/fill balance.
Online 4 Do Minimum	Allowances included for further rock falls and associated mitigation may be insufficient.
Online 7	Solution requires rock excavation and disposal, disruption to road and railway. Assumptions made for closures and mitigation strategy (ferry) may not be sufficient.

7.5 Monitoring and Evaluation

As has been noted, annual slope monitoring is undertaken by The Highland Council, to assess the condition of this hillside and note changes from the previous year.

The record of road closures on the A890 Stromeferry Bypass due to rock fall events should be maintained by The Highland Council in order to monitor the annual duration of road closures due to rock fall events.

The Do Minimum scenario includes use of a diversion route, as detailed earlier within this report. The following should be monitored to facilitate evaluation of the operation of the diversion route:

- Traffic flows during use of the diversion route to assess the distribution of traffic during future road closures due to rock fall events, to consider the following sections of the road network:
  - A890 eastbound via the Achnasheen roundabout;
  - A832 to the A835 junction;
  - A835 to the A832 junction;

- A832 junction at the Muir of Ord;
- A662 from the Muir of Ord to the junction with the A833;
- A833 to the junction with the A831;
- A831 to the junction with the A82 at Drumnadrochit;
- A82 to the junction with the A887 at Invermoriston;
- A887 to the junction with the A87; and
- A87 to the junction with the A890.

· Detailed journey time records during convoy operation on the diversion route to assess the average journey time delay experienced by road users.

· Data on rail restrictions to assess the impact experienced by rail passengers.

The Do Minimum also includes dual running of road and rail and a ferry service from South to North Strome: measures which were put in place by The Highland Council to alleviate some of the traffic problems through periods of road closures following more recent rock fall events. The following should be monitored to facilitate evaluation of the operation of these contingency measures:

· Detailed journey time records during operation of the dual running road and rail scenario to assess the average journey time delay experienced by road and rail users.

· Traffic flows and rail patronage numbers during operation of the dual road and rail scenario to assess the distribution of traffic and rail passenger numbers during future road / rail closures due to rock fall events.

· Passenger numbers on the South to North Strome ferry service to assess the distribution of traffic during future road / rail closures due to rock fall events.

8. Conclusions

8.1 Summary

The approximately 4.5km long section of mainly single track road on the A890 from Ardnarff to Cuddies Point, which is located just west of Attadale, has a history of landslides and rock fall events. Between March 1990 and December 2012, there have been ten significant rock fall events, including two closures of the A890 that lasted for extended periods. The March 1990 event lasted eight weeks or approximately 60 days, and affected both the A890 and the adjacent railway line. The rock fall in December 2011 lasted four months or approximately 120 days and affected the A890. Over a period of 21 years and nine months, the A890 has been closed for circa 182 days due to a major rock fall event, and the adjacent railway line for approximately 60 of these days.

There have been rock fall events where the length of closure has not been stated and where there have been a number of planned closures and emergency inspections, notably for the years 2008 and 2009. In terms of the latter, these closures were for short periods and on an intermittent basis.

The issues with regards to ongoing rock fall events affect both the local Loch Carron area from Plockton, Starthcarron and Lochcarron Village up to Applecross, but also significant transport links from East to West, from Skye to Ullapool and Inverness and wider geographical linkages South to North between Fort William and the North West Coast of Scotland.

When the A890 Stromeferry Bypass road is closed due to a rock fall, there is only one feasible option for undertaking an alternative route. Journeys from north to south, instead of using the A890 Strathcarron junction to A890 Stromeferry junction link, a distance of approximately 8.5 miles (13.6 kilometres) and taking some 15 minutes, would require a trip of circa 130 miles (204 kilometres) and nearly three hours. Other contingency measures, including dual running of road and rail and a ferry service from South to North Strome, were put in place by The Highland Council to alleviate some of the traffic problems through periods of road closures following more recent rock fall events.

Maintenance works carried out on the A890 Stromeferry Bypass over the past years have included emergency works carried out following the rock fall event in December 2011, at a recorded total cost of £2.84M. In addition, The Highland Council estimates that around £250k is required to cover for the maintenance of rock slopes along this road on an annual basis, with future spend for emergency works unknown due to the unpredictable behaviour of the existing rock faces. This was reported to be the case despite regular inspections carried out by The Highland Council and rigorous contingency planning.

Consultation undertaken during this study enabled stakeholders to share their views about the issues experienced by road and rail users, as well as local businesses. This included the wider impacts of road and rail closures due to landslides, based on using the 130-mile temporary diversion route. The consultation exercise has informed the identification of the evidence-based transport problems in the study area.

A Business Survey has been undertaken to assess the socio-economic impact of the road closures due to rock fall events on the A890 at Stromeferry. The outcomes from this Survey provide evidence in addition to, and not in place of, the standard economic appraisal which has been undertaken.

This study examined a range of potential long-term solutions to address the rock fall issue on the A890 at Stromeferry, as summarised below.

Table 8.1 - STAG Part 2 Options

Corridor	Option	Detail	Description
North	N6	Bridge crossing and online on north shore	Route North N6 is a route option originating at Achmore, considering a western Strome Narrows crossing and following the route of the existing minor road along the northern shore of Loch Carron until Strome Wood
	N9	Bridge crossing and offline on north shore	Route N9 is an offline route option considering a western bridge crossing of the Strome Narrows, and then continues offline north of Stromemore, then ties into the existing road on the northern shore of Loch Carron at Strome Wood
Online	O2	Viaduct	Route Online O2 considers on-line improvement of the existing carriageway and a local 1.6km bypass of the rock fall area west of Cuddies Point by means of a cantilevered structure along the shoreline.
	O3	Tunnel	Route Online O3 considers online improvement of the existing carriageway and a local 1.5km bypass of the rock fall area west of Cuddies Point by means of an inland tunnel structure.
	O4	Do-minimum	Route Online O4 is the Do Minimum scenario, with no proposed improvements to the existing route. This option also includes considerations for suitable contingency measures during (future) road closures.
	O7	Avalanche Shelter	Route Online O7 considers online improvement of the existing carriageway and a local 1.7km extended rock shelter west of Cuddies Point.
South	S4	Glen Udalain	Route South S4 considers a principal southern offline bypass route from the A890 through Glen Udalain and Attadale valley, and ties back into the existing A890 at Attadale.

The conclusions of this appraisal are presented below. AECOM will continue to work with The Highland Council and Stakeholders to develop recommendations on which 'preferred route' can be selected and put to The Highland Council Full Committee, and therefore taken forward to a DMRB Stage 3 scheme design.

8.2 Overview of Option Appraisal

The outcomes of the option appraisal undertaken within this report are summarised below.

8.2.1 General Conclusions

It is essential at this stage of the process, that the full range of assessment criteria, i.e. Transport Planning Objectives, Environment, Safety, Economy, Integration, Accessibility & Social Inclusion, Deliverability, Public Acceptability & Affordability, are all considered to result in a balanced view.

Considering individual disciplines it can be seen in general terms:

- New (greenfield) options score poorly on environmental grounds;
- On-line options, are expensive, have buildability and rail interface issues and will require some element of road and railway closures.
- The North Shore route best satisfies most selection criteria but requires an expensive crossing of the Strome Narrows. During consultations carried out Spring 2014, the North Shore route received most positive responses from the public, albeit consultations were on the full north shore routes which also bypassed Lochcarron,

- The Southern route option satisfies less criteria and received less positive responses than the northern route, but emerges as the most affordable solution. The route may have more difficulties in scheme promotion due to landowner difficulties.

Considering all the appraisal criteria, the differences between the North route and the South route is marginal. However, the northern routes remain more expensive, due to the requirement of a major bridge crossing across the Strome Narrows.

8.3 Conclusions drawn from Summary Tables

The summary tables of the route options, appraised during this work, provide a tool to identify a preferred route option. Cognisance has also been taken of consultations with stakeholders and the public during workshops and the Public Exhibitions in March 2014.

8.3.1 North Routes

Routes N6 and N9 vary only in regards to their alignment through Stromemore. The most advantageous northern route has been chosen, and was found to be Option N9.

Option N9 Lochcarron Bypass crossing Strome Narrows with a low level bridge and offline through Stromemore was found to be the best North Shore Option. Bypassing the propertied at Stromemore allows for a better standard of geometry and also minimises the impact on land and especially property which fronts on to the existing road. Although Option N9 is among the most expensive route options, it performs best with regard to scheme economics when compared to the other route options.

8.3.2 Online Routes

The majority of the online routes were taken forward to STAG. Recognising how cost-driven a possible route solution would be, considerations did not just focus on construction cost, but focused on buildability issues, construction periods, road and railway closures and railway interface issues, all of which potentially impact on cost. It was also recognised that The Highland Council have liability obligations with regard to long term maintenance of the route.

The best online solution emerging from this appraisal is Option O2 the proposal for a railway viaduct, which emerged as the most cost-effective online proposal, and had many advantages in comparison to other solutions considered in relation to buildability and road closure issues. When comparing to all routes, Option O2 performs poorly when in regards to scheme economics which are comparable to those for Option S4.

8.3.3 South Route

Route S4 takes an alignment through Glen Udalain, east of Loch Nam Breac Mora through Attadale valley and continues to Attadale.

This option is the main ‘Glen Udalain’ route. It has been derived from historical work and offers the most favourable route alignment through the valley to satisfy the design parameters set in particular setting a route below the 300m contour. As a greenfield route there are environmental issues to overcome. Although Option S4 is the longest of all routes considered, it is least expensive as it does not include any major structures. Option S4 performs poorly when compared to others with regard to scheme economics, which are comparable to those for Option O2.

8.3.4 Do-Minimum Scenario

Do-Minimum Scenario. A ‘Do Minimum’ scenario has been considered. This is the base case to measure the performance of alternative route options against and is representing the existing condition of the A890 Stromeferry Bypass, with known issues of a long diversion route and rail/ferry contingency measures during road closures due to rock falls. It should be noted whilst not having an assigned capital cost, the do-minimum scenario has been assessed to require some £30M of maintenance expenditure over 60 years.

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Appendix B - Geotechnical Desk Study Report

Appendix C - Peat Management Report

Appendix D - Tunnel Report

Appendix E - Environmental Assessment

Appendix F – Online Option Buildability Study

Appendix G - Strome Narrows Crossing Technical Note

Appendix H - Statutory Processes

Appendix I - Business Survey Report

Appendix J - Appraisal Summary Tables

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