A82 Tarbet to Inverarnan Upgrade

DMRB Stage 2 Options Assessment Report

Transport Scotland

August 2015

Volume 1

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Volume 1

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Document history

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DMRB Stage 2 Options Assessment Report

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Acronyms and Abbreviations

ADS	Architecture and Design Scotland
ATC	Automatic Traffic Counter
AADT	Annual Average Daily Traffic
AOD	Above Ordnance Datum
BCR	Benefit to Cost Ratio
BT	British Telecom
CFJV	CH2M Fairhurst Joint Venture
Ch	Chainage
CPO	Compulsory Purchase Order
DMRB	Design Manual for Roads and Bridges
FEH	Flood Estimation Handbook
GWDTE	Groundwater Dependent Terrestrial Ecosystems
HGV	Heavy Goods Vehicle
HITRANS	Highlands and Islands Transport Partnership
HRA	Hot Rolled Asphalt
IRIS	Integrated Road Information System
km	Kilometres
kph	Kilometres per hour
KSI	Killed and Serious Injury
LLTNP(A)	Loch Lomond and The Trossachs National Park (Authority)
m	metres
mm	millimetres
mph	miles per hour
NB	Northbound
NESA	Network Evaluation from Surveys and Assignment
NMU	Non-Motorised User
NPV	Net Present Value
NRSWA	New Roads and Street Works Act 1991
NRTF	National Road Traffic Forecasts
OBB	Open Box Beam
OBC	Outline Business Case
OH	Overhead

PIA	Personal Injury Accidents
PSSR	Preliminary Sources Study Report
PVB	Present Value of Benefits
PVC	Present Value of Costs
QUADRO	Queues and Delays at Roadworks
SB	Southbound
SBC	Strategic Business Case
SCRIM	Sideway-force Coefficient Routine Investigation Machine
SEPA	Scottish Environment Protection Agency
SNH	Scottish Natural Heritage
SP	Scottish Power
SSD	Stopping Sight Distance
SSE	Scottish and Southern Energy
SSSI	Site of Special Scientific Interest
STAG	Scottish Transport Appraisal Guidance
STPR	Strategic Transport Projects Review
SuDS	Sustainable Drainage Systems
SW	Scottish Water
TMfS	Transport Model for Scotland
TSCS	Thin Surface Course Systems
UG	Underground
VfM	Value for Money
VRS	Vehicle Restraint Systems
WFD	Water Framework Directive

Executive Summary

Transport Scotland appointed CH2M Fairhurst Joint Venture (CFJV) to complete the Design Manual for Roads and Bridges Stage 2 assessments for the proposed upgrade of the A82 trunk road between Tarbet and Inverarnan. The scheme is approximately 17 km in length, is sited on the western shore of Loch Lomond and lies within the Loch Lomond and The Trossachs National Park.

The existing road is considered to require upgrading. This is due to a number of issues including narrow widths, poor accesses, tight bends, poor visibility and consistently wet roads, even in dry weather. All these issues cause low journey speeds, a high accident rate and poor journey time reliability.

Four potential route options have been developed.

- Route Option 1 follows the current A82 very closely.
- Route Option 2 follows the majority of the current A82, with some sections of the road being moved to the west (inland).
- Route Option 3 follows the majority of the current A82, with some sections of the road being moved to the east, including some sections on viaducts along the shore of Loch Lomond.
- Route Option 4 is the most direct route, deviating from the current A82, with more sections on viaducts along the shore of Loch Lomond than the other route options.

This Scheme Assessment Report provides the engineering assessment of the route options, includes summaries of the separate Stage 2 Environmental Assessment Report and Stage 2 Traffic and Economic Report and brings them together with a set of conclusions and recommendations.

Key issues highlighted in this report are:

- The particular constraints of this section of the A82 within the Loch Lomond and the Trossachs National Park.
- The challenges associated with engineering alignments, standards and provision of accesses, laybys and overtaking opportunities.
- The requirement for a large number of structures for all route options including retaining walls, bridges and viaducts.
- The improved ability to treat road drainage in comparison with existing arrangements.
- A review of the ground conditions and requirements for types of foundations for structures.
- The challenge of constructing the road adjacent to a key trunk road for the west and north west of Scotland.

In consideration of the assessments carried out, the report concludes with the recommendation that Route Option 1, which closely follows the existing route, is taken forward to DMRB Stage 3. This Stage 2 Study has considered a carriageway of 6.0 m width plus 1.0 m hardstrips. The report recommends that a 7.3 m carriageway width plus 1.0 m hardstrips is also considered during Stage 3.

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1. Introduction

1.1 Background

In June 2013, Transport Scotland commissioned the '*A82 Tarbet to Inverarnan, Single-Supplier Framework Agreement for Provision of the Design, Investigative and Environmental Services*'. This was to carry out the necessary works to complete a Design Manual for Roads and Bridges (DMRB) Stage 1 and Stage 2 Scheme Assessment for the proposed upgrade of a section of the A82 Trunk Road between Tarbet and north of Inverarnan. The framework agreement, being undertaken by CH2M Fairhurst JV (CFJV), allows for further stages to be undertaken pending availability of funding and appropriate commitment from Scottish Ministers.

Figure 1.1 shows the location of this section of trunk road.

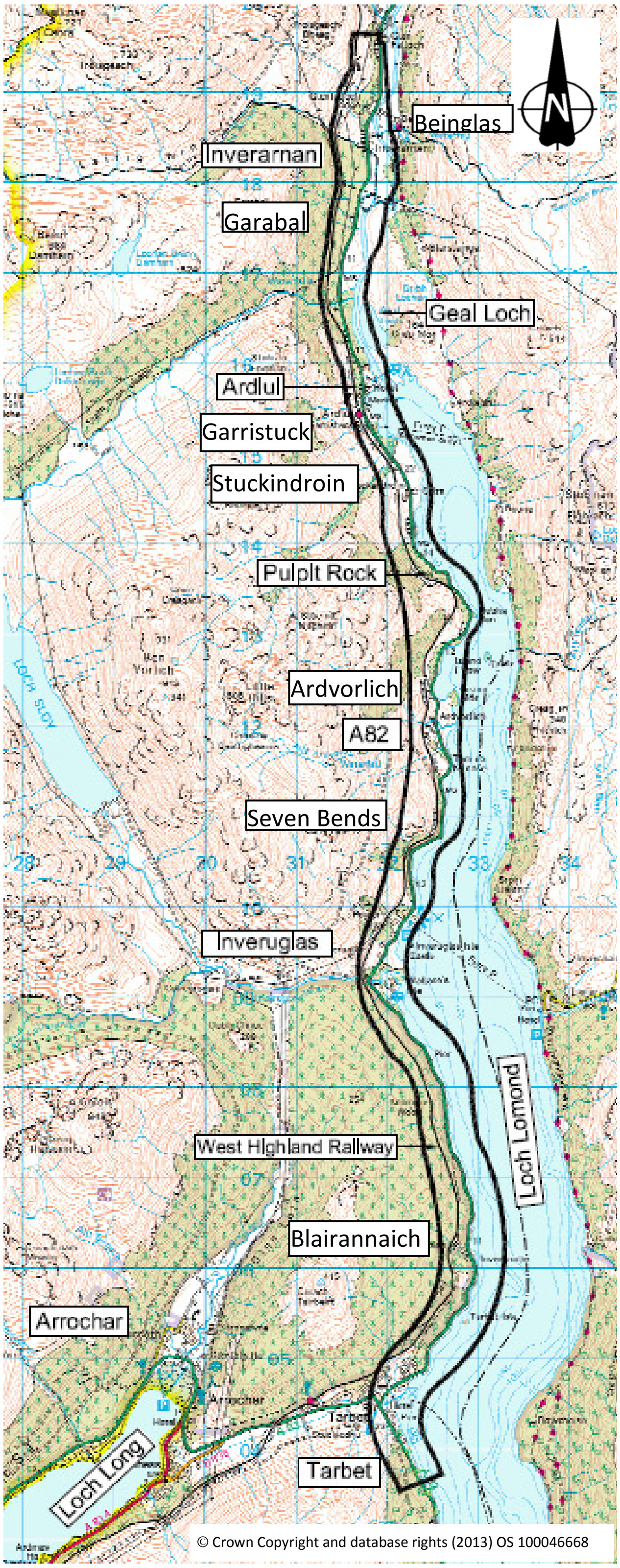


Figure 1.1: Location plan (Not to scale)

The A82 trunk road is considered to be an economic lifeline for the communities directly served by the route and also to the wider region to the west and north west of Scotland.

The existing road between Tarbet and Inverarnan consists of sub-standard cross-sections over much of its length and sub-standard horizontal and vertical geometry, characterised by tight radii and lack of forward visibility, See **Figure 1.2**. In addition, existing drainage is poor over significant lengths of the route, resulting in surface water on the road even during dry weather.

Furthermore, the sub-standard cross-section limits the ability to carry out routine maintenance without a full road closure. This results in costly and disruptive maintenance operations.

These primary factors all contribute to traffic experiencing low average journey speeds, poor journey time reliability, and a high accident rate. As such, the road in its current state is considered to require upgrading.

Improvements to the A82 were identified within the Strategic Transport Project Review (STPR).

Following the completion of the DMRB Stage 1 in early 2014, which considered alternative corridors, Stage 2 progressed to assess route alignment options within the on-line corridor.

Figure 1.2: Section of the A82 Tarbet to Inverarnan trunk road

1.2 Scheme Development History

1.2.1 Previous Studies

A number of previous studies have been carried out by various parties. A summary of these studies is provided below. This DMRB Stage 2 assessment has taken into consideration these previous studies.

A82 Route Action Plan Study, Scott Wilson, 2006

This study reviewed conditions and issues along the A82 and recommended an implementation strategy for improvements to address road safety, carriageway restrictions, provision of laybys and rest areas, facilities for pedestrians and cyclists and carriageway improvements.

The plan included the improvement of the trunk road between Tarbet and Inverarnan, addressing the problems of journey delays caused by traffic lights at a section known as Pulpit Rock and for larger vehicles in general, due to the constrained road geometry.

STPR A82 Technical Reports, Jacobs, 2010

This study considered in more detail the improvements necessary on the A82 as proposed within Transport Scotland's Strategic Transport Project Review (STPR), published in 2009.

This study included the review of design speed, accidents, junctions, accesses and pedestrian facilities.

The study also made an initial assessment of a number of route options between Tarbet and Inverarnan and made a number of recommendations for further study.

Engineering and Environmental Surveys, Amey, 2012

The purpose of this study was to gather engineering and environmental data to support future DMRB design and assessment work, and to comment upon the issues associated with the implementation of a possible on-line upgrade.

Topographical, bathymetrical environmental and engineering surveys were carried out to improve knowledge on this section of trunk road.

The study also included a consultation with stakeholders, requesting relevant information or comments on the route improvement.

Speed Limit Review, Transport Scotland, 2012

Transport Scotland commissioned a review of speed limits on the Scottish trunk road network in 2008, with the aim of making speed limits more consistent, understood by drivers and appropriate for the environment and road use. The outcome of the review was published in 2012.

The Tarbet to Inverarnan section was reviewed and a recommendation for a reduction from the current national speed limit (60 miles per hour (mph)) to 50 mph has been made.

A Traffic Regulations Order to implement this speed limit reduction will be promoted in the future.

1.2.2 DMRB Stage 1 Assessment

CFJV completed a DMRB Stage 1 assessment to identify a preferred route corridor in February 2014.

A wide range of route corridors were identified and following an initial sifting process three feasible route corridors were taken forward to assessment. **Figure 1.3** shows the route corridors considered.

An assessment of the engineering challenges, environmental effects and traffic and economics concluded that the existing A82 route was the preferred corridor (Option 1 shown in red).

The initial brief was to consider the trunk road from the north of Tarbet (beyond the end of the 30 mph speed limit) to just north of Inverarnan. However following queries from stakeholders, Transport Scotland extended the study to the south of the A82/ A83 junction at Tarbet.

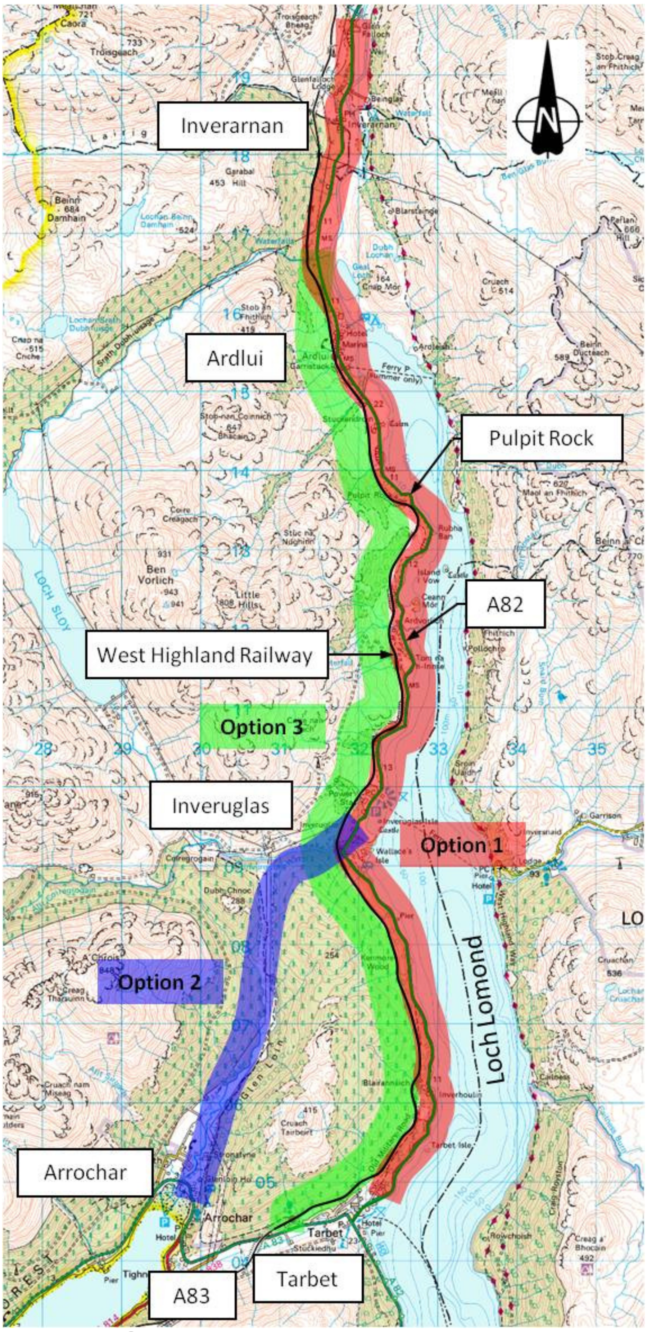


Figure 1.3: Stage 1 Route corridors (Not to scale)

1.3 Adjacent Schemes

A82 Pulpit Rock improvements

A section of the Tarbet to Inverarnan route known as Pulpit Rock has recently been improved. Site works commenced in May 2013 and were completed in May 2015.

The improvement works saw the removal of traffic signals, and the widening of the road to provide a two-way carriageway. This required the construction of a new viaduct running parallel with the existing road and extending out over the Loch. See **Figure 1.4**.

Benefits resulting from the scheme are expected to include a reduction in accidents, improvements to journey times and reduced driver frustration.

Figure 1.4: Pulpit Rock improvements under construction

A82 Crianlarich Bypass

Crianlarich is situated on the A82, 10 km north of Inverarnan at the junction with the A85 trunk road to Perth.

Crianlarich Bypass was completed at the end of 2014, providing a 1.3 km single two-lane carriageway road to the west of the village. This enables A82 road users to avoid low bridges within the village that carry the Glasgow to Oban rail line. See **Figure 1.5**.

Benefits from the scheme include a reduction in congestion within the village, improved access for local residents and tourists and improved journey time reliability.

Figure 1.5: Crianlarich Bypass under construction

1.4 Scheme Objectives

The design of the scheme is being prepared in accordance with the Government's appraisal criteria for the assessment of trunk road schemes. This takes account of integration, economy, safety, environment, social inclusion and accessibility impacts, with potential route options for road improvements being assessed in a manner consistent with the STAG (Scottish Transport Appraisal Guidance) and the DMRB process.

Following the preparation of a Strategic Business Case (SBC), the following key transport planning objectives were identified:

- To improve journey times for A82 trunk road users between Tarbet and Inverarnan (based on observed post-Pulpit Rock scheme scenario).
- To reduce personal injury accident numbers and their severity on the A82 between Tarbet and Inverarnan (based on 2008 – 2012 PIA rates).
- To provide appropriate stopping opportunities to aid driver comfort for visitors and for all trunk road users on the A82 between Tarbet and Inverarnan, taking account of the unique setting of the route within the National Park.
- Seek to provide opportunities for enhanced access by sustainable modes of travel along the A82 corridor between Tarbet and Inverarnan.
- To reduce disruption to road users resulting from the undertaking of routine maintenance activities on the A82 between Tarbet and Inverarnan.

Further details of the scheme objectives can be found in the SBC.

1.5 Consultations

The successful delivery of the Tarbet to Inverarnan Upgrade scheme will be dependent on effective engagement with key stakeholders and gaining their involvement through consultation.

Consultations and workshops were carried out during this assessment to:

- Engage and inform interested parties
- Gather knowledge, expertise and opinions from Stakeholders to inform the assessment and decision making
- Promote consultation with the community and their representatives, allowing issues and concerns to be understood and addressed
- Help de-risk the scheme promotion process

1.5.1 Stakeholders

Stakeholders, statutory consultees and interested parties were identified and include the following, (amongst others):

- A82 Partnership – an umbrella group campaigning for upgrading of the A82
- Chambers of Commerce (Fort William, Lochaber, Mid Argyll)
- Community Councils (Arrochar & Tarbet, Strathfillan)
- Council Authorities (Highland, Stirling, Argyll & Bute)
- Emergency Services
- Forestry Commission Scotland
- Freight and Haulage Associations
- Highlands and Islands Transport Partnership (HITRANS)
- Loch Lomond and The Trossachs National Park Authority (LLTNPA)
- Network Rail
- Landowners and businesses along this section of the A82
- Scottish Environment Protection Agency (SEPA)
- Scottish Natural Heritage (SNH)
- Transport Scotland
- Utility suppliers (Scottish Gas Networks, Scottish Power Scottish Water and Scottish and Southern Energy)

1.5.2 A82 Stakeholder Forum

Key stakeholders were invited to form the 'A82 Stakeholder Forum' during the Stage 1 assessment. It was hoped that this forum would act as a focus through which consultation and engagement workshops could be structured. This forum has continued through Stage 2, with stakeholders being informed of the developing route options.

Three A82 Stakeholder Forum workshops have been held, where CFJV and Transport Scotland informed Stakeholders on progress, presented emerging proposals and listened to comments made.

The A82 Stakeholder Forum workshops are summarised below:

- Workshop No 1, 2 October 2013. Discussed objectives for the development of the scheme and possible route corridors.
- Workshop No 2, 29 May 2014. Presented the preferred route corridor and discussed the next assessment stage.
- Workshop No 3, 20 November 2014. Presented the route options being assessed. See **Figure 1.6**.

Figure 1.6: Stakeholder Workshop No 3

Reports were prepared as a record of each event and the comments made by stakeholders considered as part of this assessment.

In February 2015, to coincide with the issue of the Workshop No 3 report, stakeholders (both statutory and non-statutory) were also invited to give a formal response on the route option proposals.

1.5.3 Local Engagement

The local community has been informed on the developing study during Stage 1 and Stage 2. This has included issuing scheme update leaflets at key stages in the project and posting scheme details on Transport Scotland's project website.

(http://www.transportscotland.gov.uk/project/a82-tarbet-inverarnan-upgrade)

An exhibition on the preferred route option and the reasons for its selection will be held following the decision to move to the next assessment Stage. At that time the local community will be able to comment on the selected route and assist in the detailed development of the route alignment.

1.6 Method of Assessment

This Stage 2 Options Assessment Report for the A82 Tarbet to Inverarnan Upgrade has been prepared in accordance with the guidance for '*Preparation of the Stage 2 Report*' as contained in the DMRB, Volume 5, Section 1, Part 2, TD 37 '*Scheme Assessment Reporting*'.

The report describes the current A82 alignment and the proposed route options.

At Stage 2, the route options have been sufficiently developed to enable an assessment of their comparative impact and performance and to enable the appraisal of costs, engineering, traffic and environmental impacts of each.

Preliminary layout drawings have been prepared which illustrate the extent of the route option proposals, and are provided in Volume 2 of this Stage 2 Options Assessment Report.

1.7 Report Structure

The report is structured around the DMRB, Volume 5, Section 1, Part 2, TD 37 '*Scheme Assessment Reporting*' and broadly follows the principles set out in the guidance on the preparation of the Stage 2 Report.

Reporting has been split into three parts as follows:

- The DMRB Stage 2 Options Assessment Report containing the engineering assessment, conclusions and the overall Stage 2 recommendations
- The DMRB Stage 2 Environmental Assessment Report
- The DMRB Stage 2 Traffic and Economic Assessment Report

This Options Assessment Report has been further sub divided into two volumes as follows:

- Volume 1: Stage 2 DMRB Options Assessment Report and Appendices
- Volume 2: Stage 2 DMRB Options Assessment Drawings

The chapter headings within this report generally follows the guidance given in Annex A of TD37:

- Chapter 2 outlines the existing conditions.
- Chapter 3 describes the route options under consideration and provides a summary of the construction cost estimates associated with each route option.
- Chapter 4 considers the engineering assessment.
- Chapter 5 provides a summary of the Stage 2 Environmental Assessment.
- Chapter 6 provides a summary of the Stage 2 Traffic and Economic Assessment.
- Chapter 7 draws the engineering, environmental and traffic and economic assessments together in a set of conclusions.
- Chapter 8 makes recommendations of the route option considered appropriate to be taken forward to the DMRB Stage 3 Assessment.

2. Existing Conditions

2.1 Introduction

This section of the report describes the existing conditions of the A82 within the limits of the study area.

2.2 Scheme Location and Environment

2.2.1 Location

The scheme is located on the A82 trunk road, the strategic link between the population centres of Glasgow, Fort William and Inverness.

The Tarbet to Inverarnan section of the A82 is approximately 17 km in length, commencing to the south of Tarbet at the start of the 30 mph speed limit and ending at a point approximately 800 m north of the village of Inverarnan.

The route lies within the Loch Lomond and The Trossachs National Park (LLTNP) and is sited on the western shore of Loch Lomond. The route also passes through two local authority areas, Argyll and Bute, and Stirling.

2.2.2 Topography

The study area is located within the dramatic mountains and glens of the LLTNP. See **Figure 2.2.1**.

Figure 2.2.1: Loch Lomond and Trossachs National Park overlooking Ardvorlich

Loch Lomond is a prominent feature, is the largest area of fresh water in Great Britain and lies immediately to the east of the A82.

The loch is 36 km long, covers an area of 71 km^2 and has an average depth of 37 m. It has a normal operating water level between 7.8 m and 9.0 m Above Ordnance Datum (AOD). It has three distinct basins:

- The deep, narrow northern basin, extending from Ardlui to Rowardennan, reaches a maximum depth of 190 m and at its widest point measures 1.5 km across.
- The middle basin, between Rowardennan and Luss reaches a depth of 60 m.
- The wide and relatively shallow southern basin south of Luss is around 8 km across and has a maximum depth of 23 m.

The land rises steeply from the Loch Lomond shoreline, reaching over 900 m AOD in places. Beyond the railway line to the west of the loch are a number of hills and mountains.

Beginning at the southern end they include:

- Cruarch Tairbert at 415 m AOD
- Kenmore Wood at 254 m AOD
- Dubh Chnoc at 288 m AOD
- Little Hills at 808 m AOD
- Ben Vorlich at 931 m AOD
- Stob nan Coinnich Bhacain at 647 m AOD
- Stob an Fhithich at 419 m AOD
- Garabal Hill at 453 m AOD
- Troisgeach at 733 m AOD

2.2.3 Climate

Overall, the climate of the Loch Lomond area can be described as mild and wet. The average temperature range for the area is approximately 1°C to 18°C.

Annual rainfall in the southern part of the catchment is around 1,500 mm (30 year average) with a minimum mean annual rainfall of 1,300 mm in Drymen. In the north, the 30 year average rises to over 2,500 mm with a maximum of 3,600 mm on the slopes of Ben Ime above Loch Sloy. The higher rainfall in the mountainous north, coupled with the thin soils and steep slopes, provides a considerable source of run-off to the loch.

2.2.4 Land Use

With the exception of Tarbet and other villages along the route, the majority of land within the study area is predominantly used for either forestry or agriculture, with open fields used for both grazing and crops. The forestry consists of commercially farmed and ancient woodland. Set within the LLTNP, the land also has an attraction for tourism and outdoor activities (walking, climbing, shooting, etc.).

2.2.5 Man-Made Features

Major Carriageways

There are two trunk roads located within the study area:

- The A82 Glasgow to Inverness trunk road passes from south to north through the study area. The particular section of A82 within the study area from south of Tarbet to beyond Inverarnan is single carriageway, of varying standard.
- The A83 Tarbet to Campbeltown trunk road, heading west, commences at the ghost island junction within Tarbet and is also single carriageway.

Junctions & Side Roads

There is only one trunk road junction within the study area.

The A82/A83 junction in Tarbet consists of a major/ minor priority junction in the form of a ghost island right hand skew junction. The arrangement of the junction is such that the major priority is given to traffic to/ from the A82 to/ from the A83 i.e. the major road is the A82/ A83 link.

The southbound approach from the A82 is considered the minor road and is required to give way to the major A82/ A83 road at the major/ minor junction. See **Figure 2.2.2**.

Figure 2.2.2: A82/ A83 trunk road junction within Tarbet

Rail Lines

The Glasgow to Fort William single track rail line lies to the west of the A82 trunk road. The line is known as part of the "West Highland Line" and is considered to be one of the top rail journeys in the world, due to the breath-taking and varied scenery it passes through.

There are rail stations within the villages of Tarbet and Ardlui.

The rail line generally runs high above the trunk road along the hillside, although in places it runs immediately adjacent to the road, either above the road supported by embankment or masonry retaining wall (e.g. as part of the retaining walls leading to the Creag an Arnain Viaduct, north of Inveruglas), or at a similar level (e.g. south of Ardlui).

Residential Settlements

The main settlement of Tarbet is situated in the south of the study area. Other residential settlements are found along the length of the route including at Blairannaich, Inveruglas, Ardvorlich, Stuckindroin, Garristuck, Ardlui, Garabal, Inverarnan and Beinglas. See **Figure 1.1**.

Agricultural Land

The land within and surrounding the study area is categorised (on the Land Capability for Agriculture in Scotland map) as Classes 5.2, 5.3 and 6.1 and is considered to be capable of supporting grass production and rough grazing. The vast majority of agricultural land within the study area is currently used as pasture (land just south of Ardlui and land surrounding Ardvorlich and Inveruglas).

Commercial Properties

There are several commercial businesses and properties situated close to the A82, including hotels, B&B's, restaurants, inns, marinas, boatyards, holiday parks, outdoor activity centres and camping sites.

Industrial Properties

The main industrial property is the Loch Sloy Power Station, and its associated apparatus, within Inveruglas.

2.2.6 A82 Trunk Road

The strategic route of the A82 between Glasgow and Inverness is, at 269 km in length, the second longest trunk road in Scotland after the A9. It comprises mainly of single carriageway and some smaller sections of dual carriageway, of differing standards, constructed at various times.

The route provides an important connection between central Scotland and the north-west and islands. The route supports economic links and provides access to the many tourist and recreational areas located along the route.

A82 Southern Section

The A82 begins in central Glasgow as Great Western Road at a junction with the M8 and the A804. It continues as a de-trunked road for 6 km, then generally as dual carriageway in a north-westerly direction for 10 km before joining the A898 from Erskine Bridge, providing critical links to the M8, the M77 and the M74.

From this point north, the A82 becomes a trunk road all the way to Inverness. It continues as dual carriageway in a general north-westerly direction through Dumbarton for 14 km to Balloch (Stoneymollan) Roundabout near the western shore of Loch Lomond, bypassing Alexandria and Bonhill.

From this point, the route continues as a single carriageway road in a general northerly direction parallel to the Old Military Road for approximately 27 km following the western shores of the loch.

The section between Balloch and Tarbet is generally of good standard, having been widened to a cross-section of 7.3 m carriageway with hardstrips during the 1980's.

A82 Tarbet to Inverarnan Upgrade Section

The A82 leads directly onto the A83 at Tarbet, heading west to Campbeltown. At the same point in Tarbet, the A82 branches off via a priority T-junction before continuing northwards for approximately 17 km along the western shores of the loch to Inverarnan. The junction consists of road markings, with a central hatched ghost island for northbound vehicles waiting to turn across the oncoming traffic.

This section of the A82 is tightly constrained within a narrow corridor between the loch to the east, and the hillside and West Highland Line to the west. The road is generally less than 7.3 m in width, frequently narrowing to below 6.0 m with no hardstrips and sub-standard verges. See **Figure 2.2.3**.

Figure 2.2.3: Route constraint between Loch Lomond and hillside

Until recently this section contained a pinch point at Pulpit Rock, where traffic signals controlled single-lane operation. Works have just been completed at this location to widen the road allowing two-way running.

A82 Northern Section

North of Inverarnan, the road widens to a 7.3 m cross-section and continues in a general north-easterly direction for 10 km to Crianlarich, where there is a junction with the A85 and continues for 8 km to Tyndrum.

From Tyndrum, the A82 continues in a general northerly, then north-westerly direction for 50 km to Glencoe. It continues in a north-easterly direction for 27 km to Fort William. There is a short section of dual carriageway within Fort William.

There it meets with the A830, before continuing in a north-easterly direction for 16 km to a junction with the A86 at the River Spean, then a north-easterly direction along the south-eastern shore of Loch Lochy for 25 km, to a junction with the A87 at Invergarry.

The A82 then continues in a general north-easterly direction to Fort Augustus for approximately 13 km, then along the north-western shore of Loch Ness for approximately 41 km before running parallel to the River Ness for approximately 10 km to Inverness.

The A82 becomes dual carriageway at Telford Roundabout, crossing the River Ness and continuing in a general north-easterly direction for 2 km to end at a junction with the A9 at Longman Roundabout, immediately south of the Kessock Bridge.

2.3 Engineering Conditions

2.3.1 General

This section of the report describes the existing conditions on the A82 trunk road within the study area.

2.3.2 The Existing A82 Trunk Road

Travelling from south to north, the existing section of the A82 included in the study begins at the start of the 30 mph speed restriction to the south of Tarbet.

The road generally follows the route of the Old Military Road, located just to the west of the A82.

The A82 diverges eastwards at a right hand ghost island junction where it continues through the eastern side of Tarbet. The A83 road continues beyond the junction passing through the western side of Tarbet. The 30 mph speed restriction ends on the A82 at the northern edge of Tarbet. Beyond this point the A82 is subject to the national speed limit. A recent speed limit review carried out on behalf of Transport Scotland has recommended that the speed limit be changed to 50 mph between Tarbet and Inverarnan (refer to Section 1.2).

To the west of the A82 lies steep hillsides and rock outcrops. At several locations along the route, there are also embankments and retaining walls supporting the West Highland Line.

The section between Tarbet and Inveruglas consists of a sub-standard horizontal and vertical alignment, with a number of pinch points along the route where the carriageway is less than 6.0 m in width. See **Figure 2.3.1**.

Figure 2.3.1: Narrow carriageway

Travelling north, the access to the Home on the Loch Cafe is located approximately 1.5 km beyond Tarbet, on the west side of the road.

Immediately to the south of Inveruglas Water is the access to Loch Lomond Holiday Park, located on the east side. The A82 bridges over Inveruglas Water (See **Figure 2.3.2**) and passes the access to Inveruglas Farm located on the east.

Figure 2.3.2: A82 southbound approaching Inveruglas Water bridge

Beyond Inveruglas the A82 passes east of Sloy Power Station (A-grade listed building), bridging over the outfall from the hydro scheme (the bridge is C-grade listed). Located on the east are the accesses to the Inveruglas Visitor Centre.

With the exception of the section of road at Ardvorlich, the A82 between Inveruglas Visitor Centre and Pulpit Rock is generally tightly constrained between the West Highland Line and the loch as it follows the curvature of the loch side. Of particular note is the narrow and tight section of A82, known as ‘the Seven Bends’ (also known as Seven Sisters’), a series of back to back bends constrained between the loch edge and the retaining walls of the West Highland Line.

From Pulpit Rock to Ardlui, at the north end of the loch, the route becomes more constrained between the loch shore and the West Highland Line.

Passing between Ardlui railway station to the west, and the Ardlui Marina and Ardlui Hotel to the east, the road traverses north between the railway and the River Falloch.

Continuing north, the A82 passes to the east of the substation and then to the west of the Drovers Inn as it passes through Inverarnan and onto the end of the study area at a point approximately 800 m north of the village.

The vertical geometry of the existing road typically follows the local topography and the edge of Loch Lomond. Road elevations on the existing A82 within the study area range from a minimum of approximately 10 m AOD at the lowest point, immediately south of Garabal, to a maximum of approximately 33 m AOD just south of Inveruglas Water. Elevations fall to approximately 17 m AOD at the end of the study area, north of Inverarnan.

The route is currently subject to the national speed limit (subject to review as noted in Section 1.2); however the alignment, restricted visibility and confined cross-section make this speed difficult to achieve safely.

There is also no continuous pedestrian or cycle provisions along the route (Refer to Section 2.3.10).

The design speed for the existing alignment has been calculated to be 85B kph, and it has been noted that the Pulpit Rock scheme specifies a design speed of 70 kph. The observed average journey speed in October 2014 was noted as 40 mph, although this is dependent upon traffic flow.

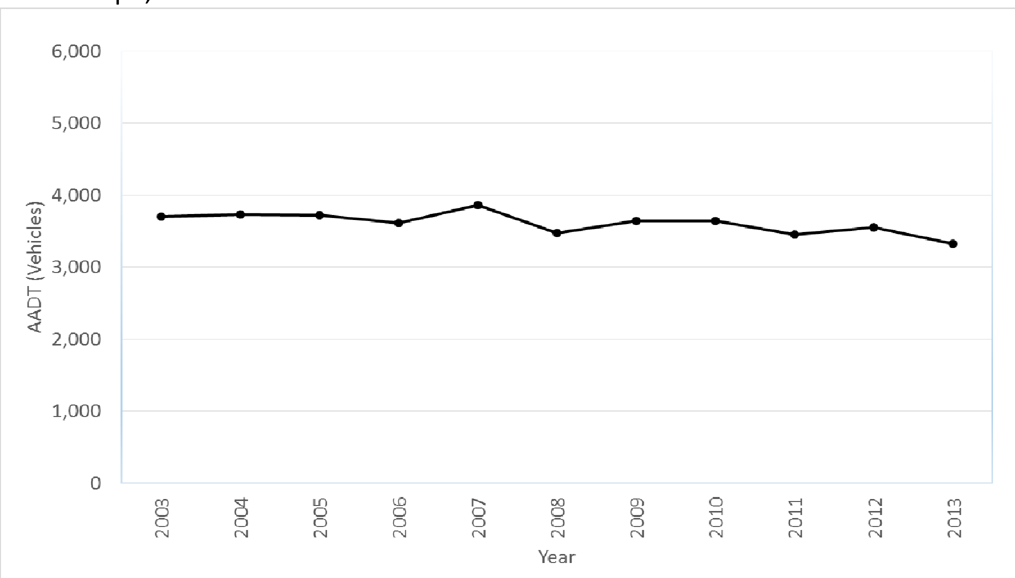
The horizontal alignment of the road also generally follows the shore of Loch Lomond, incorporating tight radius curves of up to 4 steps below DMRB standards. The cross-section of the road is also sub-standard, with all sections generally below 7.3 m width, and many below 6.0 m. Hardstrips are generally not present and verges are sub-standard and of poor quality. In addition, there are numerous sections where the road is bounded by rock faces, safety barriers and masonry walls at the edge of the narrow carriageway.

2.3.3 Traffic Flows

The 24-hour annual average daily traffic flows from 2003 to 2013 recorded by the Automatic Traffic Counter (ATCCS001) on the A82 to the north of Tarbet are presented in **Figure 2.3.3**.

The Annual Average Daily Traffic (AADT) flow on this section of the A82 is approximately 3,500 vehicles, with flows in the peak summer months reaching between 5,000 and 5,500 vehicles, which is up to three times higher than in the lower winter months.

Whilst the AADT flows above suggest a slight downward trend, overall, traffic volumes on the A82 have been fairly consistent since 2008.



Note: 2013 flow estimated based on available data.

Figure 2.3.3: A82 AADT flows (2003 to 2013)

2.3.4 Traffic Accidents

A review of accident data for the A82 between Tarbet and Inverarnan covering the period 2009 to 2013 indicates KSI accident rate of 13.6 KSI accidents per million vehicle-kilometres, which is over four times the national average of 2.9[1].

A summary of accident numbers on the A82 by severity is presented in **Table 2.3.1**.

Table 2.3.1: Accident numbers on the A82 Tarbet to Inverarnan (2009 – 2013)

Year	Accident Severity			
	Fatal	Serious	Slight	Total
2009	0	3	9	12
2010	0	4	6	10
2011	0	4	9	13
2012	0	3	9	12
2013	0	1	8	9
Total	**0**	**15**	**41**	**56**

It can be seen from the summary that annual accident numbers between Tarbet and Inverarnan have been fairly consistent over the past five years, totalling 56 personal injury accidents – none of which were fatal, 15 serious and 41 minor. Six accidents involved a motorcycle, all of which resulted in serious personal injury.

Accidents are generally spread along the route, however, clusters are evident in the vicinity of the Loch Sloy Power Station and at Pulpit Rock.

The main contributory factors are illustrated in **Figure 2.3.4**. Slippery road conditions, due to weather, is noted as the greatest single contributory factor to 25 % of accidents, followed by road layout at 13 %.

Further examination of the 56 accidents that have occurred show that 25 (45 %) occurred on a bend and 16 (29 %) involved a vehicle leaving the road and hitting an object.

1 Source: total of fatal and serious accident rates from Road Casualties Scotland 2013, Table 5b

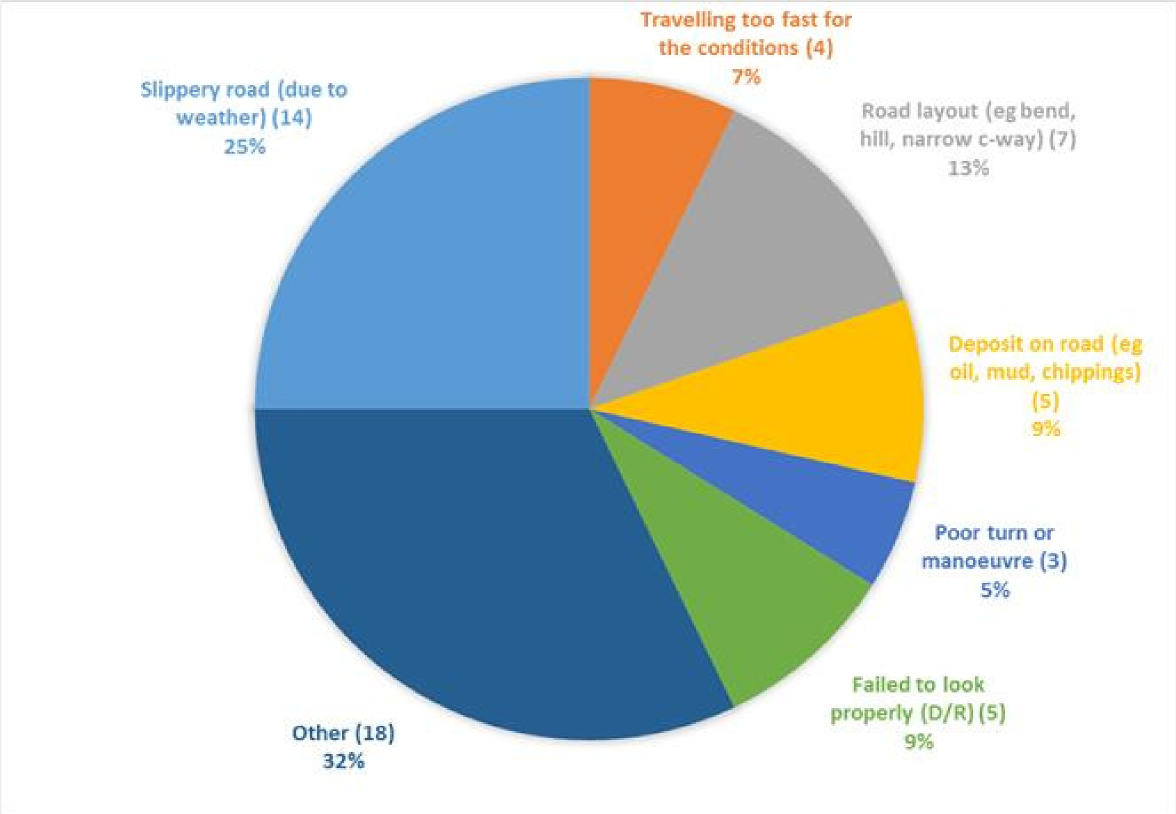


Figure 2.3.4: Main accident contributory factors

2.3.5 Existing Junctions and Accesses

Major Junctions

As mentioned in paragraph 2.2.5 there is only one trunk road junction within the study area, which is located within Tarbet village and consists of a major/minor priority T-junction.

The trunk road speed limit within Tarbet is 30 mph.

Accesses are located within the stopping sight distance of the junction, which include:

- On the A82 northbound after the junction is the access to the Tarbet Hotel car park, and directly opposite is the access to the Tarbet Pier car park.
- Opposite the Tarbet Hotel, on the A83 at the major/minor junction, is an access to a former service station, now utilised as additional car park with tourist information services. The original separation between the road and the garage forecourt is retained providing two access/egress points. This particular site has been identified in the LLTNP Development Plan as suitable for redevelopment, so access to the site should be considered when developing a junction strategy.

Within Tarbet, north of the A82/ A83 junction, footways are provided on the west and east side of the A82 and the east side of the A83. There is footway provision on the west side of the A82 south of the A82/ A83 junction. The footway on the A82 at the junction location is segregated from the carriageway by a grass verge.

There are two crossing points in close proximity to the junction, which are:

- On the A82, dropped kerbs indicate a crossing point at the front of the Tarbet Hotel, to the rear of the bus layby.
- On the A83, a dropped kerb indicates a crossing point at the bus stop to the Tourist Information building, however the dropped kerb is not replicated on the southern footway.

Minor Junctions and Accesses

The STPR A82 Technical Reports (2010), the Engineering and Environmental Surveys (2012) and the DMRB Stage 1 Report all note that there are a number of existing junctions and accesses along the route, and that many of these are of a poor standard with limited visibility, largely imposed by the horizontal geometric constraints.

These junctions and accesses generally do not comply with current design standards. A list of existing accesses is provided in **Table A.1** in **Appendix A** and indicated on **Drawings 476416-CF-ZZ-RDZ-DR-RD-0050 to 0061** within Volume 2.

2.3.6 Public Transport Facilities

There are four designated locations along the route that are noted as bus stop locations, which are:

- Tarbet
- Inveruglas
- Ardlui
- Inverarnan

Within Tarbet, existing public transport bus stops are located in close proximity to the existing A82/ A83 Tarbet junction. The A82 stops are located at and opposite the entrance to the Tarbet Hotel. The southbound stop is set back from the existing road in a layby. The northbound stop is located at the entrance to the hotel. Public transport also utilises the entrance bell-mouth of the hotel as an unofficial layby.

On the A83, two existing bus stops are located to the north of the A82/ A83 Tarbet junction. Laybys are not provided for the stops and public transport vehicles are required to stop on the trunk road carriageway.

Bus shelters are provided on the A83 northbound carriageway and the A82 southbound carriageway only.

At Inveruglas (in front of Loch Sloy Power Station) and Ardlui (outside Ardlui Hotel) buses stop on the trunk road carriageway if flagged, but there are no facilities such as signage or shelters.

Within Ardlui, the bus stop location is connected to the railway station via an unbound gravel footpath running adjacent to the east side of the A82.

The Inverarnan bus stop has signage and is located at the north end of the bridge over the Allt Arnan watercourse.

2.3.7 Existing Parking and Laybys

A number of informal or sub-standard laybys exist along this section of the route. A list of existing parking areas and laybys is provided in **Table A.2** in **Appendix A**.

Additionally, the A82 Route Action Plan Study (2006) identified four parking areas of a poor standard on the section from Tarbet to Pulpit Rock. These consist of areas of hard standing at the side of the carriageway, though it is recognised that the local topography and road geometry are such that these areas are unsuitable for safe usage.

There are also two designated picnic sites within this section, at Tarbet and Inveruglas, located on the lochside.

2.3.8 Road Pavement Condition Summary

A desk study and drive-over visual survey was carried out to determine the existing pavement construction and to form a preliminary assessment.

The information used in the desk study was obtained from the operating company BEAR Scotland and included raw Deflectograph and SCRIM data.

Deflectograph data provides a measurement of the strength of the carriageway and SCRIM is a measurement of its skidding resistance in the wet.

Within the study area, the A82 is understood to be of fully flexible construction. The bituminous layer depth varies significantly. A combination of historic Hot Rolled Asphalt (HRA) surfacing and Thin Surface Course Systems (TSCS) surfacing was observed.

The residual life of the existing pavement has been assessed based on the deflectograph data. This is summarised in **Table 2.3.2**.

Table 2.3.2: Pavement Residual Life between Tarbet and Inverarnan (based on May 2010 survey data)

Residual Life (years)	Length of Section (m)	% Length of Section
<5	1935	16 %
6 to 10	1057	9 %
11 to 20	1948	16 %
>20	7414	60 %

Based on the 12.3 km of survey data received, it can be seen that 60 % has a residual life of more than 20 years and 16 % has a residual life approaching a critical condition of less than 5 years.

The SCRIM deficiency of the existing pavement has been summarised in **Tables 2.3.3**.

Table 2.3.3: Pavement SCRIM deficiency between Tarbet and Inverarnan (based on June 2013 survey data)

SCRIM Deficiency	Length of Section (m)	% Length of Section
< -0.05	3484	23 %
-0.05 to 0	2140	14 %
>0	9622	63 %

Based on the 15.2 km of survey data received, it can be seen that 63 % has a positive SCRIM deficiency (the surface is satisfactory against skidding). 14 % has a SCRIM deficiency between 0 and -0.05 (the surface requires to be monitored for skidding) and 23% has a value lower than -0.05 (the surface requires repair to improve skid resistance).

Given the pavement desk study carried out is limited by the accuracy of the data received, it is recommended that a programme of pavement investigation be carried out in the following Stage at locations where the proposed finished road level permit the pavements possible re-use. This will verify this information and further inform the Assessment process.

2.3.9 Vehicle Restraint Systems

Generally Open Box Beam (OBB) Vehicle Restraint Systems (VRS) are located along the east side of the carriageway, adjacent to the loch. OBB VRS is also located at some locations on the west side adjacent to streams and rivers.

At some locations adjacent to the loch, shallow cement bound stone walls offer a measure of restraint, as part of retaining walls supporting the road.

2.3.10 Side Roads, Bridleways, Cycle Paths and Footpaths

Due to the rural nature of the existing A82 trunk road, there are few formal connections to the wider roads and/ or core path networks in the area. There is no continuous footway, cycle path or bridleway along the length of the A82 in the study area.

Side Roads

No side roads connect directly onto the A82 within the scheme extents, although a number of accesses to both residential and commercial properties are noted in Section 2.3.5 of this report.

Bridleways

No formal bridleways have been identified within the selected route corridor.

Cycle Paths

Formal cycle facilities have been identified within the route corridor.

However, it is worth noting that the West Loch Lomond Cycle Path (Regional Route 40) from Balloch Station enters Tarbet from the south and terminates at Tarbet station. This runs adjacent to the existing A82.

Anecdotal evidence from the stakeholder workshop held on the 2 October 2013 suggested that significant numbers of touring cyclists currently use the A82, despite the lack of facilities currently existing between Tarbet and Inverarnan, particularly during the busy summer tourist season.

Further details will be obtained to inform further studies during DMRB Stage 3.

Footpaths/Footways

The Engineering and Environmental Surveys (2012) identified that intermittent, and in some cases narrow sections of footway and footpath exists along the scheme extents.

A footway is a Non Motorised User (NMU) route adjacent to the road, whereas a footpath is an NMU separate and not adjacent to the road.

These are shown in **Drawings 476416-CF-ZZ-RDZ-DR-RD-0050 to 0061** within Volume 2. These are generally associated with the villages. Current footway and Right of Way arrangements include:

- A footpath on the eastern side of the A82, south of the A82/A83 junction in Tarbet. This footpath continues along the southern side of the A82 east of the junction, separated by grass verge in places. This footpath ends just beyond the 30 mph signage east of Tarbet.
- A footpath on the north side of the A82, in front of the Tarbet Hotel, continuing northwards along the eastern side of the A83

- A footpath on the north side of the A82 to the east of Still Brae, terminating opposite Arrochar Primary School. There is no formal crossing to the school.
- A narrow footway in the west verge extending out of Tarbet for less than 1 km. There is no direct linkage from this to other footways within Tarbet.
- A footpath linking into the hills at Loch Sloy from Inveruglas Water to Inveruglas Visitor Centre. This footpath is noted as a "core path".
- Footpath access into the land to the west at Ardvorlich, although this does not extend along the A82
- Localised footways within Ardlui and a narrow footway extending northwards towards Ardlui Church. There is a Right of Way extending into the land to the west, linking to Ardlui at the railway station.
- Localised footways within Inverarnan and extending a short distance northwards, but not connecting to Rights of Way at Beinglas Farm, which form part of the West Highland Way

2.3.11 Departures from Standards

Alignment

Throughout the route corridor many Departures from Standard (also referred to as Departures) are inherent in the existing alignment and should be addressed if realignment of the existing A82 was to proceed.

The A82/ A83 junction within Tarbet has Departures from current standards within the existing junction arrangement. In particular, they relate to access positions and spacing, alignment, and carriageway cross section. Furthermore the existing crest on the A82 to the south of this junction has a reduced Stopping Sight Distance (SSD) to the junction. These Departures should be addressed should the junction be improved.

Structures

For existing structures, where information is presently lacking or where existing structural elements are considered sub-standard (i.e. parapets, available carriageway widths etc.), Departures or Relaxations from standard may be required during the development of the Stage 3 proposals.

2.3.12 Overtaking Opportunities

The existing A82 has a substantially sub-standard cross-section width and alignment and has a poor accident rate. Much of the carriageway is less than 7.3 m wide and many sections do not have hardstrips or verges.

Owing to topographical constraints and frequent low radius bends, sight visibility is of a poor standard thus, there are no overtaking opportunities between Tarbet and Ardlui, and very limited opportunities between Ardlui and Inverarnan.

2.3.13 Structures

In this section the existing structures between Tarbet and Inverarnan are outlined with their geometric and structural details given, together with their condition and assumed live load capacities. This information has been extracted from the most recent Principal and General Inspection reports held within the Transport Scotland's inventory database, IRIS (Integrated Road Information System).

Where specific structure elements are considered to be non-compliant to current codes of practice, these have been identified.

Bridge Structures

There are nine existing road bridge structures present along the A82 between Tarbet and Inverarnan, and three timber footbridges to accommodate pedestrian traffic.

The locations of existing bridge structures are noted on **Drawings 476416-CF-ZZ-RDZ-DR-RD-0050 to 0061** and also in **Table A.3** in **Appendix A**.

It is noted that many of these bridges cause a width restriction to the A82 between the parapets, with some being less than 6 m.

A82 380 Tarbet Smithy - Ch (Chainage) 200

The existing A82 380 single span masonry arch is situated on a relatively straight section of carriageway approximately 150 m east of Tarbet Hotel. See **Figure 2.3.5**.

Constructed in 1875, the bridge carries the existing A82 across Tarbet Burn. The clear span length is 4.8 m and the arch is assumed to be founded upon spread footings on rock. The span width is 6.0 m with a clear distance between parapets of 5.5 m, causing a constraint for two vehicles to pass.

Although there are no provisions for pedestrians across this structure, access is provided on the south side via an adjacent single span timber footbridge with structure reference A82 381F. This footbridge has an overall width of 2.3 m and a clear width between parapets of 2.0 m. The timber parapets are 1.15 m high.

A second footbridge of possible steel construction is provided on the north side. None of these three structures are noted to be of historical interest.

Figure 2.3.5: A82 380, Tarbet Smithy

The road bridge has reinforced concrete parapets approximately 1.0 m high which taper towards the verges on each approach. There is currently no VRS provided outwith the approaches and consequently no protection to the parapet ends.

The structures inventory indicates the structure has been assessed in 1990 as capable of carrying 38 units of HB loading, as well as the BD 21 standard loading. The actual assessment and supporting documentation for this capacity rating is not available.

The most recent General Inspection reported the structure to be in a reasonable condition, with only minor masonry defects noted.

Tarbet Bridge - Ch 310

Approximately 100 m east of the A82 380 masonry arch bridge there is another structure of similar configuration. See **Figure 2.3.6**.

The structural records of this bridge are not available however given its proximity to the Tarbet Smithy Bridge, it is conceivable they were constructed around the same time with similar techniques. This bridge carries the existing A82 across an unnamed watercourse.

Figure 2.3.6: Tarbet bridge and pedestrian bridge

Masonry parapets approximately 1.0 m high are located on each side and reduce the available carriageway width to 5.7 m. There is currently no VRS provided outwith the approaches and consequently no protection to the parapet ends.

As no records have been made available for this structure neither the capacity nor the condition is known. Records for this structure will be sought as part of the DMRB Stage 3 assessment.

Although there are no provisions for pedestrians, a separate crossing is provided on the south side via an adjacent single span timber footbridge with structure reference A82 382F. This footbridge has an overall length of 7.0 m and width of 2.25 m with a clear distance between parapets of 2.0 m. The timber parapets are 1.15 m high. This footbridge is supported upon reinforced concrete foundations. Neither structure is of historical interest.

A82 390 Inveruglas Water - Ch 5500

The existing A82 390 masonry arch bridge carries the A82 over Inveruglas water and was constructed in 1916 with a 9.0 m span. See **Figure 2.3.7**. The foundations are assumed to be spread footings on rock.

The structure has been widened on the downstream side with a 0.65 m reinforced concrete arch of span 13.5 m. The date of these works is not recorded. The abutments have been constructed on the northern side “in line” and “stepped” on the southern side.

The clear width between parapets is 9.1 m however a metal safety barrier on the structure reduces the trafficable width to 8.1 m.

Figure 2.3.7: A82 390 Inveruglas Water

The bridge deck has solid masonry parapets approximately 1.0 m high. This is deemed by TD 19/06 to be substandard for normal pedestrian protection.

The structure is located on a sharp bend which presents severely restricted forward visibility particularly for southbound traffic. See **Figure 2.3.8**. On the southbound side there is no raised verge present and the cross-section includes a hardstrip margin of only around 300 mm. On this side the masonry parapet follows the curve of the road (left hand bend as travelling southbound).

On the northbound side, the masonry parapet is straight and diverges from the existing carriageway on the southern side with a "pinch point" created on the north side of the deck. A VRS is provided in front of the northbound parapet although this does not appear to have the required clear working width to the masonry behind. Both verges are substantially sub-standard.

Figure 2.3.8: Poor visibility on Inveruglas Water Bridge

The structures inventory indicates that the structure has been assessed in 1990 as capable of carrying 38 units of HB loading, as well as BD 21 standard loading. The actual assessment and report supporting this capacity rating is not available.

The most recent General Inspection reported the bridge to be in fair condition, although general masonry defects were noted. The report also recorded evidence of past vehicle strikes on the masonry parapets.

A82 400 Sloy Tail Race - Ch 6200

The existing A82 400 bridge is located on a relatively straight section of carriageway with reasonable visibility and carries the existing A82 past Loch Sloy power station. See **Figure 2.3.9**.

Constructed in 1948, this two-span reinforced concrete arch spans 12.2 m with spread footing foundations assumed to be on rock. The structure spans the watercourse forming the tail race for the existing power station.

The bridge presently has non-standard solid masonry parapets approximately 1.0 m high. Between the parapets the clear available width is approximately 13.7 m and this contains a surfaced pedestrian verge on the west and a grassed verge on the east with the existing A82 between.

Figure 2.3.9: A82 400 Sloy Tail Race

The structures inventory indicates that the structure was assessed in 1994 as capable of carrying 45 units of HB loading, as well as BD 21 standard loading. The actual assessment and supporting documentation for this capacity rating is not available. The latest General Inspection report stated that the bridge is in good condition and no repair work is recommended.

A VRS is provided on the east verge on the approach to the bridge.

This bridge is a C grade listed structure.

Immediately west of the Sloy Tail Race bridge is a parallel 'bridge-like' structure which acts as a 'baffle' to prevent high-pressure water from hitting the A82 and road bridge when the power station's relief valves are open. See **Figure 2.3.10**.

This is not a trunk road structure therefore no review of its structural capacity has been carried out.

Figure 2.3.10: Sloy Tail Race Baffle

A82 410 Ardvorlich North - Ch 8760

The existing A82 410 bridge, constructed in 1875, carries the A82 over the Allt Ardvorlich watercourse and comprises a 3.7 m single span masonry arch with foundations assumed to be spread footings on rock. The span width is 6.7 m with a clear distance between parapets of 5.5 m. There are no raised verges or provisions for pedestrians. The structure is not noted to be of historical interest. See **Figure 2.3.11**.

Figure 2.3.11: A82 410 Ardvorlich North

The bridge is provided with non-standard solid masonry parapets approximately 0.6 m high, which is less than the required height for normal pedestrian protection in accordance with TD 19/06.

VRS is provided on the north and southbound Departure ends only with none on the approaches. The VRS is not tied into the parapets.

The structures inventory indicates the structure was assessed in 1990 as been capable of carrying 38.4 units of HB loading, as well as BD 21 standard loading. The actual assessment and report supporting this capacity rating is not available.

It was noted within the most recent General Inspection that the bridge was in a reasonable condition, with no repair work recommended.

A82 420 Stuckindroin - Ch 12225

The existing A82 420 bridge is located on a relatively straight section of carriageway and comprises three forms of construction that carry the existing A82 across an unnamed watercourse.

The parent structure, a masonry arch, was constructed in 1875 with a span of 11.1 m. The available records indicate that the structure was widened on the upstream side with a concrete arch of matching profile and span 11.1 m. The date of this extension is unknown. Downstream, a reinforced concrete portal of 14.4 m span was constructed during 2012. The spread footings of the downstream portal are assumed to be founded on rock. See **Figure 2.3.12**.

Figure 2.3.12: A82 420 Stuckindroin

The available width between parapets is approximately 13.0 m, which presently accommodates an 8.0 m carriageway (including hardstrips) between kerbs with 2.5 m verges either side. Were it deemed a requirement for the deck to accommodate a 4.0 m combined verge/ cycleway on the east side, then the required clear deck width would need to increase to 14.5 m necessitating a widening of this structure.

The solid masonry parapets are approximately 1.0 m in height and deemed non-standard in accordance with TD 19/06. See **Figure 2.3.13**.

Figure 2.3.13: A82 420 Stuckindroin

The structures inventory indicates that the bridge was assessed in 1990 as capable of carrying 40.9 units of HB loading, as well as BD21 standard loading. The actual assessment and report supporting this assessment is not available.

A82 430 Strath Dubh-Uisge South - Ch 14060

The existing A82 430 single span masonry arch was constructed in 1875 and carries the existing A82 across the Strath Dubh-Uisge south watercourse.

The clear span length is 5.9 m and the arch is founded upon spread footings on rock. The span width is 6.5 m with a clear distance between parapets of 5.5 m. There are no raised verges or provisions for pedestrians across this bridge. The structure is not noted to be of historical interest. See **Figure 2.3.14**.

Figure 2.3.14: A82 430 Strath Dubh-Uisge South

The bridge is provided with non-standard solid masonry parapets approximately 0.9 m high and is less than the required height for normal pedestrian protection in accordance with TD 19/06. There is currently no VRS provided on the approaches and consequently no protection to the parapet ends.

The structure has been strengthened through the provision of a 0.3 m concrete lining to the original masonry arch and also widened on the west side by approximately 2.0 m with a concrete arch matching the original cross section profile.

The structures inventory indicates that the structure has been assessed in 1990 as capable of carrying 32 units of HB loading, as well as the BD 21 standard loading. The actual assessment and supporting documentation for this capacity rating is not available.

The most recent General Inspection reported the structure to be in a fair condition, although general masonry defects were noted.

A82 440 Strath Dubh-Uisge North - Ch 14135

The existing A82 440 single span masonry arch was constructed in 1875 and carries the A82 across the Strath Dubh-Uisge north watercourse.

The clear span length is 6.37 m and the arch is founded on spread footings upon rock. The span width is 6.4 m with a clear distance between parapets of 5.4 m. There are no raised verges or provisions for pedestrians across this bridge. The structure is not noted to be of historical interest. See **Figure 2.3.15**.

Figure 2.3.15: A82 440 Strath Dubh Uisge North

The bridge is provided with non-standard solid masonry parapets approximately 0.7 m high which is less than the required height for normal pedestrian protection in accordance with TD 19/06. See **Figure 2.3.16**. There is currently no VRS provided on the approaches and consequently no protection to the parapet ends.

Figure 2.3.16: A82 440 Strath Dubh Uisge North

The arch has been strengthened with a 0.37 m deep concrete lining beneath the original masonry arch. It is also widened on the west side by approximately 1.5 m, with a concrete arch which matches the original cross section profile.

The structures inventory indicates that the structure was assessed in 1990 as capable of carrying 40 units of HB loading, as well as the BD 21 standard loading. The actual assessment and supporting documentation for this capacity rating are not available.

The most recent General Inspection reported the structure was in a fair condition, although general masonry defects are noted.

A82 450 Inverarnan - Ch 15790

The existing A82 450 structure is situated on a relatively straight section of carriageway due south of the Drovers Inn and carries the existing A82 across the Allt Arnan watercourse.

Constructed in 1979, the bridge comprises a simply supported reinforced concrete slab upon reinforced concrete abutments. The deck has an 8.0 m clear span with a skew angle of 30°. The foundations comprise spread footings upon natural ground.

A 9.1 m carriageway (including hardstrips) is contained by 1.0 m high vehicle/ pedestrian parapets with full height mesh infill panels. The parapet height is noted to be less than the required height of pedestrian protection in accordance with TD19/06. See **Figure 2.3.17**.

Figure 2.3.17: A82 450 Inverarnan

No record drawings, assessment records or material properties are currently available for Inverarnan Bridge.

Retaining Walls

The structures inventory records approximately 30 gravity retaining walls between Tarbet and Inverarnan. The majority of these retaining structures support the adjacent carriageway and are located below the road, by the loch foreshore. See **Figure 2.3.18**.

Figure 2.3.18: A82 400 W56 Coire Nan Each Retaining Wall

Comprising random masonry construction, the lengths of these walls vary from 14 to 250 m, with average maximum and minimum retained height range between 1.075 and 3.1 m. Structure records note that the majority are in a fair/ good condition although some are in need of repair.

Of particular note are the large retaining walls adjacent to the northbound carriageway at the 'Seven Bends/Sisters'. These are of masonry construction, are assets of Network Rail, and provide support to the elevated West Highland Line.

The location of existing retaining walls is noted on **Drawings 476416-CF-ZZ-RDZ-DR-RD-0050 to 0061** and presented in **Table A.4** in **Appendix A**.

Culverts

Between Tarbet and Inverarnan the existing carriageway crosses approximately 150 culverts of varying diameter and geometric configuration. The location of existing culverts is shown on **Drawings 476416-CF-ZZ-RDZ-DR-RD-0050 to 0061** and in **Table A.5** in **Appendix A**.

These structures in general have an internal diameter less than 0.9 m and comprise a variety of types, including: vitrified clay, masonry, metal and reinforced concrete. They form single or double culverts that facilitate the discharge of water from the hillside into the adjacent loch.

The depth of fill above the culverts varies and the internal profile of the culverts is not always constant.

For many of the culverts, masonry headwalls have been extended vertically to provide parapet containment. In the majority of cases these are deemed to be non-standard in terms of height for pedestrians or cyclists. One such example is a double pipe (0.5 m and 0.25 m) culvert by the A82 423F Ardlui Footbridge. See **Figure 2.3.19**.

Figure 2.3.19: Double pipe culvert by the A82 423F Ardlui Footbridge

The available information suggests the condition of these culverts varies from good to fair, with defects noted such as cracked pipes and deteriorating masonry.

2.3.14 Drainage

Along the route from Tarbet to Inverarnan informal drainage paths generally convey runoff from the existing road surface either to filter drains or culverts or directly into the loch/ River Falloch. The existing drainage can be broadly grouped into two forms:

- South of Pulpit Rock there are limited longitudinal cut-off drains, filter drains and open drainage channels located at the bottom of steep hillsides and rock outcrops. The drainage in this area is characterised by direct run-off from the hillside onto the carriageway.
- North of Pulpit Rock, over-the-edge drainage is used, although this is poorly performing as a result of shallow height above the flood plains, with flood waters frequently encroaching on to the carriageway. See **Figure 2.3.20**.

Figure 2.3.20: Flooding on the A82 at Garabal

Drainage from the west side of the A82 passes below the carriageway via a series of culverts and outfall either directly into Loch Lomond or large expanses of marsh land adjacent to the River Falloch in the north of the study area. These culverts also convey an extensive network of high energy watercourses, which drain the woodlands and rough pasture on the hillsides to the loch.

Road drainage within the curtilage of the village of Tarbet is provided via a positive drainage network. No records are available at this stage and a full drainage survey should be carried out as part of the DMRB Stage 3.

2.3.15 Watercourses

A large number of watercourses are present within the scheme extents, generally flowing from west to east to either Loch Lomond or the River Falloch. There are over 150 existing culvert crossings and 10 bridge crossings on the A82 within the preferred corridor extent. The most significant water features identified along the proposed route of the scheme are noted below.

Loch Lomond

Loch Lomond covers an area of approximately 71 km^2 and has a catchment area of approximately 696 km^2.

It is the largest UK inland freshwater body by surface area and is classified as a large raised reservoir under the Reservoirs Act 1975.

Loch Lomond discharges to the River Leven to the south and the normal operating water level is maintained between 7.8 m AOD and 9.0 m AOD by a barrage positioned across the River Leven. The barrage enables the water level in the loch to be controlled to facilitate Scottish Water abstractions for drinking water. The loch is designated as a Drinking Water Protection Zone under the Water Framework Directive (WFD).

The loch is used for a variety of commercial, recreational and amenity purposes including fishing, swimming and boating.

River Falloch

The River Falloch is one of the main tributaries of Loch Lomond and has a catchment area of approximately 108 km². The catchment is essentially rural and includes several small lochans. The northern section of the existing A82 between Ardlui and Inverarnan is generally outwith the 200 year flood extent of the River Falloch, although one or two locations are shown as being partially within the 200 year flood extent according to the SEPA Flood Maps. Further discussion of the SEPA Flood Maps is provided in Section 4.4.

Inveruglas Water

Inveruglas Water has a catchment area of approximately 33 km². The catchment is essentially rural and includes Loch Sloy and a number of small lochans. Inveruglas Water is classified by SEPA as 'heavily modified' due to the Loch Sloy dam and associated hydro-power generating scheme.

Geal Loch and Dubh Lochan

According to Scottish Natural Heritage (SNH), Geal Loch and Dubh Lochan are 'oligotrophic' and groundwater dependant loch features. They are located to the north of Loch Lomond in an extensive area of saturated marshland or 'mire' and are both designated Sites of Special Scientific Interest (SSSI).

Other Watercourses

A significant number of smaller watercourses and existing drainage crossings within the preferred corridor area will be assessed in greater detail as the scheme develops. They will be considered in a detailed flood risk assessment for the selected route option at DMRB Stage 3.

2.3.16 Geology and Geomorphology

Solid and drift geology have been researched from available geological mapping, historic borehole records, geological guides and memoirs.

This information has been supplemented with findings from both non-intrusive and intrusive geotechnical surveys carried out as part of this Stage 2 assessment.

A non-intrusive rock outcrop survey was carried out along the A82, examining exposed rock faces and recording rock discontinuity data (orientation of joints and fractures).

A preliminary ground investigation was also carried out to inform the route options assessment. This preliminary ground investigation was carried out between October and December 2014 and involved cable percussion boreholes, rotary drilled holes and machine excavated trial pits. See **Figure 2.3.21**.

Figure 2.3.21: Ground Investigation

Drift Geology

The 1:625,000 scale online Geology of Britain viewer, available on the BGS website, indicates the presence of Glacial Till or Diamicton locally throughout the study area and Alluvium along the River Falloch floodplain from Ardlui to the northern most part of the route. There are also significant areas where drift is shown to be absent or has not been mapped.

The 1:50,000 scale online geology of Britain viewer on the BGS website shows drift deposits to be largely not mapped, with relatively isolated areas of River

Terrace Deposits comprising Gravel, Sand, Silt and Clay at Glen Loin and Tarbet.

The 1:25,000 scale BGS superficial geology map shows the geology of the area to just south of Ardlui. There is no geology mapping available at this scale south of this point.

Alluvial Fan Deposits comprising Gravel, Sand, Silt and Clay are present at the mouths of rivers or larger burns, for example at Inveruglas and just south of Ardlui.

North of Ardlui recent geological mapping indicates that mainly Moundy Glacial Deposits are present comprising Diamicton and sand and gravel, although there are areas of Till in the form of Diamicton in the north of the study area.

The Glacial Deposits are interspersed with sands and gravels deposited in Glaciofluvial Fans, Glaciofluvial Sheets and in River Terraces.

There are some localised areas of shallow rock and Head Deposits and there are localised areas of peat.

The types of materials encountered in the recent ground investigations are broadly as indicted on relevant geological maps and in the Preliminary Sources Study Report (PSSR). In general terms, the distribution of material is a little different from that suggested in desk based research (although it is recognised that some information was lacking at this stage).

The thickness of superficial deposits is also generally greater than anticipated south of Ardlui. There were also sporadic deposit of thick peat (up to 4.0 m) encountered particularly close to the loch shores, south of Ardlui.

Solid Geology

The study area lies to the north of the Highland Boundary Fault which cuts through Loch Lomond in a south west/ north east orientation some 15 km south of Tarbet.

This fault separates the younger sedimentary and igneous rocks in the Midland Valley of Scotland from the older predominantly metamorphic rocks of the Scottish Highlands.

From Tarbet to Ardlui the solid geology mainly comprises Dalradian metamorphic rocks (circa 540-1,000 million years old) belonging to the Southern Highland group indicated by the geological map to comprise the Beinn Bheula Schist Formation – which is described as a sequence of Psammite and Pelite.

The metamorphic rocks contain a number of younger igneous intrusions of Permo-Carboniferous and Lower Devonian and Upper Silurian Age.

The Permo-Carboniferous intrusions are approximately west-east orientated Quartz-Tholeiite dykes which are often several kilometres long.

The Lower Devonian intrusions are generally north-south orientated porphyritic dykes of Felsite and more rarely Lamprophyre and are generally less than 1 km long.

There are also localised intrusions of Lower Devonian –Upper Silurian rocks comprising Breccias, Diorites, Granodiorites and Gabbros for example at the northern end of Glen Loin and south of Ardlui.

North of Ardlui, more recent geological mapping is available which indicates that the solid geology also mainly comprises Dalradian metamorphic rocks belonging to the Southern Highland Group indicated to comprise the Ben Ledi Grit Formation. These rocks are largely metamorphosed sandstones, varying from fine to coarse grained in nature which are locally pebbly and are interbedded with pelites and semi pelites. This Ben Ledi Grit Formation also locally includes metamorphosed Volcaniclastic rocks, including para-amphibolites, hornblendic, epidotic and chloritic psammites and semi pelites.

There are similar younger minor igneous intrusions in the form of dykes as noted south of Ardlui. There is also a much larger area of Devonian and Silurian Age igneous rock termed the Glen Fyne Pluton occupying Garabal Hill to the north west of Ardlui. These rocks include Granodiorite, Diorite, Gabbro and Pyroxenite.

The solid geology encountered by the recent ground investigation was generally as anticipated from desk based research with Schist and Psammitic strata predominating where bedrock was encountered.

Geomorphology

The geomorphology of the study area largely results directly or indirectly from glaciation, which most recently affected the area some 10,000 to 13,000 years ago, however some post glacial features are also evident locally.

The ice left the smoothed bedrock surfaces, 'hanging' valleys and steep, land-slipped valley sides which are present in the study area.

Local land slippage is noted on the east side of Glen Loin, with more minor features noted circa 0.5 to 2 km west of the Loch from Inveruglas northwards.

Over its history, Loch Lomond has fluctuated between sea and fresh water in nature, in response to changing sea levels following the end of glaciation.

Around 13,000 years ago, as the ice melted, Loch Lomond became an arm of the sea. As overall uplift of the land continued, following ice removal, sea level fell rapidly and by 11,000 years ago lay at around the present level or below.

With the onset of glaciation again between 10,000 and 11,000 years ago, marine conditions again ensued. In the last 10,000 years the loch has fluctuated between marine and freshwater, with a more significant marine phase between 6,800 and 5,500 years ago, which has left the remnants of a series of former shorelines at 9, 12 and 13 m above sea level.

Recent alluvium has formed fans locally where rivers enter the loch such as the Inveruglas Water and more generally in floodplains or sheets for example along the River Falloch.

2.3.17 Lighting

Street lighting and illuminated signs are provided within the verge and at the back of footpath along the existing A82 in Tarbet. Further street lighting, in addition to illuminated bollards, are provided at the junction with the A83 in Tarbet.

No other form of road lighting is provided between Tarbet and Inverarnan.

2.3.18 Communications

No trunk road communication apparatus is provided along this section of the A82.

2.3.19 Public Utilities

Preliminary studies carried out by Amey indicated that a number of public utilities are present within the current A82 corridor.

In order to confirm the presence and locations of these utilities as part of this assessment, a request was made for utility information under procedure C2 of the New Roads and Street Work Act 1991 (NRSWA). C2 requests were sent to the following utilities companies in October 2013:

- Applied Traffic
- Argyll and Bute Council
- BEAR Scotland
- BP NSI
- **British Telecom**
- Cable & Wireless (incl. Thus)
- Forestry Commission
- Gamma Telecom
- Hutchison 3G
- Ineos
- Loch Lomond & Trossachs National Park
- National Grid
- Network Rail
- Orange
- Premier Transmission
- **Scottish & Southern Energy**
- Scottish Gas Networks
- **Scottish Power**
- **Scottish Water**
- Serco
- Shell UK Exploration & Production
- Stirling Council
- The Gas Transportation Company
- Traffic Scotland
- TrafficMaster
- Transco
- Virgin Media

Utilities companies that responded indicating the presence of plant within the study area are indicated in **bold** text.

The locations of these utilities are shown on **Drawings 476416-CF-ZZ-RDZ-DR-RD-0050 to 0061** provided in Volume 2.

Electricity

The local electricity distribution network within the study area is operated by Scottish & Southern Energy (SSE).

South of Tarbet, overhead (OH) electricity lines run parallel to the A82, approximately 100 m to 250 m west of the road, with occasional OH road crossings.

North of the A82/ A83 Tarbet junction, OH distribution lines run along the toe of the West Highland Line embankment, terminating near the Home on the Loch Cafe. Underground (UG) cables generally provide power to properties at both sides of the A82 through numerous road crossings.

At Inveruglas, a SSE subsea line crosses Loch Lomond to provide power to the village through OH lines and to mobile phone masts in the area through UG connections.

SSE OH distribution lines originating at Sloy Hydro Station provide power to properties to the west of the A82 at Ardvorlich.

South of Pulpit Rock, an SSE OH line crosses to the west of the West Highland Line. OH lines provide power to properties to the west of the A82 at Burnside.

At Ardlui, UG cables connecting to this line provide electricity supply to both sides of the A82 with numerous road crossings.

North of Ardlui Church, the line crosses to the east of the West Highland Line, with OH connections providing power to both sides of the A82.

At Inverarnan, north of Drovers Inn, the line crosses to the east of the A82, with OH lines serving the properties to this side of the road.

In addition to its local distribution network, SSE operates transmission lines through the study area. These are associated with Sloy Power Station, which is part of the Scottish Power Sloy Awe scheme.

These overhead transmission lines run to the west of the A82, towards Arrochar and then along Loch Long.

The SSE transmission lines terminate at Sloy Power station, approximately 70 m west of the A82, north of Inveruglas. Further distribution lines continue north, approximately 4 km west of the A82. See **Figure 2.3.22**.

Figure 2.3.22: Transmission Lines at Sloy Power Station

Scottish Power (SP) also operates transmission lines through the study area. Just south of Inverarnan, these lines enter a substation immediately to the west of the A82. From this substation, lines continue north between the A82 and the West Highland Line, northwest to the west of the railway, and southeast across the A82 and the River Falloch.

Telecommunications

The existing telecommunications network within the study area is provided by British Telecom (BT).

South of the A82/A83 Tarbet junction, BT apparatus comprises overhead cables located directly to the west of the A82 carriageway, within the verge. Properties to the east of the carriageway are served through a mix of overhead and underground crossings. See **Figure 2.3.23**.

Within Tarbet village, along both the A83 and the A82, BT apparatus is present underground within the road. It is unclear whether this apparatus is located in the east or west verge, footways or carriageway. It is likely the plant crosses the carriageway at various locations.

North of Tarbet, BT apparatus typically comprises overhead cables located to the east of the existing A82, within the verge, with multiple overhead crossings to serve properties located to the west of the A82.

BT have advised that a fibre optic cable may be located within Loch Lomond and is believed to enter the loch at Tarbet and run within the loch to Ardlui. BT have been unable to confirm its presence or location at present and further investigation will be required at Stage 3.

Figure 2.3.23: Overhead telecoms in eastern verge

Scottish Water

Properties in and around Tarbet village are served by a Scottish Water (SW) potable water supply and SW sewer lines.

South of Tarbet, a SW water main is present in the east verge of the A82.

At the A82/ A83 Tarbet junction, a SW water main is present in the west verge of both roads. A SW combined sewer is present within the carriageway.

North of the A82/A82 Tarbet junction, a SW combined sewer is present in the footway to the east of the A82, continuing past Arrochar Primary School, where it crosses the A82 and terminates at the junction with the Old Military Road.

A SW water main is present in the footway to the east of the A82 and then in the carriageway itself, terminating at the access to Ben Cruach Lodge, south of Clattochbeg.

No other locations within the study area are served by public water or sewage supplies.

A number of properties are served by private water supply and further investigation will be carried out in the next Stage.

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3. Description of Route Options

3.1 Introduction

Following the completion and recommendations of the DMRB Stage 1 Assessment, Transport Scotland advised that route options should be developed along the existing road corridor and these were to be taken forward to DMRB Stage 2 reporting.

The route corridor is constrained both by the natural features of the hillside and loch and also the rail line and existing villages. An initial review of potential routes considered this and identified areas where there may be a potential to consider an off-line section away from the existing road.

Various route alignments and sub-options within these alignments were drafted for consideration by the project team and an initial sift of unsuitable options made in consideration of environment and engineering.

As part of this process, environmental opportunities and constraints were identified and opportunities and constraints drawings produced. These drawings formed the basis for discussions and alterations of the alignments (where necessary) based on environmental grounds. This was an iterative process and ensured that issues were adopted early in the route options development.

Opportunity and constraints drawings can be found in **Drawings 476416-CF-ZZ-LZ-DR-L-0010 to 0020** and **0060 to 0070** (DMRB Stage 2 Environmental Report; Volume 2 – Drawings).

To carry out a comparative assessment of the route options between Tarbet and Inverarnan it was necessary to combine the identified offline sections into single route options covering the 17 km route. As multiple options and combinations of routes could be made, it was considered impractical to assess them all.

As a result, four route options were selected that combined similar principles.

The four mainline route options have been considered as shown in **Figure 3.1** and described in the sections below:

- Route Option 1 – On-line route
- Route Option 2 – On-line route with inland sections
- Route Option 3 – On-line route with over loch sections
- Route Option 4 – Option with least bends

Figure 3.1: Route Options (Not to scale)

3.2 Do Minimum

The Do-Minimum scenario comprises the structural maintenance schemes included in the Operating Company's 3-year programme from 2014 to 2017. There are currently no planned interventions within the study area.

3.3 Route Option 1

Route Option 1 is illustrated in **Drawings 476416-CF-RO1-RDZ-DR-RD-0001 to 0012**.

Route Option 1 utilises much of the existing A82 road corridor between Tarbet and Inverarnan.

Between Tarbet and Inveruglas, Route Option 1 generally follows the existing road alignment, with the following exceptions:

- South of the Home on the Loch Cafe, for approximately 300 m, the alignment is to the west of the existing A82.
- North of Blairannaich, for approximately 500 m, the alignment is to the west of the existing A82.
- South of Inveruglas Water, for approximately 300 m, the alignment is to the west of the existing A82.
- At Inveruglas Water, for approximately 250 m, the alignment is to the east of the existing A82, and crosses over the river on a new structure.
- In Inveruglas, Route Option 1 ties into either side of the existing road bridge structure (C grade listed) that crosses the outfalls from the Loch Sloy power station.

Between Inveruglas and Pulpit Rock, Route Option 1 generally follows the existing road alignment, with the following exceptions:

- At Creag an Arnain (Seven Bends/Sisters), for approximately 400 m, the alignment is to the east of the existing A82, and runs along the side of the loch on a new viaduct.
- To the north of Creag an Arnain (Seven Bends/Sisters), for approximately 250 m, the alignment is to the east of the existing A82 road, supported by a large retaining wall structure.
- At Tom na h-Innse, for approximately 250 m, the alignment is to the west of the existing A82.

Near Pulpit Rock, the alignment ties into either side of the new viaduct structure.

Between Pulpit Rock and north of Inverarnan, Route Option 1 generally follows the existing road alignment, with the following exceptions:

- North of Pulpit Rock, for approximately 300 m, the alignment is to the west of the existing A82.
- At McGregor's Landing, for approximately 400 m, the alignment is to the west of the existing A82.
- South of Inverarnan, for approximately 300 m, the alignment is to the east of the existing A82.
- North of Inverarnan, for approximately 100 m, the alignment is to the east of the existing A82.

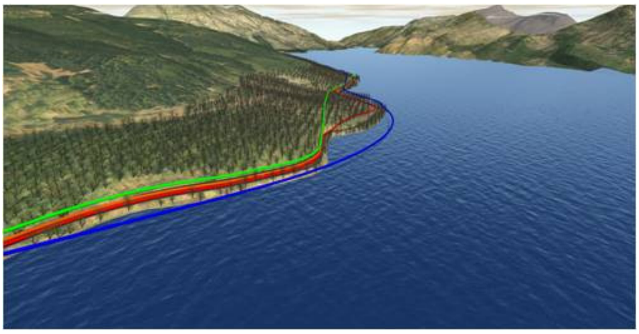


Figure 3.2: 3D visualisation of route options (North of Tarbet)

3.4 Route Option 2

Route Option 2 is illustrated in **Drawings 476416-CF-RO2-RDZ-DR-RD-0001 to 0012**.

Route Option 2 is similar to Route Option 1, but incorporates several sections of road that are realigned to the west of the existing A82.

Between Tarbet and Inveruglas, Route Option 2 generally follows the Route Option 1 alignment with the following exceptions:

- From the boatyard in Tarbet, for approximately 500 m, it follows an alignment to the west of the existing A82 road.
- To the south of Blairannaich, for approximately 500 m, the alignment is to the west of the existing A82 road and the Home on the Loch Cafe.
- At Inveruglas Water, for approximately 300 m, the alignment is located to the east of the existing A82 road, and crosses over the river on a

new structure (and to the east of the Route Option 1 alignment).

Between Inveruglas and Pulpit Rock, Route Option 2 generally follows the Route Option 1 alignment, with the following exceptions:

- At Tom na h-Innse, for approximately 400 m, the alignment is to the west of the existing A82.
- At Ardvorlich, for approximately 300 m, the alignment is to the west of the existing A82.

Between Pulpit Rock and north of Inverarnan, Route Option 2 generally follows the Route Option 1 alignment, with the following exceptions:

- At Ardlui Hotel, for approximately 300 m, the alignment is to the west of the existing A82.
- At Ardlui Church, for approximately 900 m, the alignment is to the east of the existing A82.

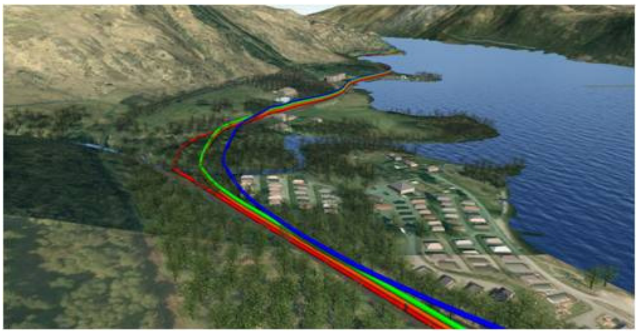


Figure 3.3: 3D visualisation of route options (Inveruglas)

3.5 Route Option 3

Route Option 3 is illustrated in **Drawings 476416-CF-RO3-RDZ-DR-RD-0001 to 0012**.

Route Option 3 is similar to Route Option 1, but incorporates several sections of road that are realigned to the east of the existing A82. Of particular note is that the route option includes a number of sections located over the loch.

Between Tarbet and Inveruglas, Route Option 3 generally follows the Route Option 1 alignment, with the following exceptions:

- To the south of Blairannaich, for approximately 500 m, the alignment is located to the west of the existing A82 road and the Home on the Loch Cafe.
- At Inveruglas Water, for approximately 200 m, the alignment is located to the east of the existing A82 road (and to the east of the Route Option 1 alignment), and crosses over the river on a new structure.

Between Inveruglas and Pulpit Rock, Route Option 3 generally follows the Route Option 1 alignment, with the following exceptions:

- South of Tom na h-Innse, for approximately 600 m, the alignment is located to the east of the existing A82, and runs along the loch on a new viaduct.
- At Ardvorlich, for approximately 300 m, the alignment is to the east of the existing A82 road, and runs along the loch on a new viaduct.

Between Pulpit Rock and north of Inverarnan Route Option 3 generally follows the Route Option 1 alignment, with the following exceptions:

- At Ardlui Hotel, for approximately 300 m, the alignment is to the west of the existing A82.
- At Ardlui Church, for approximately 500 m, the alignment is to the west of the existing A82.

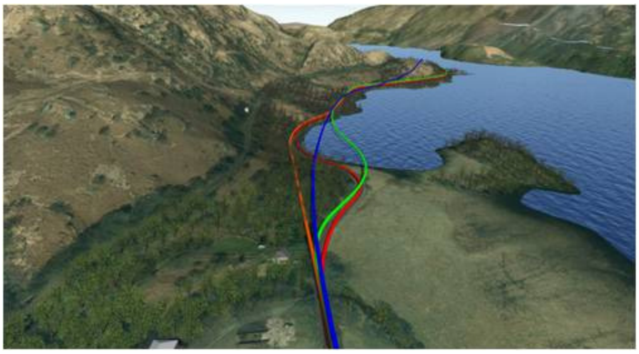


Figure 3.4: 3D visualisation of route options (Ardvorlich)

3.6 Route Option 4

Route Option 4 is illustrated in **Drawings 476416-CF-RO4-RDZ-DR-RD-0001 to 0012**.

Route Option 4 shares several similarities with Route Option 2 and Route Option 3, but also offers a number of additional improvements to the overall alignment.

Between Tarbet and Inveruglas, Route Option 4 follows an alignment as follows:

- From the northern extent of Tarbet, for approximately 300 m, the alignment runs to the west of the existing A82 (and to the east of Route Option 2).

- From the Tarbet Isle to Inverhoulin, for approximately 900 m, the alignment is to the east of the existing A82 road, and runs along the loch on a new viaduct.
- At Blairannach, for approximately 200 m, the alignment is to the east of the existing A82.
- North of Blairannach, for approximately 700 m, the alignment is to the west of the existing A82. Immediately north of this, for approximately 250 m, the alignment is to the east of the existing A82 road.
- Near Kenmore Wood, for approximately 400 m, the alignment is to the west of the existing A82.
- To the south of Inveruglas Water, for approximately 400 m, the alignment is located to the east of the existing A82 road, and runs along the loch on a new viaduct.
- At Inveruglas Water, for approximately 400 m, the alignment is located to the east of the existing A82 road, and Route Options 2 and 3, and crosses over the river on a new structure.

Between Inveruglas and Pulpit Rock, Route Option 4 follows an alignment as follows:

- At Creag an Arnain (Seven Bends/Sisters), for approximately 450 m, the alignment is to the east of the existing A82, and runs along the loch on a new viaduct. Immediately north of this location, for approximately 200 m, the alignment is located to the west of the existing A82.
- North of Creag an Arnain (Seven Bends/Sisters), for approximately 300 m, the alignment is to the east of the existing A82. Immediately north of this, at Tom na h-Innse, for approximately 200 m, the alignment crosses back over to the east of the existing A82 and runs along the loch on a new viaduct.
- At Ardvorlich, for approximately 200 m, the alignment is to the west of the existing A82. Immediately north of this location, for approximately 300 m, the alignment is situated to the east of the existing A82 road, and runs along the loch on a new viaduct.
- To the south of Pulpit Rock, for approximately 200 m, the alignment is to the east of the existing A82 road, and runs along the loch on a new viaduct. Immediately to the north of this location, for approximately 600 m, the alignment is located to the west of the existing A82.

Between Pulpit Rock and north of Inverarnan, Route Option 4 follows an alignment generally as Route Option 1 with the following exception:

- North of Pulpit Rock, for approximately 350 m, the alignment is located to the west of the existing A82 road.

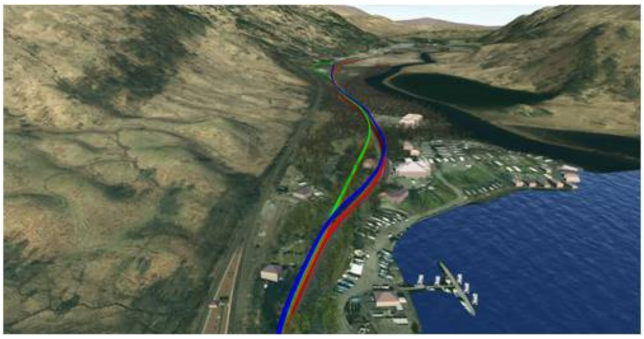
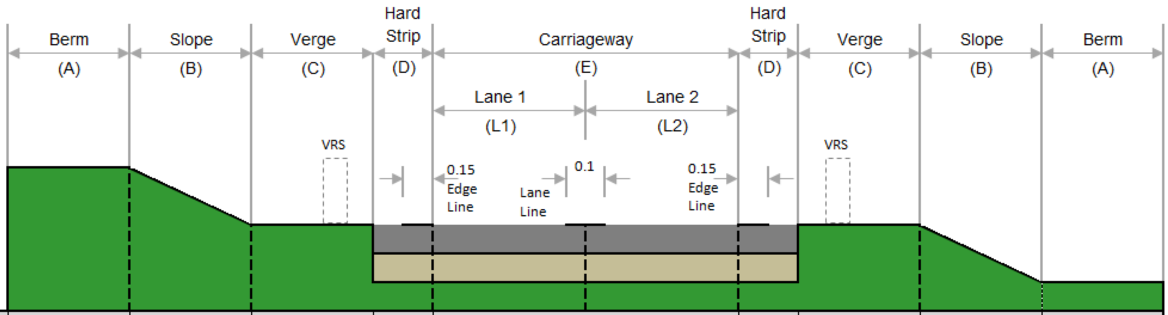


Figure 3.5: 3D visualisation of route options (Ardlui)

3.7 Tarbet Junction

The following improvement options have been considered for the existing junction between the A82 and A83 trunk roads in Tarbet village. These options are illustrated in **Drawing 476416-CF-ZZ-RDZ-DR-RD-0016**.

- Changed Priority: major/ minor priority T-junction with ghost island, reconfiguring the existing layout with the A82 as the major road and the A83 as the minor road. Improvements are also proposed to the A83 bend opposite the Tarbet tearoom.
- Roundabout: Providing a 4-arm normal roundabout. Improve the A83 bend opposite the tearoom.
- Priority changed and junction relocated: major/ minor priority T-junction with ghost island reconfiguring the existing layout, with the A82 as the major road and the A83 as the minor road. The junction is also relocated to the east of the Tarbet Hotel.



Road Type	A	B	C	D	E		D	C	B	A
					L1	L2				
Single (S2)	Vaires	Varies	2.50	1.00	6.00		1.00	2.50	Varies	Varies
					3.00	3.00				

Figure 3.6: S2 carriageway cross section

- Signal controlled junction on the existing 3-arm T-junction layout. Improvements also made to the A83 bend opposite the Tarbet tearoom.

The Do Minimum option, (not shown on the drawing) would retain the existing junction layout with minor improvements to geometry and provision for NMUs and improved accessibility.

The operation of the existing junction has been reviewed and is considered to be satisfactory. It is noted however, there are records of collisions at the junction and several known Departures from standard have been identified.

However, considering the potential development plans for Tarbet, which includes commercial/ business and residential proposals, we would currently only recommend the Do Minimum option. As such, these junction options are not assessed in detail within this report. This will be reviewed further as part of the DMRB Stage 3 assessment, and will also consider the needs of all road users and seek to provide safe facilities for NMU’s.

3.8 Carriageway Cross Section

The carriageway cross section being assessed in all route options is a rural all-purpose single carriageway (S2) in accordance with DMRB TD27/05 and as outlined in **Figure 3.6**.

The carriageway width being assessed is 6 m with 1 m hardstrips either side.

The design year traffic flow is forecast to be less than 5,000 AADT (in comparison with present AADT of 3500), accordingly, in Scotland it is permissible under the DMRB standards to provide a 6 m wide carriageway.

1 m hardstrips are provided on either side of the carriageway to facilitate additional overrun facilities, driver comfort, pavement integrity and to assist maintenance.

The carriageway would also be widened on corners in accordance with TD 9/93.

It is noted that some stakeholders consulted during Stage 2, have requested that the carriageway width be increased to 7.3 m. A 7.3 m wide carriageway with 1 m hardstrips will also be considered during DMRB Stage 3.

The nominal verge width is 2.5 m and this would accommodate a VRS. In addition to this, the verge widths are increased in places as follows:

- The left-hand verge is increased to 3.5 m in places to accommodate a combined rock trap and swale where necessary.
- The right-hand verge is increased to 4.5 m to accommodate a 2 m wide footway/cycleway.
- The verge would also be increased to provide required sight lines in accordance with TD9/93.

Drawing 476416-CF-ZZ-RDZ-DR-RD-0062 provides additional detail of the cross sections assessed.

The cross section within Tarbet is constrained by existing properties on either side of the Trunk Road. The cross section within Tarbet will retain a pedestrian facility and consideration on the location of a cycle facility will be made during the DMRB Stage 3 assessment.

3.9 Accommodation works

It is expected that accommodation works will be required for a number of properties and field accesses along the route. This may include the stopping up and/ or rationalising of existing accesses and provision of new accesses. Further consideration will be given to this at the next Stage of design.

3.10 Preliminary Cost Estimate of Route Options

3.10.1 Introduction

The following section provides a preliminary cost estimate for the route options.

3.10.2 Cost Estimate Assumptions

Indicative cost estimates for the route options have been prepared using Spon's 2015 Civil Engineering and Highway Works Price Book.

The cost estimates prepared are based on the material quantities required for each route and include preliminaries, earthworks, road construction and structures. While Spon's listed costs for most of the materials and operations required, costs for a number of specific items which were not listed were taken from comparable projects.

The preface to Spon's 2015 states that rates are based on general review of all prices up to May/ June 2014. Cost estimates have therefore been prepared at Quarter 2, 2014 prices.

An independent cost estimate of the options was carried out by Benchmark Estimating which has enabled some adjustments to be made.

In preparing cost estimates, certain assumptions have been made:

- Preparation at 9 % of Construction Cost (including preliminaries and land).
- Supervision at 5 % of Construction Cost (including preliminaries and land).
- Non-recoverable VAT has been added for construction activities outside of Ministers land ownership.
- 10 % of cut earthworks are unsuitable for re-use.
- Unsuitable materials and surplus earthworks are transported to a distant land fill.
- An allowance for up to 2 km of carriageway overlay has been made although generally, full reconstruction of the road is provided.
- Utility diversion costs have been supplied by relevant utilities.
- An allowance for land cost has been made.
- The quantities and volumes used are based on topographic surveys undertaken during Stage 2 and indicative designs developed. These figures will be subject to change while the design develops.
- An allowance for ground improvement has been made based on the preliminary ground investigations carried out during Stage 2. This will be subject to change during the development of the design.
- Further consideration of environmental mitigation costs and landscaping requirements will be required as the design develops in subsequent Stages.
- No allowance has been made for maintenance of any sections of existing road that are bypassed by the route options.
- It should be noted that due to the difficult terrain and particular constraints of the route corridor the estimates may have a high degree of variability.

The cost estimate also allows for Optimism Bias. Optimism Bias is the demonstrated systematic tendency for appraisers to be overly optimistic about key parameters. For this reason uplift is applied to the risk adjusted cost. The uplift applied is dependent upon the nature of the scheme and its stage of development.

Due to the constraints of this route corridor and the particular construction requirements (including working within water) an uplift of 44 % has been applied for both roads and structures.

3.10.3 Cost Estimate

Table 3.1 provides a summary of the total capital costs including construction, preparation, supervision, non-recoverable VAT and Optimism Bias for each route option at Q2 2014 prices. Costs are also expressed as a range of -5 % (low end) to +25 % (high end) of the scheme total.

For use in the DMRB Stage 2 Traffic and Economic assessment report non-recoverable VAT and the cost range is removed. **Table 3.2** provides these costs at Q2 2014 prices with an adjusted Optimism Bias.

Assuming an annual 4.4 % construction price inflation, and a portioned spend over three years the cost range including Non-recoverable VAT and Optimism Bias in the estimated 2020 opening year would be as presented in **Table 3.3.**

Table 3.1: Outline Scheme Cost Estimate Range at Q2 2014 prices (incl. non-recoverable VAT)

		Route Option 1	Route Option 2	Route Option 3	Route Option 4
Preliminaries (25 %)		£24.61 m	£31.57 m	£32.84 m	£56.30 m
Roadworks		£37.14 m	£39.76 m	£38.02 m	£41.98 m
Structures		£34.32 m	£30.57 m	£63.55 m	£102.31 m
Earthworks		£25.62 m	£54.49 m	£28.49 m	£79.59 m
Utilities		£0.58 m	£0.66 m	£0.59 m	£0.41 m
Other Works		£0.60 m	£0.63 m	£0.54 m	£0.70 m
Land Costs		£0.17 m	£0.19 m	£0.17 m	£0.21 m
Preparation & Supervision (14 %)		£17.22 m	£22.10 m	£22.99 m	£39.41 m
Non-Recoverable VAT		£18.45 m	£23.68 m	£24.63 m	£42.22 m
Construction Phase Total (incl. Non-Recoverable VAT)		**£158.71 m**	**£203.65 m**	**£211.82 m**	**£363.13 m**
Optimism Bias (44 %)		£69.83 m	£89.61 m	£93.20 m	£159.78 m
Scheme Total Range (incl. Optimism Bias)	**Low End (-5 %)**	**£217.12 m**	**£278.60 m**	**£289.77 m**	**£496.77 m**
	Total	**£228.54 m**	**£293.26 m**	**£305.02 m**	**£522.91 m**
	High End (+25 %)	**£285.68 m**	**£366.57 m**	**£381.28 m**	**£653.64 m**

Table 3.2: Outline Scheme Cost Estimate Range at Q2 2014 prices (excl. non-recoverable VAT)

	Route Option 1	Route Option 2	Route Option 3	Route Option 4
Preliminaries (25 %)	£24.61 m	£31.57 m	£32.84 m	£56.30 m
Roadworks	£37.14 m	£39.76 m	£38.02 m	£41.98 m
Structures	£34.32 m	£30.57 m	£63.55 m	£102.31 m
Earthworks	£25.62 m	£54.49 m	£28.49 m	£79.59 m
Utilities	£0.58 m	£0.66 m	£0.59 m	£0.41 m
Other Works	£0.60 m	£0.63 m	£0.54 m	£0.70 m
Land Costs	£0.17 m	£0.19 m	£0.17 m	£0.21 m
Preparation & Supervision (14 %)	£17.22 m	£22.10 m	£22.99 m	£39.41 m
Construction Phase Total (excl. Non-Recoverable VAT)	**£140.26 m**	**£179.97 m**	**£187.19 m**	**£320.91 m**
Optimism Bias (44 %)	£61.71 m	£79.19 m	£82.36 m	£141.20 m
Scheme Total for Economic Assessment (incl. Optimism Bias)	**£201.97 m**	**£259.16 m**	**£269.55 m**	**£462.11 m**

Table 3.3: Outline Scheme Cost Estimate Range at opening year (incl. Inflation at 4.4 % and non-recoverable VAT)

Route Option	Low End	High End
Route Option 1	£259.11 m	£340.93 m
Route Option 2	£332.47 m	£437.47 m
Route Option 3	£345.81 m	£455.02 m
Route Option 4	£592.84 m	£780.05 m

3.11 Scheme Procurement

The procurement strategy will be influenced by the extent of risk deemed acceptable to Scottish Ministers/ Transport Scotland in relation to:

- time
- cost
- quality

Discussions between Transport Scotland and CFJV have yet to consider these aspects.

There are various contract options that can be used to procure the scheme, each having its own advantages and disadvantages compared to others.

As yet, no decision has been made on which option to adopt or which form of associated payment mechanism should be used. Consideration of the procurement methodology will be given during the course of Stage 3.

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4. Engineering Assessment

4.1 Introduction

This section of the report provides the engineering assessment of the route options. In line with headings outlined in the DMRB, Volume 5, Section 1, Part 2, TD 37/93 topics such as: engineering standards, structures, ground conditions, hydrology and drainage and public utilities have been evaluated.

This section also broadly considers the 'buildability' of the route options.

4.2 Engineering Standards

As the context of this report is the identification of broadly defined route corridors, the designs have not been progressed in sufficient detail to consider compliance with all current DMRB design standards. However, the alignments for route corridor options have been developed taking cognisance of the following DMRB design standards:

- TD 9/93 Highway Link Design
- TD 16/07 Geometric Design of Roundabouts
- TD 27/05 Cross-Sections and Headrooms
- TD 41/95 Vehicular Access to All Purpose Trunk Roads
- TD 42/95 Geometric Design of Major/Minor Priority Junctions
- TA 46/97 Traffic Flow Ranges for Use in the Assessment of New Rural Roads

Further design work will be undertaken on the preferred route option as part of the DMRB Stage 3 Assessment.

The design hierarchy described in DMRB permits Relaxations to be introduced at the discretion of the designer, where they can be justified on environmental and economic grounds without adversely affecting safety and level of service.

In situations of exceptional difficulty, which cannot be overcome by Relaxations, it may be necessary to apply for a Departure from Standard.

Departures from Standard must be approved by the Overseeing Organisation (Transport Scotland in this instance) before being incorporated into the design layout.

Design speed, road layout and junction provision are discussed in further detail in this chapter.

4.3 Engineering Descriptions of Route Options

Four different route options have been designed and assessed as part of this report:

- Route Option 1 – On-line route
- Route Option 2 – On-line route with inland sections
- Route Option 3 – On-line route with over loch sections
- Route Option 4 – Option with least bends

All four route options include on-line improvements of the existing A82 road through the village of Tarbet.

The following sections provide an engineering description of each route option as they progress northwards from Tarbet towards Inverarnan. Refer to Chapter 3 and the engineering drawings noted, in the following sections.

4.3.1 Route Option 1

Route Option 1 is illustrated in **Drawings 476416-CF-RO1-RDZ-DR-RD-0001 to 0012**. This route option is 16.85 km in length.

Route Option 1 is primarily an on-line alignment, generally following the route of the existing A82 along the shores of Loch Lomond.

Within Tarbet the route will follow the existing road alignment. This alignment is identical in all four route options.

Between Tarbet and Blairannaich, the route option is particularly constrained by the topography and numerous bends are provided with radii of 180 m or less, including several with radius of 90 m. The vertical alignment generally follows a gently undulating profile with typical gradients less than 1 %.

Between Blairannaich and Inveruglas the topography follows a more free flowing alignment, with bends opening up to radii of 180 m, 255 m and 360 m. A ghost-island T-junction is proposed at the entrance to the Loch Lomond Holiday Park.

To the south of Inveruglas Water, the route option follows an initial uphill gradient of 5 % before reducing to 3 %. Following the Inveruglas Water crossing, the route option descends at a gradient of 3% to tie-in with the existing bridge structure over the Sloy Power Station outfall.

From Inveruglas to Ardvorlich the route option includes several relatively straight sections, albeit separated by a number of bends with radii of 90 m and in one instance a bend with radius of 60 m. A ghost-island T-junction is proposed at the entrance to the Inveruglas Visitor Centre car park.

The route option continues northwards beyond Ardvorlich to Pulpit Rock by way of several bends with radii ranging from 60 m to 255 m.

The route option tends to follow a gently undulating profile between Inveruglas and Pulpit Rock and includes gradients of up to approximately 2.6 %.

North of Pulpit Rock the route option turns through a right-hand bend with radius of 90 m. However, beyond this location, and extending to the north of Inverarnan, the existing road is less constrained by the topography and the route option features straights of several hundred metres and allows sympathetic use of bends with radii typically 255 m or greater.

From Stuckindroin to the south of Ardlui, where the route option runs adjacent to the existing railway line, the alignment climbs uphill using a gradient of approximately 2 % to an elevation of approximately 23 m AOD. Elsewhere between Pulpit Rock and north of Inverarnan the route option tends to follow a gently undulating profile using gradients up to 1 %.

A ghost-island T-junction is proposed at the entrance to the Ardlui Marina and Holiday Park. At the village of Inverarnan a staggered T-junction with ghost islands is proposed at the access to the Drovers Inn and associated facilities.

Cross Section

Route Option 1 has a standard single carriageway section (S2) throughout, as described in TD 27/05 ‘Cross Sections and Headrooms’.

The carriageway width is 6 m as permitted in Scotland for rural single carriageway roads with an AADT of less than 5000 as per TD 27/05. Hardstrips measuring 1 m wide are provided on each side to all sections of routes classified as rural, with the exception of Tarbet where no hardstrips are provided.

The minimum verge width throughout is 2.5 m as per TD 27/05.

The verge to the east of the route option has been widened to provide opportunity for a 2 m wide shared footway/ cycleway along the route with the verge to the west being widened to allow for SuDS (Sustainable Drainage Systems) provision and/ or rock traps as required. Verge widening has been applied at numerous locations to provide the required SSD to the higher object height.

Horizontal Alignment

Route Option 1 generally follows an on-line route coincident with the alignment of the existing A82 within the chosen corridor, and hence the horizontal alignment includes several bends with radii below the desirable minimum and with limited use of transition curves.

Where possible, the bends present on the existing A82 have been improved and a minimum radius of 90 m has been adopted, while remaining generally within the existing A82 corridor as it follows the loch shore line. However, to the north of Coire Nan Each (Ch 8007) a 60 m radii curve has been used to follow the shoreline and minimise encroachment into the loch.

At Inveruglas Water (Ch 5450), the existing bridge structure is situated within an alignment comprising a series of bends, the smallest of which has a radius of approximately 30 m.

The existing Inveruglas Water bridge has been the location of a number of recorded incidents in the past, including bridge strikes (refer to Section 2.3.13).

Route Option 1 proposes to replace this existing bridge (Ref. A82 380) with a new structure with a radius of 127 m.

The route also deviates off-line at a location between the West Highland Line viaduct at the 'Seven Bends/Sisters' and the loch shore line (Ch 7100).

At this location, an existing series of six bends of sub-standard radius will be replaced by a straight viaduct structure within Loch Lomond.

Details of proposed structures are included in Section 4.4 of this report.

Vertical Alignment

The vertical alignment of Route Option 1 closely follows that of the existing A82, which generally follows the natural topography of the loch shore between Tarbet and Pulpit Rock.

The proposed alignment is generally at or just above existing A82 levels, with the road specifically raised at strategic locations to accommodate watercourse crossings.

The alignment has been designed with a minimum proposed road level of 11.075 m (Ch 9170.0) to reduce flood risk from Loch Lomond, the River Falloch and other watercourses located in the vicinity of the A82. The road rises to a maximum level of 29.863 m immediately north of the Loch Lomond Holiday Park access, south of the Inveruglas Water bridge.

The maximum gradient present is 5 %, over a short distance (Ch 4930.9 to 4984.8). The recommended minimum longitudinal gradient of 0.5 % is not achieved in all locations due to the natural flat topography of the loch shore edge. Over-edge drainage is therefore proposed to mitigate locations where the minimum longitudinal gradient is not achieved (locations listed in **Table B.1** in **Appendix B**).

The minimum crest value in Route Option 1 is K=-30.00 and the minimum sag value is K=20.00

The design will be developed during DMRB Stage 3 to ensure adequate drainage of the carriageway through appropriate application of crossfall and design of drainage solutions.

Consideration of improvements to the existing crest on the A82 to the south of the Tarbet junction, will also be made.

Anticipated Departures from Standard

The anticipated Departures from Standard and Relaxations associated with horizontal or vertical geometry, and SSD have been identified for comparative purposes using the proposed alignment information shown on the route option drawings. They exclude Departures from Standard where the existing alignment is unaltered or any Departures associated with the separate Pulpit Rock scheme.

It is worth noting that a number of the Departures from Standard result from reduced geometry and SSD occurring in combination.

Horizontal Geometry:

- 26 no. Departures
- 26 no. Relaxations

Vertical Geometry:

- 3 no. Departure
- 4 no. Relaxations

SSD

- 44 no. Departures
- 31 no. Relaxations

The horizontal geometry has been used to determine the corresponding level of applied transition curves and superelevation with Departures from Standards likely to be required.

It is anticipated that provision of VRS will be necessary within verges and that this will influence the number of resultant additional SSD Departures to the low object height. **Table B.1** in **Appendix B** contains a summary of Relaxations and Departures from Standard associated with vertical and horizontal alignment and Stopping Sight Distance.

Earthwork Volumes

Approximate earthworks volumes are provided below. Further breakdown of these figures is provided in **Appendix C**.

Cut Volume:	387,000 m^3 (52 %)
	(Rock: 262,000 m^3, Other: 125,000 m^3)
Fill Volume:	362,000 m^3 (48 %)
Surplus Volume:	25,000 m^3
Maximum cut height:	17.1 m

Maximum fill/Retained height: 13.0 m

4.3.2 Route Option 2

Route Option 2 is illustrated in **Drawings 476416-CF-RO2-RDZ-DR-RD-0001 to 0012**. This route option is 16.65 km in length.

Route Option 2 is a similar alignment to Route Option 1, with certain off-line sections situated through the hillside to the west of the existing A82 and to the east of the West Highland Line. Where Route Option 2 differs from Route Option 1, this is described in detail below.

The route option turns through a left-hand bend with radius of 510 m and passes between the Clattochbeg cottage and Ben Cruach Lodge. This is followed by a straight section of approximately 190 m in length as the route option passes through a cutting before returning to the on-line alignment.

To the south of Blairannach the route option follows a straight of approximately 450 m in length, passing to the west of the Home on the Loch Cafe. The off-line section returns to the on-line alignment with a right-hand bend with radius of 510 m.

At Inveruglas Water, Route Option 2 passes to the east of the existing road (and the alignment proposed in Route Option 1), via a right-hand bend with radius of 255 m (compared to a radius of 127 m used for Route Option 1).

To the south of Ardvorlich House B&B, the route option passes to the west of the existing A82, creating a cutting through the hillside. This off-line section utilises radii of 510 m and 720 m separated by a straight approximately 85 m in length.

To the north of Ardvorlich House B&B, the route option passes to the west of the existing road close to the railway line, creating a cutting through the hillside. This allows a straight section, approximately 270 m in length to be created off-line.

In Ardlui, adjacent to the hotel and to the west of the existing road, the route option creates a straight approximately 305 m in length.

Immediately north of the former Ardlui Church building, Route Option 2 is located to the east of the existing road, where it crosses two consecutive watercourses. This improves the existing horizontal and vertical alignment and would allow the new watercourse crossings to be constructed off-line.

Cross Section

The cross section for Route Option 2 is the same as Route Option 1.

Horizontal Alignment

Where the horizontal alignment of Route Option 2 differs from Route Option 1, this is described below:

- Between Ch 380 and Ch 880, Route Option 2 deviates to the west of the existing A82, into the hillside. This removes a series of sub-standard bends and replaces them with a single curve with a radius of 510 m, followed by a transition and a straight section.
- Between Ch 1650 and Ch 2225, Route Option 2 deviates to the west of the existing A82, cutting into the adjoining hillside, west of Inverhoulin and east of Blairannaich. This removes three sub-standard bends and replaces them with a straight and a right-hand curve with a radius of 510 m.
- Between Ch 5225 and Ch 5475, the existing bridge carrying the A82 over Inveruglas Water will be replaced by a new bridge located to the east of the existing A82. This will be made possible by the introduction of a radius of 255 m, which will be an improvement over both the existing radius and the 127 m radius provided on Route Option 1.
- Between Ch 7850 and Ch 8550, Route Option 2 deviates to the west of the existing A82, into the hillside at Tom-na h-Innse. This removes a series of sub-standard bends and replaces them with a right-hand curve with a radius of 510 m and a left-hand curve with a radius of 720 m with appropriate transitions.
- Between Ch 12600 and Ch 14250, Route Option 2 deviates to the west of the existing A82 in Ardlui. This removes a series of sub-standard bends and replaces them with larger radius curves with appropriate transitions.

Route Option 2 has been designed with a minimum radius of 90 m.

Vertical Alignment

Where the vertical alignment of Route Option 2 differs from Route Option 1, this is described as follows:

- Between Ch 380 and Ch 880, Route Option 2 deviates to the west of the existing A82. The gradient over this section is limited to 2 % with a crest of K=-55.0, requiring significant cut into the hillside.
- Between Ch 1650 and Ch 2225, Route Option 2 deviates to the west of the existing A82, west of Inverhoulin and east of Blairannaich. The gradient over this section is limited to 5 % with a crest of K=-55.0, requiring significant cut into the hillside.
- Between Ch 5225 and Ch 5475, it is proposed to replace the existing bridge carrying the A82 over Inveruglas Water with a new bridge with a crest of K=-55.0 and the gradient limited to 5.9 %.
- Between Ch 7850 and Ch 8550, Route Option 2 deviates to the west of the existing A82, into the hillside at Tom-na h-Innse. The gradient over this section is limited to 5 % with a crest of K=-30.0 and K=-55.0.
- Between Ch 12600 and Ch 14250, Route Option 2 deviates to the west of the existing A82 in Ardlui. The gradient over this section is limited to 2 % with minimum crests of K=-55.0.

The minimum proposed road level is 11.067 m (Ch 8900.0) to reduce flood risk from Loch Lomond, the River Falloch and other watercourses located in the vicinity of the A82.

The road rises to a maximum level of 29.841 m immediately north of the Loch Lomond Holiday Park access, south of the Inveruglas Water bridge.

The maximum gradient present in Route Option 2 is 5.5 %, over a short distance (Ch 7972.2 to 8284.1). The recommended minimum longitudinal gradient of 0.5 % is not achieved in all locations due to the natural flat topography of the loch shore edge. Over-edge drainage is therefore proposed to mitigate locations where the minimum longitudinal gradient is not achieved (locations listed in **Table B.2** in **Appendix B**).

The design will be developed during DMRB Stage 3 to ensure adequate drainage of the carriageway through appropriate application of crossfall and design of drainage solutions.

Consideration of improvements to the existing crest on the A82 to the south of the Tarbet junction, will also be made.

The minimum crest value in Route Option 2 is K=-17.00 and the minimum sag value is K=20.00.

Anticipated Departures from Standard

The anticipated Departures from Standard and Relaxations associated with horizontal or vertical geometry, and SSD have been identified for comparative purposes using the proposed alignment information shown on the route option drawings. They exclude Departures from Standard where the existing alignment is unaltered or any Departures associated with the separate Pulpit Rock scheme.

It is worth noting that a number of the Departures from Standard, result from reduced geometry and SSD occurring in combination.

Horizontal Geometry:

- 15 no. Departures
- 22 no. Relaxations

Vertical Geometry:

- 6 no. Departures
- 5 no. Relaxations

SSD

- 45 no. Departures
- 38 no. Relaxations

In comparison with Route Option 1, Route Option 2 has 11 less horizontal, 3 more vertical and 1 more SSD Departure.

The horizontal geometry has been used to determine the corresponding level of applied transition curves and superelevation with Departures from Standard likely to be required.

It is anticipated that provision of VRS will be necessary within verges and that this will influence the number of SSD Departures to the low object height. **Table B.2** in **Appendix B** contains a summary of Relaxations and Departures from Standard associated with vertical and horizontal alignment and Stopping Sight Distance.

Earthwork Volumes

Cut Volume:	655,000 m^3 (65 %) (Rock: 513,000 m^3, Other: 142,000 m^3)
Fill Volume:	352,000 m^3 (35 %)
Surplus Volume:	303,000 m^3
Maximum cut height:	21.6 m
Maximum fill/Retained height:	13.4 m

4.3.3 Route Option 3

Route Option 3 is illustrated in **Drawings 476416-CF-RO3-RDZ-DR-RD-0001 to 0012**. This route option is 16.78.km in length.

Route Option 3 is similar to Route Option 1 with certain off-line sections situated to the east of the existing A82 and out into the loch. Where Route Option 3 differs from Route Option 1, this is described below.

To the south of Blairannaich, the route option follows a straight of approximately 450 m in length, passing to the west of the Home on the Loch Cafe. The off-line section returns to the on-line alignment with a right-hand bend with radius of 510 m.

At Inveruglas Water, Route Option 3 passes to the east of the existing road (and the alignment proposed in Route Option 1), via a right-hand bend with radius of 255 m (compared to a radius of 127 m used for Route Option 1).

To the south of Ardvorlich, the route option passes to the east of the existing road, running on a viaduct along the loch. This allows for an improved alignment, with a right hand bend with radius of 510 m followed by a left hand bend with radius of 270 m in length, to be created off-line.

To the north of Ardvorlich, the route option passes to the east of the existing road, running on a viaduct along the loch. This allows for an improved alignment, with a left hand bend with radius of 255 m followed by a right hand bend with radius of 510 m in length, created off-line.

In Ardlui, adjacent to the hotel and to the west of the existing road the route option creates a straight approximately 305 m in length.

North of Ardlui, the route passes to the west of the former Ardlui Church building, where it crosses two consecutive watercourses. This improves the existing horizontal and vertical alignment and would allow the new river crossings to be constructed off-line.

Cross Section

The cross section for Route Option 3 is the same as Route Option 1.

Horizontal alignment

Where the horizontal alignment of Route Option 3 differs from Route Option 1, this is described below:

- Between Ch 1675 and Ch 2300, Route Option 3 deviates to the west of the existing A82, into the hillside, west of Inverhoulin and east of Blairannaich. This removes three sub-standard bends and replaces them with a straight and a right-hand curve with a radius of 510 m.
- Between Ch 5300 and Ch 5600, it is proposed to replace the existing bridge carrying the A82 over Inveruglas Water with a new bridge located to the east of the existing A82. This will include the introduction of a 255 m radius, which will be an improvement over both the existing geometry and the radius of 127 m provided on Route Option 1.
- Between Ch 7650 and Ch 8250, Route Option 3 deviates to the east of the existing A82, over Loch Lomond at Tom-na h-Innse. This will remove a series of sub-standard bends replacing them with a right-hand curve with a radius of 510 m, a left-hand curve with a radius of 360 m, including appropriate transitions.
- Between Ch 8850 and Ch 9250 Route Option 3 deviates to the east of the existing A82, over Loch Lomond at Ceann Mor. This removes a series of sub-standard bends and replaces them with a left-hand curve with a radius of 255 m and a right-hand curve with a radius of 510 m.
- Between Ch 12750 and Ch 14250, the route deviates to the west of the existing A82 in Ardlui. This removes a series of sub-standard bends and replaces them with larger radius curves with appropriate transitions.

Route Option 3 has been designed with a minimum radius of 90 m.

Vertical Alignment

Where the vertical alignment of Route Option 3 differs from Route Option 1, this is described below:

- Between Ch 1675 and Ch 2300, Route Option 3 deviates to the west of the existing A82, west of Inverhoulin and east of Blairannaich. The gradient over this section is limited to 5.0 % with a crest of K=-55.0, requiring significant cut into the hillside.
- Between Ch 5300 and Ch 5600, the existing bridge carrying the A82 over Inveruglas Water is proposed to be replaced with a new bridge with a crest of -55.0 and the gradient limited to 5.0 %.
- Between Ch 7650 and Ch 8250, Route Option 3 deviates to the east of the existing A82, over Loch Lomond at Tom-na h-Innse. The gradient over this section is limited to 5.0 %.
- Between Ch 8850 and Ch 9250 Route Option 3 deviates to the east of the existing A82, over Loch Lomond at Ceann Mor. The gradient over this section is limited to 5.0 % with crests of K=-100.0, and K=-55.0.
- Between Ch 12750 and Ch 14250, Route Option 3 deviates to the west of the existing A82 in Ardlui. The gradient over this section is limited to 1.8 % with crests of K=-55.0 and K=-120.0.

The minimum proposed road level is 11.096 m (Ch 9510.0) to reduce flood risk from Loch Lomond, the River Falloch and other watercourses located in the vicinity of the A82.

The road rises to a maximum level of 29.763 m immediately north of the Loch Lomond Holiday Park access, south of the Inveruglas Water bridge.

The maximum gradient present in Route Option 3 is 4.6 %, over a short distance (Ch 7430.2 to 7462.5). The recommended minimum longitudinal gradient of 0.5 % is not achieved in all locations due to the flat natural topography of the loch shore. Over-edge drainage is therefore proposed to mitigate locations where the minimum longitudinal gradient is not achieved (locations listed in **Table B.3** in **Appendix B**).

The design will be developed during DMRB Stage 3 to ensure adequate drainage of the carriageway through appropriate application of crossfall and design of drainage solutions.

Consideration of improvements to the existing crest on the A82 to the south of the Tarbet junction, will also be made.

The minimum crest value in Route Option 3 is K=-17.00 and the minimum sag value is K=20.00.

Anticipated Departures from Standard

The anticipated Departures from Standard and Relaxations associated with horizontal or vertical geometry, and SSD have been identified for comparative purposes using the proposed alignment information shown on the route option drawings. They exclude Departures from Standard where the existing alignment is unaltered or any associated with the separate Pulpit Rock scheme.

It is worth noting that a number of the Departures from Standard result from reduced geometry and SSD occurring in combination.

Horizontal Geometry:

- 19 no. Departures
- 24 no. Relaxations

Vertical Geometry:

- 4 no. Departures
- 5 no. Relaxation

SSD:

- 38 no. Departures
- 49 no. Relaxations

In comparison with Route Option 1, Route Option 3 has 7 less horizontal, 1 more vertical and 6 less SSD Departures.

The horizontal geometry has been used to determine the corresponding level of applied transition curves and superelevation with Departures from Standard likely to be required.

It is anticipated that provision of VRS will be necessary within verges and that this will influence the number of SSD Departures to the low object height. **Table B.3** in **Appendix B** contains a summary of Relaxations and Departures from Standard associated with vertical and horizontal alignment and SSD.

Earthwork Volumes

Cut Volume: 412,000 m^3 (55 %)
(Rock: 300,000 m^3, Other: 112,000 m^3)

Fill Volume: 331,000 m^3 (45 %)

Surplus Volume: 81,000 m^3

Maximum cut height: 21.6 m

Maximum fill/retained height: 14.0 m

4.3.4 Route Option 4

Route Option 4 is illustrated in **Drawings 476416-CF-RO4-RDZ-DR-RD-0001 to 0012**. This route option is 16.52.km in length.

Route Option 4 is located to both the east and west of the existing A82, within the corridor between the West Highland Line and the loch and includes large sections of viaducts over the loch. The route option adopts criteria in general accordance with the DMRB standards.

Cross Section

The cross section for Route Option 4 is the same as Route Option 1.

Horizontal alignment

Route Option 4 is a generally an off-line alignment curving to the east and west of the existing A82 as required to produce a generally compliant design (Departures limited to tie-ins), with short on-line sections.

Route Option 4 has been designed with a minimum radius of 127 m.

The route option begins with an off-line radius of 255 m left-hand bend just south of Clattochbeg, before following the existing on-line route between Ch 950 and Ch 1200.

At Ch 1200, the proposed route continues in a straight line, running on a viaduct along the loch, then curving back towards the shore with a left-hand radius of 510 m curve.

Between Ch 2000 and Ch 2100, Route Option 4 follows an on-line alignment, before cutting across the shallower waters of the loch with a right-hand curve with a radius of 360 m and transitions through Ch 2350.

A long left-hand curve of over 1 km length and a radius of 2040 m then takes the road to the west of existing alignment, cutting through the hillside in a near straight line before returning on-line near Ch 3400.

From this point, another left-hand bend with a radius of 2040 m (1.4 km in length) takes the alignment more or less straight through the hillside to the west of the existing A82 through Ch 4000, and then over Loch Lomond between Ch 4550 and Ch 4850, before returning to an on-line alignment.

At Ch 5400, Route Option 4 crosses Inveruglas Water via a proposed new bridge with a radius of 360 m, this will be an improvement over both the existing arrangement and that proposed in Route Option 1 2 and 3.

Route Option 4 continues on-line, with the listed Sloy Power station bridge structure at Ch 6100 being retained.

At Ch 6550, the route deviates just to the east of the existing A82, before sweeping across the loch with a right-hand curve with a radius of 360 m just south of Creag an Arnain.

A left-hand curve with a radius of 360 m then cuts into the hillside, requiring geotechnical engineering works in order not to impact on the West Highland Line.

Between Ch 7425 and Ch 7950, Route Option 4 is supported on a viaduct before continuing into the hillside to the west of the existing A82 with a left-hand curve with a radius of 510 m at Tom na h-Innse.

From Ch 8200 to Ch 8550, Route Option 4 follows an on-line alignment before continuing approximately straight into the hillside, and by then over the loch by means of a right-hand curve with a radius of 2040 m through Ch 9200.

At Ch 9200, the route curves onto the loch shore by means of a right-hand curve with a radius of 510 m. This is followed by a left-hand bend with a radius of 510 m that cuts into the rock outcrop at Creag a Phuirt, before tying in on-line south of Pulpit Rock (Ch 10140).

Route Option 4 ties into Pulpit Rock at Ch 10360, with a right-hand bend with a radius of 127 m. It then continues just to the west of the existing road alignment before tying in at Ch 10700.

Route Option 4 continues on-line until the end of the scheme, north of Inverarnan.

Vertical Alignment

The minimum proposed road level is 11.003 m (Ch 550) to reduce flood risk from Loch Lomond, the River Falloch and other watercourses located in the vicinity of the A82.

The road rises to a maximum level of 30.004 m immediately north of the Loch Lomond Holiday Park access, south of the Inveruglas Water bridge.

The maximum gradient present is 5.4 %, over a short distance (Ch 9424.9 to 9991.2. The recommended minimum longitudinal gradient of 0.5 % is not achieved in all locations due to the natural flat topography of the loch shore edge. Over-edge drainage is therefore proposed to mitigate locations where the minimum longitudinal gradient is not achieved (locations listed in **Table B.3** in **Appendix B**).

The design will be developed during DMRB Stage 3 to ensure adequate drainage of the carriageway through appropriate application of crossfall and design of drainage solutions.

Consideration of improvements to the existing crest on the A82 to the south of the Tarbet junction, will also be made.

The minimum crest value in Route Option 4 is K=-30.00 and the minimum sag value is K=20.00.

Anticipated Departures from Standard

The anticipated Departures from Standard and Relaxations associated with horizontal or vertical geometry, and SSD have been identified for comparative purposes using the proposed alignment information shown on the route option drawings. They exclude Departures from Standard where the existing alignment is unaltered or any associated with the separate Pulpit Rock scheme.

It is worth noting that a number of the Departures from Standard result from reduced geometry and SSD occurring in combination.

Horizontal Geometry:

- 2 no. Departures
- 20 no. Relaxations

Vertical Geometry:

- 0 no. Departures
- 7 no. Relaxations

SSD:

- 8 no. Departures
- 23 no. Relaxations

In comparison with Route Option 1, Route Option 4 has 24 less horizontal, 3 less vertical and 36 less SSD Departures.

The horizontal geometry has been used to determine the corresponding level of applied transition curves and superelevation with Departures from Standard likely to be required.

It is anticipated that provision of VRS will be necessary within verges and that this will influence the number of SSD Departures to the low object height. **Table B.4** in **Appendix B** contains a summary of Relaxations and Departures from Standard associated with vertical and horizontal alignment and SSD.

Earthwork Volumes

Cut Volume: 887,000 m^3 (70 %)
(Rock: 792,000 m^3, Other: 95,000 m^3)

Fill Volume: 377,000 m^3 (30 %)

Surplus Volume: 510,000 m^3

Maximum cut height: 33.6 m

Maximum fill/Retained height: 15.0 m

4.3.5 Overtaking Opportunity

The previously mentioned challenging topography associated with the route, specifically along the edge of the Loch, means that overtaking opportunities are limited within the extents of the scheme.

The overtaking opportunity provided by each of the route options has been assessed based on the road being classified as Category 2 (a Single carriageway 2, lane road with 1 m hardstrips) for the purposes of determining the applicable minimum overtaking value of 30 % (Table 7, TD 9/93). This minimum overtaking value should be applicable in each direction for the length of the road improvement, with overtaking sections distributed along the length of the road improvement.

Based on the design speed of 85 kph the Overtaking Sight Distance has been assessed to be 490 m. **Table 4.1** provides a summary of the overtaking values applicable to each of the route options. The results are low for all route options due to the unique, constrained topography of the route corridor.

Following the identification of a preferred route option, opportunities to increase the overtaking provision will be reviewed in detail to maximise the overtaking value during Stage 3.

Should the overtaking value not achieve 30 %, then a Departure will be necessary.

Table 4.1: Summary of Overtaking Values

Route Option	Overtaking Value	
	NB	SB
1	9 %	9 %
2	10 %	10 %
3	8 %	9 %
4	12 %	12 %

4.3.6 Junctions and Accesses

Junctions

All four route options have been developed with several "Ghost Island" junctions included. These are referenced on **Drawings 476416-CF-RO1-RDZ--DR-RD-0001 to 0012, 476416-CF-RO2-RDZ-DR-RD-0001 to 0012, 476416-CF-RO3-RDZ-DR-RD-0001 to 0012** and **476416-CF-RO4-RDZ-DR-RD-0001 to 0012** and referenced as follows:

- AC20 (Loch Lomond Holiday Park)
- AC32 (Inveruglas Visitor Centre)
- AC55 and AC56 (Ardlui Hotel and Ardlui Marina Holiday Park)
- AC69, AC70 and AC71 (Drovers Inn, Drovers Lodge and Residential)
- AC74 (Beinglas Farm Campsite)

A summary of the junctions and accesses is included in **Table C.1** in **Appendix D**.

As these are considered junctions, Relaxations below 1.5 times the desirable minimum SSD are not permitted on their approaches, however, the results from junction turning counts collected during late summer 2014 will be used to inform the Stage 3 preferred alignment design, and whether the junctions should be considered as accesses. Should junctions be considered appropriate then the DMRB Stage 3 design will be carried out seeking to remove any Departures relating to SSD.

By referencing TD 42/95 entitled "Geometric Design of Major/ Minor Priority Junctions", the "X" distance associated with junction visibility is likely to be relaxed at a number of locations from 9.0 m to 4.5 m, and in exceptionally difficult circumstances, further relaxed to 2.4 m. There are therefore no anticipated Departures associated with a reduction in "X" distance.

Accesses

The detail of all accesses will be developed during DRMB Stage 3, following the identification of a preferred route option. For this DMRB Stage 2 Assessment, a number of the accesses (listed in **Table C.1** in **Appendix D**) considered "significant" have been subjected to a preliminary Engineering review in terms of levels and visibility.

Subject to the preferred route selected, further consideration will be required for access to some sections of bypassed and detrunked sections of redundant A82.

Due to the presence of villages along the route, the intention is to relax the "X" distance from 4.5 m to 2.4 m, and possibly to 2.0 m in difficult circumstances; however, it should be possible to provide sufficient visibility at all accesses without any Departures resulting from a "X" distance below 2.0 m.

For all of the accesses reviewed during this DMRB Stage 2, the provision of a dwell area and appropriate gradient has been considered.

As there are a number of properties abutting the carriageway, a Relaxation to an "X" distance of 4.5 m is likely to be necessary in a number of circumstances where the design year forecast for the access does not exceed 500 AADT. For lightly used accesses such as those serving a single dwelling or a small cul-de-sac of a half a dozen dwellings, the set back "X" may be reduced to 2.4 m as a Relaxation. In the case of lightly used accesses where the site conditions are particularly difficult, then the set back

"X" may be reduced to 2.0 m as a Relaxation.

In certain instances, such as AC02 (Blairannaich) where the existing access does not meet current design standards due to the steep gradient and absence of dwell area, compliant accesses will be developed during DMRB Stage 3 for the preferred route option. Once all of the accesses have been developed during DMRB Stage 3 any Departures associated with gradients and dwell areas will be identified.

A number of existing accesses are sited such that their visibility requirements encroach onto those of adjoining accesses. Examples where this situation occurs include:

- Home on the Loch (AC16) and Blairannaich (AC17)
- Residential property (AC28 and AC29) and Sloy Power Station (AC30).
- Ardvorlich House (AC36) and Ardvorlich Cottage (AC37).
- Ardlui Hotel (AC55) and Ardlui Marina Holiday Park (AC56).
- Drovers Lodge Car Park (AC69), residential (AC71) and Rose Cottage B&B (AC72).

At Stage 3 a rationalisation exercise will be carried out, which may propose the relocation of certain accesses, while others may be combined where appropriate to provide a single point of access. Although it should be possible to mitigate the encroachment of visibility requirements onto adjacent accesses during Stage 3 there may be a residual requirement for Departures.

4.3.7 Laybys and Rest Areas

Laybys

In carrying out the DMRB Stage 2 assessment a

number of 'type A' laybys have been proposed based on the requirements noted in TD 16/07. These laybys are listed in **Table 4.2** as well as being indicated on the route option drawings.

For a single carriageway, with a two-way annual average daily traffic flow between 2,500 and 8,000, the recommended layby spacing is between 5 km and 8 km.

By including the use of the current public parking facility within Tarbet, this means that over the 17 km of the route there is a minimum requirement for three layby locations in both directions. This assessment does not take account of the potential to reuse any discontinued sections of the existing A82 or facilities at existing businesses located along the route that serve passing trade.

A number of potential parking locations suggested by the LLTNPA have also been considered when identifying the layby locations listed in **Table 4.2** as part of this Stage 2 assessment.

The provision of additional laybys will assist in meeting the objective to provide appropriate stopping opportunities.

During the DMRB Stage 3 assessment the opportunity to use discontinued sections of the existing A82 and existing businesses will be explored. Also, there are currently no proposed bus laybys or maintenance hardstandings, but the requirement to provide these will be reviewed at DMRB Stage 3.

Table 4.2: Location of Laybys

Ref.	Route Option 1 Chainage	Route Option 2 Chainage	Route Option 3 Chainage	Route Option 4 Chainage	Direction (NB / SB)
LB01	2470	2390	2450	2450	NB
LB02	4340	4240	4300	4270	SB
LB03	6830	6730	6780	7720	NB
LB04	8550	8370	8500	8350	SB
LB05	11530	11340	11430	11200	NB
LB06	14310	14120	14230	13980	SB

As previously mentioned, a number of accesses considered "significant" have been assessed, with the remainder to be included in the development of the preferred alignment during DMRB Stage 3.

In accordance with TD69/07, it is appreciated that the separation between a layby and a junction or access, both upstream and downstream, must be at least 3.75*V* metres (where *V* is the design speed of 85kph for the scheme), which equates to a spacing of approximately 319 m. All laybys will require a Departure from Standard. Route Option 1 has a layby that would require a Departure as a result of not achieving the necessary SSD on the southbound approach, the remaining laybys would require a Departure due to their proximity to accesses.

Although it should be possible to mitigate the Departure associated with laybys during Stage 3 there may be a residual requirement for Departures.

Rest Areas

According to DMRB guidance "Rest Areas are to be provided in addition to laybys, at not more than 45 km intervals and at no more than 30 minutes driving time apart, on each side of the road".

In the case of the A82 it is appreciated that there are a number of local businesses located within the route corridor that could be considered to provide amenities associated with a rest area. These businesses include the Home on the Loch Cafe, Inveruglas Visitor Centre, Ardlui Hotel and Drovers Inn.

Possible rest areas located in communities on the approaches to the Scheme that offer facilities including accommodation, shop, bars and restaurants include:

- Crianlarich - located approximately 10.3 km north of Inverarnan
- Luss - located approximately 13.5 km south of Tarbet
- Arrochar - located approximately 3 km west of Tarbet

4.4 Preliminary Consideration of Structures

4.4.1 Introduction

Within this section a general overview is provided of the structure requirements between Tarbet and Inverarnan for each of the four route options proposed.

Where individual structures are described, only generic details are provided, as further detail will be developed and provided in the DMRB Stage 3 Report following development of the preferred route option.

All new structures will comply with the DMRB and it is not envisaged that any Departures from Standard will be required at this stage of the scheme development for those proposed. For existing structures which will be retained, Departures may be required but these have not been investigated at this Stage in the scheme development. It is envisaged that within Stage 3 these possible Departure requirements will become more apparent.

The structure proposals outlined here are based on adopting concrete construction, either cast in-situ or precast where span lengths permit, as this is generally perceived to be the most cost effective type of construction.

Where larger spans cannot be avoided, steel concrete composite construction may be proposed. Where the opportunity presents itself, the intention will be to retain, as far as possible, existing structures and widen them.

In addition, wherever possible, integral construction (i.e. no bearings) has been proposed to minimise long term maintenance costs. This could be used for structures which do not exceed 60 m in length or where the skew does not exceed 30 degrees.

In other cases, bearings and movement joints will be provided in conjunction with abutment inspection galleries where integral construction is not deemed appropriate.

The location of structures along each of the four proposed route option alignments are denoted on **Drawings 476416-CF-RO1-RDZ-DR-RD-0001 to 0012, 476416-CF-RO2-RDZ-DR-RD-0001 to 0012, 476416-CF-RO3-RDZ-DR-RD-0001 to 0012** and **476416-CF-RO4-RDZ-DR-RD-0001 to 0012**.

4.4.2 Testing of existing structures

It is reasonable to assume that this scheme will be procured under a design and build contract, as this is widely used by Transport Scotland.

To allow the necessary transfer of design liability from Transport Scotland to the Contractor, it would be necessary to carry out both intrusive and non-intrusive investigations. This will be to determine any unknown structural material properties, allowing the assessment capacities to be determined.

This information would also inform any strengthening works which may be required. It is also envisaged that boreholes would also be required to confirm the founding strata assumptions of the existing and proposed structures.

4.4.3 Bridge Structures

The structures proposals described in this section for each bridge structure consider the relevant route option.

Tarbet Smithy - Route Options 1, 2, 3 & 4

For all four route options, the present cross section would require substantial alterations to accommodate the desired carriageway width and associated verge and foot/cycle path. It is therefore recommended both the road bridge and adjacent footbridge be demolished and replaced.

The most likely form of construction would be a reinforced concrete portal with the abutments on spread footings. Boreholes to confirm the buildability of the founding strata will also be required.

The proposed new structure would accommodate a 6.0 m carriageway with 1.0 m hardstrips with a 2.0 m on the western side and a 4.0 m verge on the eastern side, which incorporates a footway/cycle path. The new bridge parapets on the widened deck would require to be 1.4 m high with mesh infill for cycle/pedestrian usage with a minimum N2 containment standard.

A flood assessment will be required to confirm the required cross section. For initial assessment purposes, a span of 6 m has been assumed which would permit the new abutments to be constructed clear of the watercourse.

Tarbet Bridge - Route Options 1, 2, 3 & 4

For all four route options the present cross section would require substantial alterations to accommodate the desired carriageway width and associated verge and foot/cycle path. It is therefore recommended that both structures be demolished and replaced.

As with Tarbet Smithy, the most likely form of construction would be a reinforced concrete portal with the abutments on spread footings. Boreholes will also be required to confirm the buildability of the founding strata.

The proposed new structure would accommodate a 6.0 m carriageway with 1.0 m hardstrips with a 2.0 m on the western side and a 4.0 m verge on the eastern side, which incorporates a footway/cycle path. The new bridge parapets on the widened deck would require to be 1.4 m high with mesh infill for cycle/pedestrian usage with a minimum N2 containment standard.

A flood assessment will be required to confirm the required cross section. For initial assessment purposes a span of 6 m has been assumed, which would permit the new abutments to be constructed clear of the watercourse.

Inveruglas Water - Route Options 1, 2, 3 & 4

Considering the off-line nature of all route options, a new structure would be required at this location.

Boreholes would be required to confirm the suitability of the founding strata.

This new structure would render the existing structure redundant and would be constructed east of the existing one and would span Inveruglas Water.

A flood assessment will be required to confirm the required cross section. For initial assessment purposes, a span of 25 m is proposed for the new structure, to ensure construction works and permanent obstructions are set back from the river edge. The most likely construction would involve pre-cast pre-tensioned bridge beams, integral with reinforced concrete spread footing abutments.

The proposed road alignment at the chosen location would incorporate a widened verge at the bridge to afford the required forward visibility. This may result in the east verge increasing in width to 9.5 m with an overall deck width of 22 m.

The proposed new structure would accommodate a 6.0 m carriageway with 1.0 m hardstrips with a 2.0 m on the western side and a 4.0 m verge on the eastern side, which incorporates a footway/cycle path. The parapet would be a minimum N2 containment standard, 1.4 m high with mesh infill for cycle/pedestrian usage.

Sloy Tail Race - Route Options 1, 2, 3 & 4

It is proposed to retain this structure on its present alignment and with a reduced verge on the east side of approximately 3.2 m, compared to the provision of 4.0 m for other structures along the route.

There are no issues associated with retention of the structure, other than the masonry parapet on the cycleway (east) side which would need to be raised to 1.4 m to comply with current standards. A Departure will require to be granted to retain the masonry parapets. To obtain this, it would be likely that suitable VRS transitions would be required to be installed on the structure's approaches, with possible ground beams to resist the imposed lateral impact loads. For the existing masonry parapets, it is likely that a concrete slab would be required above the arch, to support or tie-in the masonry parapets.

As this is a listed structure, permissions would be required for these works.

As no records are available to support the current load assessment, it would be necessary to undertake both intrusive and non-intrusive investigations to inform a new load assessment. In addition, boreholes to confirm the suitability of the founding strata will be required. Collectively, this data will enable the capacity of the existing structure to be assessed and the design parameters for the modified bridge to be determined.

Creag an Arnain - Route Options 1, 2 & 3

The section of A82 locally referred to as the 'Seven Bends/Sisters' extends for approximately 350 m and has a poor alignment, with substandard visibility and cross section for road users. In addition, this section of road is severely constrained to the west by steep slopes and the West Highland Line above and on its eastern side by the loch shore.

The railway is supported by the existing Creag an Arnain rail viaduct and has a masonry retaining wall at its north end, coinciding with the southern end of the 'Seven Bends/Sisters'. Two lochside retaining walls are also present and support the existing A82 road on its eastern boundary.

To accommodate a compliant carriageway it will be necessary to widen the existing road. Further encroachment to the west is not considered desirable nor economically viable given the proximity of the adjacent railway. Therefore advancing eastward into the foreshore is deemed more favourable and would enable an independent viaduct to be constructed with a more direct horizontal alignment.

The proposed new structure would accommodate a 6.0 m carriageway with 1.0 m hardstrips with a 2.0 m on the western side and a 4.0 m verge on the eastern side, which incorporates a footway/cycle path. The proposed new structure would accommodate a 6.0 m carriageway with 1.0 m hardstrips with a 2.0 m on the western side and a 4.0 m verge on the eastern side, which incorporates a footway/cycle path. The copes of the viaduct would host 1.4 m high mesh infill N2 metal parapets.

The intention would be for the viaduct to comprise 13 no. 20 m spans, with each span fixed at one abutment, and free sliding with lateral restraints on the opposing intermediate piers and abutment.

The substructure would comprise circular columns of approximate 1.5 m diameter on circular mono-piles, assumed to be 2 m diameter. The substructure would be constructed integral with the reinforced cross head piers and cantilever abutments. The deck would comprise pre-cast, pre-tensioned Y3 beams at 1 m centres with an in-situ cast deck slab approximately 225 mm thick.

A preliminary assessment into the feasibility of constructing such a structure was undertaken with due consideration afforded to:

- Avoiding day time road closures
- Avoiding impact on rail operations and rail assets
- Minimising disruption and delays to the travelling public, with a view to maintaining two-way traffic running at all times

- Ensuring the safety of construction personnel bearing in mind the requirements for working over water and adjacent to live traffic
- Buildability of the viaduct including delivery of materials to site
- Durability and maintenance provisions for future inspections and operational maintenance.

It has been deemed that the above considerations could be satisfactorily achieved through proper planning, staged construction and traffic management and the ability to work within in the loch.

Utilising off-site fabricated components was deemed essential and the form of construction considered for initial assessment purposes utilises standard pre-tensioned pre-cast bridge beams.

To minimise delivery and transportation issues, beams were restricted to 20 m lengths and crane lifting requirements also considered. The use of integral crossheads over the intermediate piers is considered to achieve a continuous deck structure which will enhance the aesthetics and avoid down-stand cross beams.

At present detailed bathymetric survey information is not available, so the suitability of using barge mounted plant for construction and delivery of materials and piling operations cannot be fully investigated.

The present assessment, however, assumes that certain operations, in particular piling works, will be undertaken from barges. Deck construction using barge mounted cranes probably represents a more practical solution, however alternative land based construction are also considered feasible.

Access for future maintenance and inspection has been considered using standard under bridge access equipment.

Drawing 476417-CF-ZZ-BZ-DR-S-0200 illustrates the proposed Creag an Arnain Viaduct General Arrangement.

Coire Nan Each - Route Options 1, 2 & 3

The existing 300 m stretch of A82 at this location is poor, with substandard alignment, visibility and cross section. The existing carriageway is severely constrained throughout by the steep hillside and West Highland Line to the west and loch shore to the east.

There are two existing masonry retaining walls on the east side, below the road, both of which will become redundant as part of the proposed works.

In terms of space to undertake road improvements, route options to further encroach to the west towards the railway are not considered desirable or economically viable. As such, it is proposed that to accommodate a widened road, the alignment is moved eastward into the loch by the minimum amount which is considered feasible.

A lateral movement of the present alignment is just sufficient to permit a new retaining wall structure to be built, whilst maintaining two–way traffic running for the majority of the construction period. Consequently this also minimises the required encroachment into the loch shore.

A preliminary assessment into the feasibility of constructing such a structure was undertaken, with due consideration afforded to:

- Avoiding day time road closures.
- Avoiding impact on rail operations and rail assets.
- Minimising disruption and delays to the travelling public, with a view to maintaining two-way traffic running at all times.
- Ensuring the safety of construction personnel bearing in mind the requirements for working over water and adjacent to live traffic.
- Buildability of the viaduct including delivery of materials to site.
- Durability and maintenance provisions for future inspections and operational maintenance.

The use of off-site fabricated components has considered, where possible, to reduce the requirement for working in and over the water and reduce the potential for spillages and contamination.

At present, detailed bathymetric survey information is not available, so the suitability of using barge mounted construction plant for construction and delivery of materials and piling operations cannot be fully investigated. The present proposal assumes that barge access will be possible for most of the construction activities.

The proposed new structure would accommodate a 6.0 m carriageway with 1.0 m hardstrips with a 2.0 m on the western side and a 4.0 m verge on the eastern side, which incorporates a footway/cycle path. Loch side a 1.4 m high mesh infilled N2 metal parapet would be installed.

This section the new road would be 310 m long and located to the west of the existing A82 with a clear separation of 2 m or greater for the majority of the structure. This would allow two-way traffic to operate at all times during the proposed construction works.

At the southern and northern ends of the structure the two roads would converge. This would require the operation of a single lane contraflow for the initial construction works before aligning to the two–way traffic regime proposed.

The proposed structure would be a cantilever retaining wall which would be constructed within the water. The form of structure would comprise a "king post" retaining wall founded on bored mono piles.

The spacing of the piles has not at present been determined, but would likely be in the order of 4 m. It would be intended that cantilever steel "I" sections would be vertically cast into the top of the mono piles to form the "king posts". The sections between the posts would then be infilled with pre-cast reinforced concrete planks designed to span between the post flanges.

It is envisaged that the lower planks below water level will be backfilled with suitable large sized stones (rip rap) to form the foundation layer for the granular structural backfill above. Once the foundation layer was completed, the upper planks would be installed and the structural backfill raised to formation level.

The wall would be completed with a reinforced concrete capping beam and pre-cast cantilever slab and cope which will be anchored on the landward side to a mass concrete counterweight. This arrangement provides a high quality, aesthetically pleasing finish to soften the visual impact of the wall. The wall will be faced using pre-cast units with a patterned finish to minimise in-situ concreting contamination risks and provide a high quality finish.

Drawing 476417-CF-ZZ-BZ-DR-S-0300 illustrates the proposed Coire nan Each Retaining Wall General Arrangement.

Ardvorlich North Bridge-Route Options 1, 2,3 & 4

In light of the present cross section and alignment, the existing bridge would need to be substantially widened on its eastern side to afford a compliant carriageway with associated verges and foot/cycle path.

This would enhance the sight lines for motorists as the bend is approached. The required verge width would be around 8.5 m and the overall required deck width would be around 22 m.

Considering the extent of the works required, it is recommended that the existing bridge be demolished and replaced with a single span reinforced concrete portal upon reinforced concrete spread footing abutments. Boreholes to confirm the buildability of the founding strata will also be required.

The proposed new structure would accommodate a 6.0 m carriageway with 1.0 m hardstrips with a 2.0 m on the western side and a 4.0 m verge on the eastern side, which incorporates a footway/cycle path. The new bridge parapets on the widened deck would require to be 1.4 m high with mesh infill for cycle/pedestrian usage and a minimum N2 containment standard.

A flood assessment will also be required to confirm the required cross section however for initial assessment purposes a span of 8 m has been assumed, which would permit the new abutments to be constructed clear of the watercourse.

In terms of construction, building the deck in sections to maintain traffic flows would be feasible under regulated traffic management.

Stuckindroin - Route Options 1, 2, 3 & 4

For all route options the intention is to maintain the road on its existing alignment, such that the present structure can be retained in its current form.

From the limited information available at present, it is considered likely that the existing bridge could be upgraded and strengthened to achieve a load capacity of 45 units of HB.

It will, however, be necessary to undertake intrusive and non-intrusive investigations to determine the material properties that comprise the three bridge types making up this structure. This will enable the capacity to be determined through an assessment. In addition, this information can be used to determine what measures may be required to enhance capacity.

It is likely that Departures from Standard for all non-compliant elements shall be required and these may pertain to the:

- Non-standard masonry bridge parapets
- Potentially sub-standard verge widths

The existing masonry parapets would need to be assessed and some upgrade / strengthening works required. Suitable VRS transitions may need to be provided on the structure's approaches, with ground beams installed to resist any laterally imposed impact loads. For the existing masonry parapets, it is likely that a concrete slab would be required above the arch to support or tie-in the masonry parapets.

The existing structure accommodates a 6.0 m carriageway with 1.0 m hardstrips. The verge on the west side has a minimum width of 2.40 m and the verge on the east side has a minimum width of 2.30 m, which would incorporate a footway/cycle path. The new bridge parapets would require to be 1.4 m high with mesh infill for cycle/pedestrian usage with a minimum N2 containment standard.

It was noted that the most recent General Inspection report found the bridge to be in a reasonable condition, with only minor defects recorded.

A flood assessment will be required to ascertain whether the existing cross section profile is adequate to accommodate an estimated 1:200 flood event.

Strath Dubh–Uisge South – Route Options 1, 2, 3 & 4

The present cross section and alignment would require substantial alterations to accommodate the desired carriageway width and associated verge and foot/cycle path for all route options. Bearing in mind the size, condition and nature of the present structure, it is recommended that this bridge is demolished and replaced.

The most likely form of construction would be a reinforced concrete portal, with the abutments on spread footings. Boreholes to confirm the buildability of the founding strata will also be required.

The proposed new structure would accommodate a 6.0 m carriageway with 1.0 m hardstrips with a 2.0 m on the western side and a 4.0 m verge on the eastern side, which incorporates a footway/cycle path. The new bridge parapets would require to be 1.4 m high with mesh infill for cycle/pedestrian usage with a minimum N2 containment standard.

A flood assessment will be required to confirm the required cross section. For initial assessment purposes, a span of 15 m has been assumed which would permit the new abutments to be constructed clear of the watercourse.

Strath Dubh–Uisge North - Route Options 1, 2, 3 & 4

The present cross section and alignment would require substantial alterations to accommodate the desired carriageway width and associated verge and foot/cycle path for all route options. Bearing in mind the size, condition and nature of the present structure, it is recommended that this bridge is demolished and replaced.

The most likely form of construction would be a reinforced concrete portal with the abutments on spread footings. Boreholes to confirm the buildability of the founding strata will also be required.

The proposed new structure would accommodate a 6.0 m carriageway with 1.0 m hardstrips with a 2.0 m on the western side and a 4.0 m verge on the eastern side, which incorporates a footway/cycle path. The new bridge parapets would require to be 1.4 m high with mesh infill for cycle/pedestrian usage with a minimum N2 containment standard.

A flood assessment will be required to confirm the required cross section. For initial assessment purposes, a span of 15 m has been assumed which would permit the new abutments to be constructed clear of the watercourse.

Inverarnan Bridge - Route Options 1, 2, 3 & 4

For all four route options it is proposed to widen the existing carriageway by up to 5.1 m, in order to achieve a clear width between parapets of 14.5 m. This will provide a 6.0 m carriageway with 1.0 m hardstrips, a 2.5 m verge on the west side and a 4.0 m verge on the east side, which incorporates a footway/cycle path. The vehicle pedestrian parapet on the east side will be replaced with a 1.4 m high parapet to current standards and suitable for cycleway use.

It is proposed to widen the bridge only on its downstream side, with the existing structure matched in terms of profile and deck form.

Due to the lack of data for the existing structure, intrusive and non-intrusive investigations shall be required to determine the material properties for the concrete and steel within the structure deck and abutments.

In addition, boreholes to confirm the suitability of the founding strata shall be required. Collectively, this data will enable the capacity of the existing structure to be assessed and the design parameters for the widened bridge to be determined.

As the proposed works will require construction within the Allt Arnan watercourse, the final form and construction methodology will require agreement with SEPA. In addition, a flood assessment will need to be undertaken to confirm that the existing cross section is adequate for an estimated 1:200 flood event.

4.4.4 Viaduct Structures Route Options 3 & 4

At three locations along the length of Route Option 3 and ten locations along the length of Route Option 4, additional viaduct structures may be required. These locations, denoted on **Drawings 476416-CF-RO3-RDZ-DR-RD-0001 to 0012** and **476416-CF-RO4-RDZ-DR-RD-0001 to 0012** coincide where the proposed road alignment is required to cross open water.

The proposed new structures would accommodate a 6.0 m carriageway with 1.0 m hardstrips with a 2.0 m on the western side and a 4.0 m verge on the eastern side, which incorporates a footway/cycle path. The new bridge parapets would require to be 1.4 m high with mesh infill for cycle/pedestrian usage with a minimum N2 containment standard.

As with the proposed Creag an Arnain Viaduct, the intention would be for these to comprise regular span lengths with each span fixed at one abutment, and free sliding with lateral restraints on the opposing intermediate piers and abutment.

The substructure would comprise circular columns of approximate diameter 1.5 m on circular mono-piles assumed to be 2 m diameter. The substructure would be constructed integral with the reinforced cross head piers and cantilever abutments. The deck would comprise pre-cast, pre-tensioned Y3 beams at 1 m centres with an in-situ cast deck slab approximately 225 mm thick.

A preliminary assessment into the feasibility of constructing these additional structures has been carried out with due consideration afforded to:

- Avoiding day time road closures
- Minimising disruption and delays to the travelling public, with a view to maintaining two-way traffic running at all times
- Ensuring the safety of construction personnel bearing in mind the requirements for working over water and adjacent to live traffic
- Buildability of the viaduct including delivery of materials to site
- Durability and maintenance provisions for future inspections and operational maintenance.

Through proper planning, staged construction and traffic management and the ability to work within in the loch, it has been deemed that the above considerations could be satisfactorily achieved.

In addition, utilising off-site fabricated components such as pre-tensioned pre-cast bridge beams is deemed essential to achieving the above aims. To minimise delivery and transportation issues, beams would be restricted to 20 m lengths. The use of integral crossheads over the intermediate piers is also considered to achieve a continuous deck structure, which will enhance the aesthetics and avoid down-stand cross beams.

At present, detailed bathymetric survey information is not available, so the suitability of using barge mounted construction plant for construction and delivery of materials and piling operations cannot be fully investigated. The present proposal assumes barge access will be possible for most of the construction activities.

Access for future maintenance and inspection has also been considered and deemed feasible, with the use of standard under bridge access equipment.

4.4.5 Culverts

Watercourses to be traversed along the considered route options will require culverts to be sized to determine the appropriate design flood flows. A ‘risk based’ approach to sizing of new watercourse crossings has been agreed through consultation with

SEPA, LLTNPA, Argyll & Bute Council and Stirling Council and is described in Section 4.5.1, Hydrology.

All culverts will generally comprise reinforced concrete pipes, precast concrete / cast in-situ box culverts or corrugated steel buried structures. The headwall and wingwalls by the inlet and outlet of each culvert may also comprise either precast or cast in-situ reinforced concrete.

Where aesthetics are deemed important, a patterned profile finish or dressed stone may be introduced to clad the permanently exposed formed surfaces.

Existing culverts which are not being replaced in their entirety, but instead extended on one or both ends shall have extensions which match the internal profile and materials of the parent culvert.

Pipes with an internal diameter less than 2 m are not classified as structures and would therefore be deemed to be part of the drainage system. The exception to this is corrugated steel buried structures for spans greater than 0.9 m which are classified as a structure.

4.4.6 Retaining Structures

For each of the route options there are sections where it will be necessary to support the new carriageway where it encroaches into the loch.

Where construction of earth retaining embankments may not be feasible, either due to site constraints such as the adjacent foreshore or where the threat of scour or wash out deems this impracticable, it would be proposed that reinforced concrete retaining walls would be constructed.

It would be necessary to determine and confirm, via testing, the suitability of the supporting bearing strata.

Where this was found to be less than desired and remediation of the existing soils was impracticable, then a modified piled solution similar to that proposed for the Coire Nan Each retaining wall could be adopted.

Where the founding strata was deemed suitable, it would be proposed to construct reinforced concrete cantilever retaining walls. The base of both these options would be protected with rip rap and the formed faces cast with either a patterned profile finish to soften the aesthetics of the elements or clad faced.

The approximate lengths of the walls required between Tarbet and Inverarnan are given within **Tables 4.4.2** to **4.4.5** for each of the considered route options. The average retained height of these elements typically varies between 1 and 3 m depending upon location. The location and their extent along the four proposed route alignments is denoted on **Drawings 476416-CF-RO1-RDZ-DR-RD-0001 to 0012, 476416-CF-RO2-RDZ-DR-RD-0001 to 0012, 476416-CF-RO3-RDZ-DR-RD-0001 to 0012** and **476416-CF-RO4-RDZ-DR-RD-0001 to 0012**.

4.4.7 Route Option Structures

Table 4.4.1 tabulates the number of structures along each of the considered route options.

Table 4.4.1: Structures Summary Table

	Viaducts	Bridges	Retaining Walls
Route Option 1	2	9	25
Route Option 2	1	9	24
Route Option 3	3	9	22
Route Option 4	10	9	12

4.4.8 Route Option 1

The structure requirements within Route Option 1 are shown in **Table 4.4.2**.

Table 4.4.2: Structures Summary for Route Option 1

Existing & Proposed	Length (m)	Start Chainage	End Chainage	Status
Tarbet Smithy - A82 380	-	-	-	Replace
Tarbet Footbridge - A82 381F	-	-	-	Replace
Tarbet Bridge	-	-	-	Replace
Tarbet Footbridge - A82 382F	-	-	-	Replace
Retaining Wall	150	570	720	New
Viaduct	260	720	980	New
Retaining Wall	150	980	1130	New
Retaining Wall	500	1270	1770	New
Retaining Wall	110	1990	2100	New
Retaining Wall	160	2190	2350	New
Retaining Wall	35	2465	2500	New
Retaining Wall	360	2800	3160	New
Retaining Wall	65	3215	3280	New
Retaining Wall	90	3300	3390	New
Retaining Wall	40	3650	3690	New
Retaining Wall	120	3910	4030	New
Retaining Wall	350	4100	4450	New
Inveruglas Water - A82 390	-	-	-	New
Sloy Tail Race - A82 400	-	-	-	Retain
Retaining Wall	340	4580	4920	New
Retaining Wall	70	6120	6190	New
Retaining Wall	230	6490	6720	New
Retaining Wall	40	6810	6850	New
Viaduct : Creag an Arnain	300	7070	7370	New
Retaining Wall : Coire Nan Each East	300	7450	7750	New
Retaining Wall : Coire Nan Each West	215	7555	7770	New
Retaining Wall	125	7920	8045	New
Retaining Wall	60	8090	8150	New
Ardvorlich North - A82 410		-	-	Replace
Retaining Wall	260	9040	9300	New
Retaining Wall	250	10230	10480	New

Existing & Proposed	Length (m)	Start Chainage	End Chainage	Status
Retaining Wall	75	11060	11135	New
Retaining Wall	140	11400	11540	New
Stuckindroin - A82 420	-	-	-	Retain
Ardlui Footbridge - A82 423F	-	-	-	
Strath Dubh Uisge South - A82 430	-	-	-	Replace
Strath Dubh Uisge North - A82 440	-	-	-	Replace
Inverarnan - A82 450	-	-	-	Widen
Retaining Wall	50	16220	16270	New
Retaining Wall	50	16280	16330	New

4.4.9 Route Option 2

The structure requirements within Route Option 2 are shown in **Table 4.4.3**.

Table 4.4.3: Structures Summary for Route Option 2

Existing & Proposed	Length (m)	Start Chainage	End Chainage	Status
Tarbet Smithy - A82 380	-	-	-	Replace
Tarbet Footbridge - A82 381F	-	-	-	Replace
Tarbet Bridge	-	-	-	Replace
Tarbet Footbridge - A82 382F	-	-	-	Replace
Retaining Wall	110	870	980	New
Retaining Wall	60	1010	1070	New
Retaining Wall	460	1210	1670	New
Retaining Wall	215	2710	2925	New
Retaining Wall	120	2950	3070	New
Retaining Wall	65	3125	3190	New
Retaining Wall	80	3210	3290	New
Retaining Wall	115	3825	3940	New
Retaining Wall	370	3990	4360	New
Retaining Wall	340	4490	4830	New
Inveruglas Water - A82 390	-	-	-	New
Retaining Wall	70	6000	6070	New
Sloy Tail Race - A82 400	-	-	-	Retain
Retaining Wall	230	6370	6600	New
Retaining Wall	50	6690	6740	New
Retaining Wall	20	6950	6970	New
Viaduct : Creag an Arnain	310	6970	7280	New
Retaining Wall	30	7280	7310	New

Existing & Proposed	Length (m)	Start Chainage	End Chainage	Status
Retaining Wall : Coire Nan Each East	340	7330	7670	New
Retaining Wall : Coire Nan Each West	145	7445	7590	New
Retaining Wall	70	7860	7930	New
Ardvorlich North - A82 410	-	-	-	Replace
Retaining Wall	160	8970	9130	New
Retaining Wall	10	9440	9450	New
Retaining Wall	250	10020	10270	New
Retaining Wall	120	10850	10970	New
Retaining Wall	120	11210	11330	New
Stuckindroin - A82 420	-	-	-	Retain
Ardlui Footbridge - A82 423F	-	-	-	
Strath Dubh Uisge South - A82 430	-	-	-	New
Strath Dubh Uisge North - A82 440	-	-	-	New
Inverarnan - A82 450	-	-	-	Widen
Retaining Wall	50	16010	16060	New
Retaining Wall	4	16070	16110	New

4.4.10 Route Option 3

The structure requirements within Route Option 3 are shown in **Table 4.4.4**.

Table 4.4.4: Structures Summary for Route Option 3

Existing & Proposed	Length (m)	Start Chainage	End Chainage	Status
Tarbet Smithy - A82 380	-	-	-	Replace
Tarbet Footbridge - A82 381F	-	-	-	Replace
Tarbet Bridge	-	-	-	Replace
Tarbet Footbridge - A82 382F	-	-	-	Replace
Retaining Wall	240	570	810	New
Viaduct	190	810	1000	New
Retaining Wall	40	1010	1050	New
Retaining Wall	50	1080	1130	New
Retaining Wall	460	1270	1730	New
Retaining Wall	200	2780	2980	New
Retaining Wall	110	3020	3130	New
Retaining Wall	65	3180	3245	New
Retaining Wall	80	3260	3340	New
Retaining Wall	40	3610	3650	New
Retaining Wall	120	3880	4000	New

Existing & Proposed	Length (m)	Start Chainage	End Chainage	Status
Retaining Wall	360	4070	4430	New
Retaining Wall	320	4550	4870	New
Inveruglas Water - A82 390	-	-	-	New
Retaining Wall	70	6070	6140	New
Sloy Tail Race - A82 400	-	-	-	Retain
Retaining Wall	220	6440	6660	New
Retaining Wall	30	6760	6790	New
Viaduct : Creag an Arnain	330	7020	7350	New
Retaining Wall : Coire Nan Each East	280	7400	7680	New
Retaining Wall : Coire Nan Each West	140	7500	7640	New
Viaduct	510	7680	8190	New
Ardvorlich North - A82 410	-	-	-	Replace
Viaduct	260	8950	9210	New
Retaining Wall	260	10120	10380	New
Retaining Wall	120	10970	11090	New
Retaining Wall	110	11320	11430	New
Stuckindroin - A82 420	-	-	-	Retain
Ardlui Footbridge - A82 423F	-	-	-	
Strath Dubh Uisge South - A82 430	-	-	-	New
Strath Dubh Uisge North - A82 440	-	-	-	New
Inverarnan - A82 450	-	-	-	Widen
Retaining Wall	45	16160	16205	New
Retaining Wall	50	16210	16260	New

4.4.11 Route Option 4

The structure requirements within Route Option 4 are shown in **Table 4.4.5**.

Table 4.4.5: Structures Summary for Route Option 4

Structures Existing & Proposed	Length	Start Chainage	End Chainage	Status
Tarbet Smithy - A82 380	-	-	-	Replace
Tarbet Footbridge - A82 381F	-	-	-	Replace
Tarbet Bridge	-	-	-	Replace
Tarbet Footbridge - A82 382F	-	-	-	Replace
Viaduct	150	800	950	New
Retaining Wall	60	950	1010	New
Retaining Wall	60	1040	1100	New

Structures Existing & Proposed	Length	Start Chainage	End Chainage	Status
Viaduct	730	1200	1930	New
Retaining Wall	60	2020	2080	New
Viaduct	140	2170	2310	New
Retaining Wall	150	2820	2970	New
Viaduct	270	3170	3440	New
Retaining Wall	40	3600	3640	New
Retaining Wall	195	4150	4345	New
Viaduct	320	4540	4860	New
Inveruglas Water - A82 390	-	-	-	New
Retaining Wall	70	6010	6080	New
Sloy Tail Race - A82 400	-	-	-	Retain
Retaining Wall	230	6400	6630	New
Viaduct : Creag an Arnain	490	6710	7200	New
Viaduct	580	7370	7950	New
Ardvorlich North - A82 410	-	-	-	Replace
Viaduct	230	8820	9050	New
Viaduct	110	9300	9410	New
Viaduct	160	9970	10130	New
Retaining Wall	110	10720	10830	New
Retaining Wall	70	11060	11190	New
Stuckindroin - A82 420	-	-	-	Retain
Ardlui Footbridge - A82 423F	-	-	-	
Strath Dubh Uisge South - A82 430	-	-	-	Replace
Strath Dubh Uisge North - A82 440	-	-	-	Replace
Inverarnan - A82 450	-	-	-	Widen
Retaining Wall	50	15890	15940	New
Retaining Wall	45	15945	15990	New

4.4.12 Structures' Aesthetics

The proposed structures associated with the selected route option will be the subject of an aesthetic review, with the intention that the form of structure will be referred to Architecture & Design Scotland (ADS) and the LLTNPA for comment.

4.5 Hydrology, Hydrogeology and Drainage

All drainage will be designed to current standards. As part of this Stage 2 Report, the following standards have been used to provide necessary information for the Engineering Assessment.

4.5.1 Hydrology

The DMRB (2006) Volume 11 recommends the following methods are used for the calculation of flows in watercourses:

- Flood Estimation Handbook (FEH)
- Institute of Hydrology Report 124 (generally for catchments of less than 2 km^2)

The FEH was published in January 2000 by the Centre for Ecology and Hydrology, Wallingford (formerly the Institute of Hydrology), a component body of the Natural Environment Research Council. The FEH provides industry standard guidance on rainfall and river flood frequency estimation in the UK.

The Institute of Hydrology Report 124 (IH124) was published in June 1994 by the Institute of Hydrology (now CEH Wallingford) and outlines a method intended for estimating flood flows in small (less than 25 km^2) rural catchments.

In consideration of planning authority requirements, the assessment of flood risk in DMRB Stage 3 will be carried out in accordance with Scottish Planning Policy, Flooding and Drainage, 2010.

Existing Floodplain and Flooding

Consultations with LLTNPA and SEPA have confirmed that full analysis of the effects on flow and storage capacity will be required where construction occurs within the functional floodplain.

A flood risk scoping report (Document No. 476416-CF-ZZ-DZ-RP-D-0002) was carried out for the Scheme as part of the DMRB Stage 2 process. Additional flood risk assessment undertaken as part of the DMRB Stage 2 process is included as an addendum to the scoping report (Document No. 476416-CF-ZZ-DZ-RP-D-0003); this work consists of three assessment subjects, summarised below:

- Loch Lomond flood levels

Further investigation has been undertaken into the perceived differences in water level between the north and south of Loch Lomond. A comparison of gauged levels, including the installation of a temporary gauge at Ardlui, predicts a negligible difference in water levels between those recorded at Ardlui and the SEPA gauge at Ross Priory even during extreme events. It is recommended that design flood levels are revisited and minor anomalies in gauging station data are investigated further and reported at DMRB Stage 3.

- River Falloch Modelling

A high level modelling study of the River Falloch flood levels was undertaken, identifying areas of the existing road potentially at risk of flooding in a 200 year event. The high level modelling study recommended the finished road level be set a minimum 300 mm above the current 200 year flood level and the road be realigned to avoid being located within the indicative 200 year flood extent. Where the existing road level is below the recommended finished level, it will be raised and flood compensation storage provided if the road cannot be realigned to avoid the indicative 200 year flood extent. Predicted flood levels in the River Falloch will be revisited at DMRB Stage 3.

- Five significant watercourses

A study of five larger watercourse crossings found that two have insufficient capacity to pass a 200 year design flow. It is expected that all five existing crossings will be replaced with structures sized to accommodate the design flow with a suitable freeboard. Predicted flood levels at these and all other watercourse crossings will be revisited at DMRB Stage 3.

Following consultation with LLTNPA and SEPA, the requirement for attenuation of road runoff prior to discharge is unlikely. However, the potential impact on flood risk downstream will be fully quantified during the DMRB Stage 3 Environmental Assessment.

The assessment of the physical road structure within the functional floodplain will be carried out in Stage 3 in accordance with DMRB; Volume 4; Geotechnics and Drainage, Section 2; Drainage, Part 1, HA 71/06; The Effects on Flooding of Highway Construction on Floodplains (2006).

Watercourse Diversions and Crossings

The design of the permanent watercourse diversions will be undertaken in accordance with the following guidance documents:

- Manual of River Restoration Techniques, RRC, 2002
- WAT-RM-02 Regulation of Licence-level Engineering Activities v4.0, 2011

Hydraulic and fluvial morphology assessments of the affected watercourses will be carried out during DMRB Stage 3, along with the design of the proposed diversions. The design approach will seek to mimic the existing flow regime and fluvial morphology, thus avoiding potential for increased flood risk, channel erosion and siltation.

For ease of identification, the watercourses in the study area are classified as follows:

- 'Major' watercourses – shown on the 1:50,000 scale OS map
- 'Minor' watercourses – shown on the 1:1,250 scale OS map
- 'Other' watercourses – not shown on OS maps but identified during surveys and walkovers

New culverts at watercourse crossings will be designed in accordance with the following guidance documents:

- Design Manual for Roads and Bridges (DMRB) (2004), Volume 4: Geotechnics and Drainage, Section 2: Drainage, Part 7 HA107/04 Design of Outfall and Culvert Details
- Culvert Design and Operation Guide, C689, 2010
- Engineering in the Water Environment: Good Practice Guide, River Crossings Second Edition (WAT-SG-25), SEPA 2010
- Policy ENV13 River Engineering Works and Culverts of the Loch Lomond and The Trossachs National Park Adopted Local Plan 2010-2015

Through consultation with SEPA, LLTNPA, Argyll & Bute Council and Stirling Council the following 'risk based' approach to sizing new watercourse crossings was agreed. This approach reflects the largely rural environs of the A82 and stricter design criteria will be adopted within residential and commercial areas.

- 1 in 100 year flood return period – urban clusters and villages
- 1 in 50 year flood return period – agricultural land of higher value and isolated properties

In both cases appropriate freeboard (minimum 300 mm) will be provided to account for silt deposition and to facilitate passage of floating debris.

Where limited headroom/cover is available, an assessment of the potential flood risk to nearby properties and the proposed road will take precedence over the stated design criteria.

Opportunities will be taken to remove existing pressures on the local morphology and ecology and bridges or bottomless arch culverts which retains the natural watercourse bed will be used, where practicable, in preference to closed circular or box culverts.

Where practicable, new culverts will be sited on-line and avoiding bends and changes in longitudinal slope to maintain the existing hydraulic conditions. Protection of the natural bed and banks against erosion will be provided and inverts of all new culverts will be lined with natural bed material.

Where required, new bridge structures and culverts will incorporate mammal ledges. Mammal passage may also be provided via a separate mammal crossing. Further consideration of this will be carried out during the DMRB Stage 3 assessment.

4.5.2 Hydrogeology

Any new development, including road construction and operation, can affect groundwater bodies. Drainage for the Scheme will thus be designed to avoid and minimise disruption to groundwater, particularly where this is likely to affect habitats (including groundwater dependent terrestrial ecosystems (GWDTE)). SuDS facilities including ponds, basins, swales or filter trenches may be lined to prevent pollution of any groundwater sources.

Development of the engineering works along the preferred route option will take into consideration the following fluvial geomorphological elements:

- Natural movement of watercourses

- Morphological diversity of watercourses
- Sediment transportation in watercourses

No specific methods to assess potential impacts of a road scheme on the fluvial geomorphology are provided within the DMRB guidance. It is recognised, however, that disruption to a geomorphological pattern within a watercourse may lead to degradation of its ecological status. This would be contrary to targets presented by the WFD.

A qualitative assessment of potential scheme impacts is reported in the separate DMRB Stage 2 Environmental Assessment. More detailed appraisal of potential impacts on local hydrogeology and geomorphology will be undertaken at the DMRB Stage 3, when the preferred route alignment is selected.

4.5.3 Drainage

Drainage Strategy

Drainage design will be based on DMRB, Volume 4a, Geotechnics and Drainage, and will adopt current best practice in Sustainable Drainage Systems (SuDS) in line with Scottish Planning Policy.

The aim of SuDS is to mimic natural catchment processes by adopting a surface water management or 'treatment train' approach. This utilises a hierarchy of sustainable drainage techniques, from prevention at source, to regional runoff control.

By adopting a multi-component 'treatment train' the following benefits can be realised:

- Maximisation of treatment efficiency by removing a wide range of pollutants
- Containment of serious pollution events thus minimising a risk of watercourse contamination
- Conveyance and storage components mitigating against flooding downstream
- Enhanced wildlife and amenity potential

The design of the SuDS system will be undertaken in line with the following guidance documents:

- Scottish Planning Policy, Flooding and Drainage, 2010
- Policy ENV12 Surface Water Drainage of the Loch Lomond and The Trossachs National Park Adopted Local Plan 2010-2015
- Design Manual for Roads and Bridges (DMRB), 2006, Volume 4: Geotechnics and Drainage, Section 2: Drainage, Part 1, HA103/06: Vegetated Drainage Systems for Highway Runoff
- The SUDS Manual, CIRIA 697, 2007
- SUDS for Roads
- Regulatory Method (WAT-RM-08), Sustainable Urban Drainage systems (SUDS or SUD Systems) v4, 2012 (SEPA).

Consultations have confirmed that the new road should ideally provide two levels of treatment to surface water runoff prior to discharge to the water environment. Where possible, this will be achieved as follows:

- Source control - roadside filter trenches with catchpits, or swales with check dams, providing conveyance and first level of treatment
- Site/regional controls - detention basins and/or bio retention areas and/or stormwater wetlands providing second level of treatment by pollutant settlement and biodegradation and runoff storage for flood control

Due to the steep terrain and environmentally sensitive nature of the considered route corridor, it may not be possible to accommodate end-of-pipe detention basins or bio retention areas. Where spatial constraints do not permit a second separate end-of-pipe SuDS facility, then a combined swale and filter trench detail will be proposed to provide two levels of treatment.

A single level of treatment may be unavoidable where spatial constraints along the route corridor prevent the installation of an end-of-pipe SuDS facility or a combined swale and filter trench detail. Further consideration will be given during Stage 3 to enhancing the single level of treatment provided by filter trenches.

Where drainage is required on long structures, such as viaducts, surface runoff will be collected in linear drainage channels with connections to drainage networks at the end of the structure via proprietary systems, such as vortex separator units.

Depending on the outcome of the environmental assessment, accidental spillage containment may be required. In such an event the proposed SuDS facilities will comprise isolating valves (or equivalent), facilitating containment of road surface runoff. The SuDS facilities will be designed to have 'a natural profile' in keeping with the surrounding landscape and wider biodiversity objectives.

As noted above, SuDS facilities may be lined (by either a natural layer of impermeable material or a synthetic liner) to prevent runoff infiltration to the ground and/or groundwater ingress.

Appropriate scour protection measures will be provided at the inlet to the SuDS facility and outlet to the water body.

New drainage pipes will be designed to accommodate a 1 in 1 year storm event plus 20 % climate change without surcharge. The drainage will be checked against a 1 in 5 year storm event plus 20 % climate change to ensure no surface flooding.

Liaison with LLTNPA and SEPA confirmed that drainage outfalls discharging directly to Loch Lomond are preferred, rather than discharge to receiving watercourses, due to the significant dilution available. Further information regarding the impact of the drainage outfalls to the receiving water environment is discussed in the Stage 2 Environmental Report.

Conceptual drainage layouts for each route option including potential locations for SuDS basins are shown on **Drawings 476416-CF-RO1-DZ-DR-D-0001 to 0006, 476416-CF-RO2-DZ-DR-D-0001 to 0006, 476416-CF-RO3-DZ-DR-D-0001 to 0006 and 476416-CF-RO4-DZ-DR-D-0001 to 0006**.

4.5.4 Route Options Assessment

An engineering assessment of the following elements has been undertaken with a comparison made between each route option:

- Type of drainage provision and proposed extent and levels of SuDS treatment
- Drainage outfalls and associated receiving water types i.e. Loch Lomond or watercourse
- Watercourse crossings and impacts on existing profile
- Watercourse realignments, including diversions and combinations.
- Works affecting functional flood plain

The proposed works at the A82/A83 junction and on the A82 through Tarbet are common to all route options. As there are no significant drainage issues influencing route selection, the drainage works along this section of the new road will not be considered in detail at this stage.

SuDS Treatment Provision

Table 4.5.1 summarises the comparative provision of SuDS treatment achieved in the conceptual drainage design for each route option.

The figures show that for the current conceptual design proposal for all route options, 100 % of the new road will receive at least one level of SuDS treatment. All route options fail to achieve the desired level of SuDS provision, with 62 % of Route Option 1, 62 % of Route Option 2, 64 % of Route Option 3 and 52 % of Route Option 4 able to provide two levels of treatment. Route Option 4 achieves the lowest coverage due to the extent of road constructed on a viaduct or bridge in Loch Lomond. For further consideration of the engineering assessment of in loch structures, refer to Section 4.4.

Table 4.5.1: Percentage of Road Length Treated by SuDS

Route Option	One level of SuDS treatment		Two levels of SuDS treatment	
	Carrier Pipe with Vortex Separator [1]	Swales or Filter Trench [2]	Combined Swale & Filter Trench [3]	SuDS Basin with combination of [1]/[2] upstream
1	4 %	34 %	28 %	34 %
2	2 %	36 %	32 %	30 %
3	5 %	31 %	28 %	36 %
4	20 %	28 %	19 %	33 %

Table 4.5.2: Drainage Outfalls

Route Option	Total no. of drainage outfalls	Receiving Waterbody	
		Loch Lomond	Watercourse
1	62	38	24
2	63	38	25
3	62	34	28
4	57	33	24

Despite providing much more treatment of surface runoff than is currently provided, the extent of new road achieving two levels of SuDS treatment is lower than desired. This reflects the physical and spatial constraints associated with the location of the route corridor i.e. the steeply sloping rock and railway line to the west and Loch Lomond to the east.

Further development of the conceptual drainage design will be required during the DMRB Stage 3. This will identify opportunities for additional lengths of combined swale and filter trench details, additional SuDS basins, and areas of widened verges which could be developed to provide enhanced swale or ribbon basin facilities.

The potential locations for improved SuDS facilities identified during Stage 2 are shown on the conceptual drainage layout drawings included in Volume 2.

Drainage Outfalls

Table 4.5.2 summarises drainage outfalls and associated receiving waters for each route option.

The number of drainage outfalls is similar for Route Options 1, 2 and 3, but a slightly lower number of outfalls have been identified for Route Option 4. This is due to more of Route Option 4 being located on 'in-loch' structures and not on land.

Due to the dilution provided by Loch Lomond, the preference is to discharge to the loch rather than discharge to local watercourses. The number of outfalls along the route may be reduced through the provision of more culverts, allowing drainage networks to pass over a culverted watercourse.

The design and detailing of watercourse crossings and associated drainage network crossings will be considered further in DMRB Stage 3.

It is evident from inspection that road surface runoff will have no measureable impact on water levels in the loch. Consequently, no specific attenuation storage is provided upstream of drainage outfalls to the loch, albeit that informal attenuation of road runoff will be achieved through the SuDS treatment facilities.

Accelerated runoff from the road to receiving watercourses could increase downstream flood risk. The adoption of SuDS measures designed to attenuate peak runoff during extreme rainfall events will avoid and minimise potential flood risk issues. Further assessment of SuDS provision for flood management will be carried out during DMRB Stage 3.

Flood risk associated with the proposed scheme is described in more detail in the DMRB Stage 2 Environmental Report.

Watercourse Crossings

Table 4.5.3 shows the number of watercourse crossings and affected watercourse profiles for each alternative route option.

Table 4.5.3: Watercourse Crossings

Route Option	Total no. of watercourse crossings	Watercourse profile unaffected	Watercourse profile affected		
			Major	Minor	Other
1	75	28	14	6	27
2	75	25	15	7	28
3	72	23	17	7	25
4	65	24	14	2	25

For the purpose of the Stage 2 assessment, it has been assumed that the profile of major watercourses should be maintained and protected whilst alterations to the profile of minor watercourses should be avoided where possible. Alterations to the profile of other watercourses are deemed acceptable, provided associated environmental impacts are minimised.

Watercourses likely to require bed profile alteration at crossings are summarised in **Table 4.5.4** for each route option. The constraints associated with each crossing are identified along with the route options affected. Watercourse references are included on the conceptual drainage layout drawings included in Volume 2.

Buildability issues of constructing the new road along the line of the existing road and keeping this open to traffic during construction will be a common constraint.

Further consideration of all affected watercourse crossings will be carried out in the DMRB Stage 3 assessment.

Table 4.5.4: Affected watercourses

Watercourse Reference	Route Option				Constraints
	1	2	3	4	
W6	-	✓	✓	-	• Increase to road profile/ gradient to accommodate increased road level
MW3	✓	✓	✓	✓	• Close proximity to private accesses on both sides of the road • Landtake/ land ownership issues
W8	✓	✓	✓	-	• Increased length and height of retaining wall structure to accommodate increased road level
W9	✓	✓	✓	-	• Increased length of retaining wall structure to accommodate increased road level
MW4	✓	✓	✓	✓	• Close proximity to private access on (AC03) west side of road • Increased length and height of embankment to accommodate increased road level
W11	✓	✓	✓	✓	• Close proximity to private access (AC03) on west side of road • Increased length and height of embankment to accommodate increased road level
W12	✓	✓	✓	✓	• Increased length and height of retaining wall structure to accommodate increased road level
MW5	-	-	-	✓	• Buildability issue of constructing new road along line of existing road and keeping road open to traffic

Watercourse Reference	Route Option				Constraints
	1	2	3	4	
W14	✓	✓	✓	-	• Increased length and height of retaining wall structure to accommodate increased road level
MW6	✓	✓	✓	✓	• Close proximity to private access (AC04) on east side of road
W15	✓	✓	✓	-	• Close proximity to private access (AC04) on east side of road
MW7	✓	✓	✓	✓	• Close proximity to private access (AC04) on east side of road
MW9	-	✓	✓	✓	• Increased length and height of embankment to accommodate increased road level
MW10	✓	✓	✓	-	• Increased length and height of embankment to accommodate increased road level
MW11	✓	✓	✓	-	• Increased length and height of embankment to accommodate increased road level
MW16	✓	✓	✓	✓	• Close proximity to private accesses on both sides of the road • Landtake/land ownership issues
MW19	✓	✓	✓	✓	• Close proximity to railway line • Close proximity to private accesses • Landtake/land ownership issues
MW20	✓	✓	✓	✓	• Close proximity to railway line • Close proximity to private accesses • Landtake/land ownership issues
MW21	✓	✓	✓	✓	• Close proximity to railway line • Close proximity to private accesses • Landtake/land ownership issues
MW22	✓	✓	✓	✓	• Close proximity to railway line • Close proximity to private accesses • Landtake/land ownership issues
MW23	✓	✓	✓	✓	• Close proximity to railway line • Close proximity to private accesses • Landtake/land ownership issues
MW25(S)	-	-	✓	-	• Landtake/land ownership issues
MW25(N)	-	-	✓	-	• Landtake/land ownership issues
MW27	✓	✓	✓	✓	• Landtake/land ownership issues
MW29	✓	✓	✓	✓	• New bridge structure required to accommodate increased road level • Close proximity to private accesses • Landtake/land ownership issues

Table 4.5.5: Watercourse Diversions / Realignments (not including vertical realignment at crossings)

Route Option	Total no.	No. of watercourses affected		
		Major	Minor	Other
1	28	2	0	26
2	26	1	0	25
3	27	1	0	26
4	23	1	0	22

Engineering works to watercourse crossings is likely to require Controlled Activities Regulations (CAR) Authorisation. Further details of the proposed engineering works will be developed in DMRB Stage 3 for consideration by SEPA.

The number of watercourses affected by road crossings is similar for Route Options 1, 2 and 3, but lower for Route Option 4. This is because Route Option 4 involves less works on land and more 'in loch' structures.

Watercourse Engineering Works

The number of engineering works activities involving diversion and/ or horizontal realignment of an existing watercourse is summarised in **Table 4.5.5**.

Engineering works to watercourses involving diversion and / or horizontal realignment is likely to require Controlled Activities Regulations (CAR) Authorisation. Further details of the proposed engineering works will be developed in DMRB Stage 3 for consideration by SEPA.

Again, the number of watercourse diversions/ realignments is similar for Route Options 1, 2 and 3, but a lower number of activities have been identified for Route Option 4. This is due to more of Route Option 4 being located on 'in-loch' structures and not on land thus affecting less watercourses.

In addition, all route options currently indicate the requirement for retaining walls on the right bank of the River Falloch at approximate Ch 16250 m. It may be preferable to move the horizontal alignment of the route at this location to the north, away from the River Falloch to avoid having to carry out this activity.

The design of engineering works to watercourses including diversions, realignments or provision of bank protection will be carried out in DMRB Stage 3.

Works Affecting Floodplains

As summarised in Section 4.5.1, a high level flood modelling study of the River Falloch has been undertaken as part of the DMRB Stage 2 process. Three locations (totalling approximately 500 m) along the existing and proposed alignments were found to be within the 200 year 'functional' floodplain.

Each route option is affected in these locations by approximately the same extent. The results of the modelling study are reported in detail in the Proposed Route Options appraisal section within the FRA Scoping Report Addendum, included as an appendix to the DMRB Stage 2 Environmental Report.

The current route options pass through the functional floodplain at several locations. Land within the corridor may be required to be kept free so like-for-like compensatory storage can be provided to mitigate for lost floodplain storage.

However, given that the Loch Lomond flood level has the greatest impact on River Falloch flood levels, it is questioned whether lost flood storage as a result of raising the road within the River Falloch functional floodplain would have any impact on flood risk elsewhere. Further discussion will be required with SEPA to confirm if compensatory storage is deemed necessary.

Environmental Impact

See the separate DMRB Stage 2 Environmental Assessment Report for Environmental Impacts.

Hydrology, Hydrogeology and Drainage Preferred Route Option

The Hydrology, Hydrogeology and Drainage assessment of the four route options indicate that all have a similar extent of engineering works.

Engineering works and the provision of SuDS treatment associated with Route Options 1, 2 and 3 are all similar, but Route Option 1 has the lowest number of outfalls discharging to watercourses and affects the lowest number of watercourses in terms of vertical alignment change. Of these three route options, Route Option 1 is considered to have the least impact on the water environment.

Route Option 4 has a lower number of drainage outfalls, a lower number of watercourse crossings and affects a lower number of watercourses than Route Option 1. However, the conceptual drainage layout developed for Route Option 4 has a much lower percentage of road length achieving two levels of SuDS treatment to surface runoff prior to discharge to the loch or receiving watercourse and also requires a substantially greater length of construction of 'in-loch' structures than Route Option 1.

4.6 Geology, Geomorphology and Ground Conditions

The following section reviews the geology, geomorphology and ground conditions associated with the route options. This is based on the findings of the PSSR, field inspections (of rock cuttings) and the Preliminary Ground Investigation (PGI) carried out as part of the Stage 2 DMRB Assessment.

The route options are close to each other in term of distance. Consequently Route Option 1 is described in detail and where ground conditions are expected to vary significantly for the other options, additional discussion is provided.

In a similar manner, engineering consideration is discussed in detail for Route Option 1 with additional or specific issues likely to be associated with Route Options 2 to 4 discussed.

Table 4.6.1 provides a summary of estimated earthworks volumes and cut and fill heights discussed in the following sections. Further breakdown of these figures is provided in **Appendix D.**

Table 4.6.1: Estimate earthworks volumes and cut and fill heights

	Route Option 1	Route Option 2	Route Option 3	Route Option 4
Approx. Cut Volumes and percentage of earthworks	387,000 m^3 (52 %) Rock: 262,000 m^3, Other: 125,000 m^3	655,000 m^3 (65 %) Rock: 513,000 m^3, Other: 142,000 m^3	412,000 m^3 (55 %) Rock: 300,000 m^3, Other: 112,000 m^3	887,000 m^3 (70 %) Rock: 792,000 m^3, Other: 95,000 m^3
Approx. Fill Volumes and percentage of earthworks	362,000 m^3 (48 %)	352,000 m^3 (35 %)	331,000 m^3 (45 %)	377,000 m^3 (30 %)
Approx. Surplus / Deficit Volume	25,000 m^3 surplus	303,000 m^3 surplus	81,000 m^3 surplus	510,000 m3 surplus
Maximum Cut height	17.1 m	21.6 m	21.6 m	33.6 m
Maximum fill/retained height	13.0 m	13.4 m	14.0 m	15.0 m

4.6.1 Route Option 1

Anticipated Ground Conditions

South of Ardlui and for the majority of the route corridor (excluding the immediate loch shore) area the ground conditions comprise mainly granular soils overlying metamorphic bedrock. These soils are likely of glacial or fluvio-glacial origin and generally comprise sands and gravels with variable proportion of cobble and boulders. Locally, some more silty and Clayey soils are noted which may be representative of Glacial Till.

The main variable in ground conditions in this area is the depth to rock.

As far as approximately Ch 5200, rock is present at depths of more than 10 m locally, but more typically found between 2 to 6 m depth.

Deeper drift is present South East of Inveruglas from approximately Ch 5200 to 6100 where rock was noted at between 5 to 10 m depth. North of Ch 6100 rock appears to be generally shallower. Where rock levels were proved they were found to lie at depths of generally less than about 4 m as far as approximately Ch 13000 in Ardlui.

Within the above zone there are significant areas of shallow bedrock, where drift deposits are thin or absent, with significant rock outcrops present generally to the west of the existing A82. These are between Ch 550-950, to 1500-1850, 2500-2750, 6300-6450, 7150-7850 and around Ch 8100, 8900 and 9600.

Peat was only locally present and was generally less than 1 m thick.

Some localised areas of made ground up to 2.8 m thick are noted, particularly associated with existing tracks, laybys and limited pre-existing development. The only contamination of note encountered was asbestos cement materials in Trial Pit No 55 near Ch 9000.

North of Ardlui, in general where proven, rock lies in excess of 10 m depth although there are some isolated rock outcrops. Drift deposits are more variable in this area and in addition sands and gravels, silts, soft clay and peat is present particularly in the lower lying River Falloch flood plain. Between approximately Ch 14150 to 14600 where compressible soils extended to circa 5 m depth with up to 3 m of peat proven in trial pits and a maximum of 7 m of soft ground indicated by peat probes. The peat / soft ground appear to be sporadic in distribution.

The ground conditions on the immediate loch shore area are generally more variable, with made ground up to 2.8 m depth present locally where laybys and informal parking areas have been created. Superficial deposits tend to be deeper (>5 m) where proven, with finer grained material such as Sand and Silt noted locally. Peat was also encountered to a maximum depth of 4 m.

Geotechnical Engineering Considerations

Topography and Geomorphology

The southern two thirds of the route traverses side long rising ground to the west of the existing A82.

The topography is often steep, with local sub vertical rock outcrops exceeding 10 m in height and reaching almost 20 m at some locations. The route corridor is constrained in these areas by the steep slopes to the west and Loch Lomond to the east.

There are areas where the ground is more gently sloping, traversing likely areas of “raised beach” as found around Ardvorlich and where it crosses areas of alluvial fans, associated with larger watercourse such as those existing at Inveruglas.

The northern third of the route generally traverses a more gentle topography, situated largely on the edge of the River Falloch flood plain. The route is locally constrained to the west by the rail line and on both sides by properties adjacent to the road, particularly within Ardlui and Inverarnan.

A landslip and rock fall in January 2014 within the Pulpit Rock site was noted and is thought to have been associated with tree clearance following a storm. There is also localised instability of the road verge around CH 16300, the origin of which has not been established.

Earthworks - Cuttings

The maximum cut depth associated with this route option is 17.1 m, a total cut volume of 387,000 m^3 is estimated

The principal issue will be a significant requirement to excavate and form cuttings in hard metamorphic rock. This may be expected to require bulk blasting, breaking and secondary processing to provide material suitable for re-use in the works.

The constrained nature of much of the site and a likely requirement to keep the existing route open during construction will require careful consideration of bulk earthworks operations, adding to construction timescales and costs.

Inspections and preliminary slope analysis suggest slope angles of up to 60^{o} should be relatively stable in competent rock. Steeper slopes are possible with an increased likelihood of requiring additional support measures. Given that the site is located within the LLTNP, aesthetic considerations will be a significant issue in slope design. These may preclude the widespread use of engineering measures to support rock slopes such as bolting and anchoring, or the use of mesh to prevent rock fall.

It is noted that there is often a significant and variable thickness of superficial deposits overlying rock and an allowance for slacker slopes in soils and or a benching at the rock / soil interface needs to be made when considering land take.

There is evidence to suggest that rock levels may vary significantly over short distances and an allowance to locally steepened soil slopes may need to be considered, using such measures as retaining structures or soil nailing.

Earthworks - Embankments/Retained Fill

The maximum fill height associated with this route option is 13.0 m, a total fill volume of 362,000 m^3 is estimated.

Significant embankments/retained fill are generally not required in those more elevated areas of the site, where the drift deposits are generally more competent and granular, so significant issues with design and construction are not anticipated.

More significant embankments are likely in those lower lying areas of the site such as the River Falloch flood plain, where compressible organic soils are present. A range of measures may be applied in such situations, which largely depend on the thickness of the compressible soils in question and the economics and practicalities of excavation and replacement. Measures which could be employed range from settlement periods to surcharging and/or band drains, or a requirement to supporting the fill on geo-grid reinforcement or on piles.

Retaining walls are proposed on the loch shore. Should it be necessary for embankments to impinge or enter the loch, earthworks design would be subject to detailed consideration of the ground conditions and the environmental issues likely to be posed.

Additional consideration will be required for the specification of suitable fill materials to ensure it remain stable when placed into water, and to be durable enough to resist erosion and degradation under exposure to fluctuating loch levels.

Earthworks - Materials

A high proportion of excavated rock will be suitable for re-use as general fill. This would however be subject to being processed to meet appropriate grading requirements. This processing and deposition is likely to involve several material handling phases.

The use of site won rock for more specialist uses, such as structural fill, sub base and within revetments (if required) would be subject to meeting appropriate durability criteria.

Re-use of drift materials should be possible subject to meeting contract acceptability criteria, with the majority of non-organic granular soils expected to be suitable for re-use as general fill within the works. The proportions of suitable material will also vary with the prevailing weather during earthworks.

It should be possible to incorporate the majority of excavated material into areas of landscaping. This is subject to material being free from significant contamination and being capable of being placed, trafficked and maintaining the required surface profile.

The bulk quantities estimated suggest a surplus of approximately 25,000 m^3 of fill material, for this route option. Unless a very high percentage of the cut material can be re-used, on the basis of the preceding discussion, a possible shortfall of fill material may be expected.

Structure Foundations

Structures required include culverts, extensive retaining walls (particularly on the loch shore area), bridges and significant over water structures, for example near Creag–an-Arnain (Seven Bends/Sisters) where the route is constrained by the railway, steep rock face and the loch.

Subject to confirmation of ground conditions at individual locations and with the exception of the overwater structure, spread foundations seem most likely in most cases.

Piled foundations for the overwater structures are to be anticipated, with a requirement for piles to bear on rock in the bed of the loch seeming likely.

4.6.2 Route Option 2

Ground Conditions

Generally the ground conditions are not substantially different for Route Option 2, with broadly similar conditions predicted on the inland section to those of Route Option 1.

Geotechnical Engineering Considerations

Topography and Geomorphology

The topography and geomorphology is broadly similar to Route Option 1.

Earthworks - Cuttings

The maximum cut depth associated with this route option is 21.6 m and a total cut volume of 655,000 m^3 is estimated.

Generally the issues are very similar issues to those presented for Route Option 1, but there is a significantly increased volume of cut, including additional cuttings in superficial materials at Ardlui.

The inland sections of the works are less constrained in nature than Route Option 1, and whilst offering alignment improvements, significant advantages in terms of buildability are not expected, as they are linked by sections that are close to or on the existing route. Consequently a requirement to keep the existing route open during construction will remain, with impact on construction timescales and costs.

Inspections and preliminary rock slope analysis suggest slope angles of up to 60^o should be relatively stable in competent rock for those slopes facing eastwards. Route Option 2 will, however, also require rock slopes facing west and preliminary analysis suggest slopes of less than 45^o may be optimal, without having to resort to engineered support measures.

Earthworks - Embankments/Retained Fill

The maximum fill height associated with this route option is 13.4 m, a total fill volume of 352,000 m^3 is estimated.

Compared to Route Option 1 there will be some additional embankments required at the proposed Inveruglas Water crossing and near Ardlui church. There are no significant differences anticipated from those discussed in Route Option 1 for embankment/retained wall design or construction.

Earthworks - Materials

Similar issues are likely to those discussed for Route Option 1. However the increased proportion of cut associated with this route option is expected to result in a significant surplus of cut material.

The bulk quantities estimated suggest a surplus of approximately 303,000 m^3 of fill material for this route option.

Structure Foundations

There are no significant differences from Route Option 1 in this respect.

4.6.3 Route Option 3

Ground Conditions

Ground conditions for the land-based part of the corridor will not differ substantially from Route Options 1 and 2, although there are additional areas of cutting west of Ardlui Church which will encounter coarse granular deposits.

The ground conditions in the loch were not investigated by the Preliminary Ground Investigation. Limited historic information suggests superficial deposits of variable nature and thickness are present, including granular and cohesive glacial and possibly alluvial materials, with organic soils possibly present. Up to 8.3 m of superficial deposits were encountered near Pulpit Rock overlying the loch bed.

Geotechnical Engineering Considerations

Topography and Geomorphology

The topography and geomorphology expected is broadly similar to that in Route Option 1.

Earthworks - Cuttings

The maximum cut depth associated with this route option is 21.6 m and a total cut volume of 412,000 m^3 is estimated.

Issues are presented are generally very similar to Route Option 1, although with an increase in bulk quantities and cut dimensions.

Earthworks - Embankments/Retained Fill

The maximum fill height associated with this route option is 14.0 m and a total fill volume of 331,000 m^3 is estimated.

A greater proportion of over water work will increase the requirement for placing of selected fill within the loch, if retaining structures are not possible.

Earthworks - Materials

Similar issues to those discussed for Route Option 1 are likely.

However the increased proportion of works within the loch could require additional volumes of selected fill materials. The cut / fill balance is, however, likely to result in an overall surplus of material when compared to Route Option 1.

The bulk quantities estimated suggest a surplus of approximately 81,000 m^3 of fill material, for this route option.

Structure Foundations

Compared to Route Options 1 and 2 there will be an increased requirement for the use of piled foundations to support the proposed over water sections.

4.6.4 Route Option 4

Ground Conditions

Generally, the ground conditions are not expected to be substantially different from those assumed in the other route options.

Geotechnical Engineering Considerations

Topography and Geomorphology

The topography and geomorphology and the issues they present are broadly similar to that discussed in the previous route options. The more significant earthworks proposed will be influenced by the topography, with a substantially increased earthworks footprint being required that may impact on existing infrastructure.

Earthworks - Cuttings

The maximum cut depth associated with this route option is 33.6 m and a total cut volume of 887,000 m^3 is estimated.

Issues presented are generally very similar to Route Option 1, but there is a significantly increased bulk volume and depth of cut for this route option. The most significant cuts are likely to need to be benched and have larger rock traps. This will increase further the required land take.

In other respects similar comments made to those for Route Options 1 and 2 apply to build-ability and rock slope design.

Earthworks - Embankments/Retained Fill

The maximum fill height associated with this route option is 15.0 m and a total fill volume of 377,000 m^3 is estimated.

Similar comments to those made for Route Option 3 apply to Route Option 4, albeit with a further increase in the proportion of works in or over water.

Earthworks - Materials

Similar issues to those discussed for Route Option 1 are likely. However the increased proportion of cut associated with this route option is expected to result in a significant surplus of earthworks materials.

The bulk quantities estimated suggest a surplus of approximately 510,000 m^3 of fill material for this route option.

Structure Foundations

Apart from an increased proportion of overwater structures, there are not expected to be any significant differences from Route Option 3 in this respect.

4.7 Non Motorised Users Infrastructure

NMUs include pedestrians, equestrians and cyclists.

A 2 m wide path is proposed within the east verge of the carriageway between Tarbet and Inverarnan. A width of 2 m is the absolute minimum for an off-carriageway, shared pedestrian and cycle space, as noted in Transport Scotland's design guide, 'Cycling by Design'. This width is noted as being able to operate for combined flows of up to 200 per hour, but requires cycles and pedestrians to take evasive action to pass each other.

A Stage 1 cycle and accessibility audit has been undertaken and the recommendations made will be considered further during the DMRB Stage 3 Assessment.

Further consideration at Stage 3 will be made to the following cycling and accessibility objectives:

- Ensure that the carriageway design recognises the safety of existing on-carriageway users of the A82, considering an average cycle speed of 20 kph and consider mitigation to limit vehicles speeds and highlight the presence of slow moving traffic (including cyclists) entering, exiting and using the carriageway.
- Providing suitable transition opportunities, exceeding minimum design standards, between the carriageway and existing/proposed off-carriageway facilities.
- Provide off-carriageway infrastructure that permits cyclists of all abilities to travel safely, bettering minimum design standards (3.0 m width) and be suitable for use by a 12-year-old unaccompanied child cyclist and family group.
- Consideration of LLTNP aspirations to; develop safe cycling along the A82 north of Tarbet; aspirations for a new off-carriageway cycle path linking Crianlarich and Tyndrum and develop cycle link improvements from Tarbet to Arrochar (National Park Outdoor recreation Plan 2013-2017)
- Give due consideration to the path surfaces to suit the types of users anticipated.
- Minimise delay and optimise safety for all pedestrians; disabled users; and horse riders. The level of provision of crossing facilities will have to be assessed taking anticipated traffic volumes into account, and will recognise existing good practice e.g. dropped kerbs flush to road surface, tactile surfaces etc.
- Provide infrastructure that permits pedestrians and disabled users to safely travel between locations and provide infrastructure that exceeds the minimum design standards.
- Ensure that the design improves linkages between the existing off-carriageway facilities and local destinations for pedestrians; disabled users; and horse riders.
- Provide rest places e.g. seat/ perch, at intervals in line with guidance, set back from any path
- Avoid features which may pose a hazard to visually impaired users (e.g. bollards, barriers) or restrict access by infirm, disabled or other users (e.g. stiles, gradients).

4.8 Public Utilities

As noted in section 2.3.19, responses to the October 2013 C2 request noted that the following statutory undertakers had apparatus within the route corridor:

- British Telecom
- Scottish & Southern Energy
- Scottish Power
- Scottish Water

In order to inform the Stage 2 assessment, requests were made to these utilities companies, in September 2014, for a NRSWA C3 budget cost estimate for any necessary utility diversions for all four route options.

4.8.1 Electricity

Scottish & Southern Energy (SSE) has indicated that their apparatus within the study would be affected by all four of the proposed route options.

SSE proposes works including all or some of the following:

- Temporary lowering of cables to allow for road construction
- Permanent installation of cables in ducts underneath the road

- Temporary and then permanent moving of overhead lines underground
- Movement of transformers
- Installation of new poles
- Shutdown of network

The proposed costs for these works are indicated in **Table 4.8.1**.

Table 4.8.1: SSE C3 Diversion Budget Estimate Costs

Route Option	Minimum C3 Budget Cost Estimate	Maximum C3 Budget Cost Estimate
1	£158,000	£174,000
2	£173,000	£191,000
3	£167,000	£184,000
4	£158,000	£174,000

All costs are presented excluding VAT.

In addition to the local SSE network, Scottish Power (SP) operates transmission lines through the study area.

These lines are located adjacent to the existing A82 road at Inverarnan, where they pass through an electrical substation.

SP has indicated that the current designs for the route options will not affect their apparatus. However, due to the close proximity of their apparatus to the road, any changes to the route options, particularly changes to road levels, may require diversion of their apparatus.

4.8.2 Telecommunications

The existing telecommunications network within the study area is provided by British Telecom (BT), generally by an underground network in Tarbet and by overhead lines located in the east verge of the A82 north of this location.

C3 returns received from BT indicate proposed works will include:

- Diversion of cables from within proposed carriageway
- Undergrounding of existing overhead lines north of Tarbet
- Construction of new underground road crossings

BT has provided a budget cost estimate of £400,431.20 excluding VAT for this work, which is the same across all route options.

Additionally, within their C3 return, BT has indicated that an underwater fibre optic cable may be present within Loch Lomond. BT is uncertain on the location of the cable and the impacts it may have on the proposed route option. Further investigation by BT will be required.

4.8.3 Scottish Water

Properties in and around Tarbet are served by a Scottish Water (SW) potable water supply and SW sewer lines present in the existing A82 carriageway and verge, with multiple crossings.

The C3 return from SW indicates a requirement to divert a water main at Tarbet by constructing a new section of water main and abandoning the section that will no longer be in use.

The C3 budget estimate cost for these works is £54,486 excluding VAT for each of the route options.

No other locations within the study area are served by public water or sewage supplies. Budget cost estimates for the diversion of private water and sewer supplies, should these be required, is outwith the scope of this report.

4.9 Buildability

4.9.1 Corridor Constraints

The road corridor passes through the LLTNP and is within an area of outstanding natural beauty and landscape character.

The route is highly constrained between Tarbet and Stuckindroin, with steep hillsides and the West Highland Line to the west and the Loch Lomond shoreline to the east. Between Stuckindroin and Inverarnan the topography opens out and the road moves inland, avoiding the loch shore. The railway still provides a significant constraint up to and beyond Ardlui, where the constraint becomes less challenging.

There are significant environmental and ecological constraints along the route corridor including protected species and a number of designated sites. These will require careful consideration both during the next stage of design and also during construction.

There are numerous residential properties, businesses and tourist facilities along the road, as well as the villages of Tarbet, Ardlui and Inverarnan. Consideration must be given to maintaining access and minimising disruption during construction works.

The existing route has two particular road asset constraints to route option development:

- The existing bridge at Sloy Power Station which is a listed structure
- The new viaduct works at Pulpit Rock

These constraints are common points in all the route options and enable the study area to be sub-divided into three sections:

- Section 1: Tarbet to Sloy Power Station, Inveruglas
- Section 2: Sloy Power Station, Inveruglas to Pulpit Rock
- Section 3: Pulpit Rock to Inverarnan

Sections 1 and 2 are highly constrained by the topography along the road corridor with Loch Lomond foreshore to the east and steep hillsides and the West Highland Line to the west.

Section 3 is less constrained by topography and north of Stuckindroin the road moves away from the loch shore and the landscape becomes flatter within the corridor.

Although the scheme will be developed and promoted as one project, the above approach will permit Transport Scotland to procure the works as one contract or three or more individual contracts, as budget availability dictates.

It is recommended that further route development in the DMRB Stage 3 process considers in more detail the impact of procurement as one, three or more individual contracts.

Particular issues in the procurement of the contract would include:

- Effect on Statutory Orders
- Cumulative disruption from multiple contracts or a longer single contract
- Effect on economic benefits of sectional completion
- Environmental impacts
- Construction risk

As stated the road corridor is heavily constrained particularly on Sections 1 and 2 and this places significant restrictions on construction work. This buildability assessment considers how the various sections may be constructed with minimum disruption to road users and the community.

4.9.2 Principal Construction Activities

Many of the construction activities are common between all four route options, albeit to differing degrees.

The most significant construction activities affecting buildability occur primarily along Sections 1 and 2 and to a lesser degree along Section 3. These include:

- Formation of cuttings (primarily rock) on the west side of the existing road in close proximity to the existing carriageway. Cutting heights up to around 22 m are proposed in some locations.
- Construction of new embankments and earthworks within and adjacent to Loch Lomond, with severely restricted access and stringent environmental constraints.
- Construction of retaining walls and viaducts adjacent to and within the loch to retain earthworks.

4.9.3 Constraints to Construction Activities

The existing and proposed carriageways are generally aligned within the same corridor for the route options being considered.

The majority of construction work will therefore be adjacent to live traffic, meaning traffic management and safety is a major consideration. This constraint will also mean that significant lengths of new road will require to be constructed in “two halves” (i.e. one lane at a time) with suitable traffic management measures to avoid widening the corridor for temporary roads.

The vast majority of earthworks fill requirements are on the east side of the existing road, whilst availability from new cuttings is on the west side.

This introduces logistical issues in transportation of material and phasing of cut/fill operations. The constrained nature of the site means that stockpiling of materials within the site boundaries for re-use will not be possible and a large proportion of the excavated material (primarily rock) will require to be processed before incorporation into earthwork embankments.

Large quantities of material will require to be removed from site, processed and stockpiled before incorporation into the works. Potential sites for these operations should be considered in the following Stage of assessment. These should be as close to the site as possible to minimise construction traffic, environmental impact and reduce cost.

To minimise the requirement for stockpiling of materials, environmental impact and construction duration, cut and fill operations should be undertaken simultaneously.

In terms of drainage, the following will need to be considered during construction and maintenance stages.

- Temporary crossings of watercourses
- Temporary diversions of watercourses to construct permanent crossing
- Haul road construction along loch edge
- Dewatering
- Possible floating construction platform in loch
- Potential flooding of construction site (e.g. due to changes in loch level or from watercourses)

4.9.4 Traffic Management Principles

Three options for managing existing traffic flows during construction have been considered and are listed below in order of desirability:

- Maintain two-way traffic operation
- Single lane working
- Road closure

Maintain two-way traffic operation: The most acceptable approach is to maintain two-way traffic operation, albeit with reduced speed limits and lane widths.

This is considered feasible on a number of the proposed key structures by utilising the widened verge as part of a temporary running lane with minimal use of sacrificial surfacing.

Singe lane working: The length and frequency of single lane working which would be permitted would require approval from the trunk road Operation Company as well as discussions with the local communities, emergency services and consideration of economic impact. Current guidance given in Chapter 8 of the Traffic Signs Manual states that the maximum length of site works on a trunk road should be limited to 4 km with a minimum of 2 km between work sites.

To maintain access for Heavy Goods Vehicles (HGVs) a minimum lane width of 3 m will be required. A temporary speed limit of 30 mph would increase safety and although a reduction in speed enables a reduction in clearance between site workforce and traffic an appropriate safety clearance would be needed. Convoy working, with a lead vehicle controlling speed, may be an appropriate method to improve safety.

Principal considerations for the implementation of single lane working are:

- Length of contraflow
- Distance between adjacent traffic management
- Operation by traffic lights or convoy
- Cumulative effects of traffic delays through the entire route
- Integration with construction traffic at access/egress points
- Effect on local residents and businesses

Road closure: Full closure of significant sections of the road for any length of time is considered undesirable, due to the length of a suitable diversionary route. The available diversionary route between Tarbet and Inverarnan is approx 117 km in length (along the A83 to Inveraray, the A819 and then the A85 via Crianlarich). Local residents and businesses will require access to be maintained.

Long term full road closures are likely to have a severe impact on maintaining the viability of small local businesses. Wherever possible, full road closures should be restricted to specific locations for targeted construction activities and if possible, limited to overnight closures.

Detailed traffic analysis would be undertaken in the Stage 3 assessment to understand traffic issues. All proposed traffic management proposals will require to be agreed with the Transport Scotland Network Management.

4.9.5 Emergency Access and Return to Service during construction

Due to the lack of diversion routes, consideration should be given to how the construction works can be returned to two-way working should there be a closure on the A83 (for example at the Rest and be Thankful). The parallel construction of a temporary lane (which could later become the combined cycle/pedestrian path) may assist in providing resilience.

4.9.6 Earthworks Operations

Earthworks Cut

It is assumed that the majority of earthworks cut will be in rock, which will generate suitable fill for use in embankments.

Large-sized rock fill, suitable for embankment starter layers, is likely to be generated "as excavated". The bulk of the rock cut will, however, require processing to produce a suitable material for general earthworks fill and other uses such as capping, sub-base and drainage filter.

To minimise impact on road users, it is assumed rock cuttings will be progressed in short, manageable sections during short-term road closures.

Blasting and removal of material would be undertaken within an agreed closure period (overnight) subject to limitations on noise at particular locations. The existing pavement would require protection using crash mats, with blasted material removed to a processing site, the road cleared and re-opened.

Earthworks Fill

Along stretches of Sections 1 and 2 the initial requirement for embankment construction will be to place a starter layer directly into the water.

This material will comprise selected large rock fill typically 0.5 m^3 size and will be placed on an individual basis.

The "as excavated" rock fill should be relatively clean, free from fines and carefully selected to ensure adequate durability within the water environment. Large stones would be positioned individually, rather than by random tipping and this procedure should minimise disturbance to the loch bed and the local ecology. Pre-washing may be necessary if the rock fill contain an unacceptable amount of fines.

Processing and Stockpiling

A significant amount of material is expected to require processing for re-use in embankments and stockpiled prior to incorporation into the works.

It may be possible that a contractor would wish to construct a temporary jetty in the locality to service barges that may be employed in the construction of the works. Barges could be utilised for the transportation and placing of rock fill.

Further consideration in the next Stage of assessment should be given to:

- Identifying suitable areas of land which could be used for rock processing and stockpiling
- Whether such areas could be procured as a temporary servitude through the CPO process or by agreement with the LLTNPA
- Whether agreement in principle could be agreed with the LLTNPA for the provision of a temporary/permanent jetty

4.9.7 On-line Construction Methodology & Traffic Management

For efficient site working it would be necessary to programme and plan traffic management measures to permit cut and fill operations to take place simultaneously.

The following text outlines one possible methodology for on-line construction. Some variation to this methodology would be required at locations where the proposed road level is significantly higher than the existing road. This may require the minor realignment of the route and provision of temporary running surfaces.

Consideration could be given to initially constructing the combined cycle/pedestrian route as a running surface for traffic in the temporary case to facilitate the carriageway construction.

Phase 1A - Excavation on west side

To provide a safe access to excavate cuttings on the west side of the existing road the traffic would be moved to the east (southbound) side of the existing

A82 under shuttle working. A 3 m wide running lane should be provided to permit use by HGVs. Refer to **Figure 4.1** & **Figure 4.2**.

Site clearance would commence on the existing slopes. This will involve removal of trees, bushes, vegetation, topsoil etc. Fail safe methods would be required for felling of larger trees, or alternatively short term road closures introduced.

Figure 4.1: Existing conditions

Figure 4.2: Phase 1A, excavation on west side

Temporary safety barriers would be provided to protect the workforce from the traffic and the road users from the works, with the existing safety barrier on the east retained if possible.

The excavation of major rock cuttings adjacent to a live carriageway is not safe. To minimise impact on road users it is assumed that rock cuttings will be progressed in short manageable sections during overnight closures. Blasting and removal of material would be undertaken within each closure period and the road cleared and re-opened the next day. Material would be transported by using part of the closed northbound lane as a haul road.

Additional logistics which require to be addressed during construction include maintaining access to residential properties and businesses, and providing crossing points for construction plant to transport material across the live traffic from west to east.

Phase 1B - Fill on east side

Where embankment or retaining wall works are required along the shore line, the construction of a starter layer for this embankment would run concurrently with excavation on the west side. It is anticipated that once complete this would form an intermittent haul road along the scheme with intermediate access points on the trunk road.

The starter layer/haul road could be extended beyond the toe of the earthworks embankment as a permanent berm of minimum 1.5 m width. Refer to **Figure 4.3**.

Figure 4.3: Phase 1B, construction of berm on east side

This would perform a number of important functions:

- During construction the berm will provide a safety zone for construction plant, avoiding the need for plant to operate directly adjacent to the water.
- The berm would minimise the risk of earthworks fill material falling directly into the loch during placing and compaction of the main embankment fill.
- To provide a suitable surface for normal construction vehicles, the coarse rock fill starter layer would require to be infilled with smaller crushed stone material and surface dressed. Adoption of a berm would mean that this infill material need not extend into the water edge reducing the disturbance within the loch.
- The finely graded infill material would function similar to a filter drain to trap any fines washed down from the slopes during construction.
- In the permanent condition, the berm will provide a safe means of access for personnel required to maintain the landscaping planting.
- The berm could also be used to provide environmental enhancements and could be

utilised for lower level off-line sections of the proposed combined cycle/pedestrian path assisting in reducing full road height earthworks.

Phase 2 – Completion of west side

Once the cutting works on the west side are complete, the existing carriageway can be widened as necessary with the construction of either the final pavement, drainage and other finishes on the west side or, if not possible, a temporary running surface.

Phase 3 – Completion of east side

Traffic would be moved, to the new northbound lane previously constructed under Phase 2 and would run under shuttle working. The east side embankment would be completed, together with drainage and road pavement. See **Figure 4.4**.

Figure 4.4: Phase 3, traffic moved to new northbound lane

Phase 4 – Road opened

The road can be opened to full two-way traffic and the combined cycle/pedestrian lane completed. See **Figure 4.5**.

Figure 4.5: Phase 4, road re-opened, path completed

4.9.8 Off line construction

Sections of new road being built off-line from the existing road will have the benefit that the existing A82 can stay open to two-way traffic.

Off line sections will largely require either the construction of cuttings into the hillside or structures out into the loch.

For new off line cuttings, buildability issues would be restricted to the logistics of blasting, excavation and transportation of materials.

For new structures being built out into the water, buildability issues would include, working in water, logistics of delivery to site of bridge elements, installation of support piles and installation of beams and deck, either incrementally from the shore, or from a barge.

5. Environmental Assessment

5.1 Introduction

This chapter provides a summary of the A82 Tarbet to Inverarnan Upgrade Stage 2 Environmental Assessment Report, which has been completed in accordance with DMRB, Volume 11: Environmental Assessment.

Full details of the Assessment can be found in the DMRB Stage 2 Environmental Assessment Report, dated June 2015.

The environmental assessment is structured around the environmental topic areas described in DMRB Volume 11 Section 3 as amended by IAN 125/09:[2]

- **Air Quality** assesses the impact of the route options on local and regional air quality.
- **Cultural Heritage** assesses the impact of the route options on designated and non-designated cultural heritage and archaeology.
- **Landscape** assesses the impact of the route options on the surrounding landscape and visual environment.
- **Nature Conservation** assesses the impact of the route options on flora, fauna and biodiversity.
- **Geology and Soils** assesses the impact of the route options on soils and underlying geology (solid and drift).
- **Materials** assesses the impact of the route options on material resource use and generation of waste.
- **Noise and Vibration** assesses the impact of the route options on the surrounding noise environment.
- **Effects on All Travellers** assesses the impact of the route options on drivers (considering driver views from the road and driver stress) and on journeys made by pedestrians, cyclists and equestrians.
- **Community and Private Assets** assesses the impact of the route options on community facilities and community severance and on agricultural land, development land and land used by the local community.
- **Road Drainage and the Water Environment** assesses the impact of the route options on the local freshwater environment, considering the implications of the drainage design and flood risk assessment information currently available.

5.2 Air Quality

Some construction activities are likely to generate dust which has the potential to cause annoyance (e.g. discolouration of surfaces) at nearby properties if uncontrolled. These effects will be mitigated through the implementation of best practicable means, such as wetting down.

A simple level assessment has been used to assess the air quality impact of the operation of the proposed scheme at receptors, using an atmospheric dispersion model.

There are no changes in traffic flows (volumes) as a result of the scheme. There are however expected to be air quality impacts due to a change in route alignment and traffic speed.

Nitrogen dioxide (NO_2) and particulate matter (PM10) concentrations are expected to be well below air quality objectives at all receptors in the Base Year (2013), Opening Year (2020) without the scheme and with the scheme (for all route options). The maximum scheme impact at receptors (for any route option) is expected to be -0.8 $\mu g\ m^{-3}$ for NO_2 and +/- 0.1 $\mu g\ m^{-3}$ for PM10.

None of the proposed route options are predicted to lead to a change in air quality at ecological designated sites.

[2] IAN 125/09 stipulates that the assessment of "Disruption Due to Construction" (DMRB Vol. 11 Section 3 Part 3) (assessment of the construction of the route options on people and the natural environment) and "Impact of Road Schemes on Policies and Plans" (DMRB Vol. 11 Section 3 Part 12) (impact of the route options in terms of the wider context of national, regional, strategic and detailed planning policies) should be absorbed into each individual topic assessment.

The overall air quality impacts of the scheme are expected to be not-significant for all route options. The scheme does not therefore conflict with local policy to protect air quality (The Loch Lomond & The Trossachs National Park Authority, 2011).

As there are no human or ecological receptors which are expected to experience a significant change in air quality as a result of any of the route options, **there is no preferred route option from an air quality point of view**.

5.3 Cultural Heritage

The review of archaeological events shows clear examples of previously unknown archaeological remains being detected. There is a low level of potential across the study area, with no standout area representing a greater potential. A preliminary watching brief on selected ground investigation pits, spread across the study area has been largely inconclusive in scoping out any particular areas for further investigation.

In terms of heritage assets, there are a number of statutory protected features, including three Scheduled Monuments, which may have their setting affected by the scheme.

The landscape surrounding the proposed scheme has potential to contain previously unknown archaeological remains from the prehistoric to the post medieval periods.

Route Option 1 is the preferred route option from a cultural heritage point of view as it offers the least visual impact to the setting of the statutory protected features. The widening of the road corridor would have some potential to impact upon previously unknown archaeological features. The overall setting impact would, however, result in the least change.

5.4 Landscape

Due to the location of the study area being within the LLTNP and therefore containing a high level of valuable / sensitive landscape resources and character types, the most significant effects have been identified on landscape receptors.

Sensitive design of any of the route options would be necessary to mitigate these effects, especially to topography and vegetation cover.

The landscape and visual impact assessment identified a number of long term significant effects: Route Option 1 has the fewest significant effects (two no.), Route Options 2 and 3 have an equal number of significant effects (five no.) and Route Option 4 has the greatest number of significant effects (six no.).

It is worth noting that in the short term, the majority of visual effects and all visual effects relating to views from properties along the existing A82, are significant effects.

In the long term, which is assessed as after 15 years on a summer's day, these effects generally reduce to minor adverse or negligible due to mitigation.

In principle, **Route Option 1 would be the preferred route option from a landscape and visual point of view**. This is due to localised widening of the existing road, thus resulting in the least alterations to landscape character and visual impact when compared to the other route options.

5.5 Nature Conservation

The baseline data has shown that features of statutory designated sites, Scottish Biodiversity List habitats and protected species including European Protected Species are present within the zone of influence. The assessment has identified measures required to mitigate for potential impacts.

For all route options, mitigation measures will be required to reduce potential impacts to a number of qualifying features of internationally important designated sites (golden eagle, western acidic oak woodland and otter), ancient woodland, other woodland, semi-improved grassland, marshy grassland, wet heath, mire, flush, standing water, running water, natural rock exposures, badger, bats, breeding birds, fish, pine marten, red squirrel and reptiles.

Detailed assessment has been undertaken for those impacts where the level of mitigation required is likely to be greater than a normal road building scheme would require, or is likely to differ greatly between route options and therefore be a key factor in the decision making process. These impacts relate to the Loch Lomond Woods Special Area of Conservation (otters), ancient woodland habitat, birds (wood warbler) and fish.

In terms of ecological receptors, Route Options 1 and 2 have slightly lower cumulative significance of residual impacts than Route Options 3 and 4.

Route Options 1 and 2 have greater potential to impact ancient woodland and Route Options 3 and 4 have greater potential to impact otter and fish.

The largest potential significant residual effect is for loss of otter habitat and this is common to all four route options.

Overall, when comparing the significance of impacts to receptors where there are differences between route options, Route Options 3 and 4 have the highest level of adverse significance (very large), which relates to disturbance to otters caused primarily by construction of viaducts along sections of the loch.

Based on this comparison commentary, **either Route Options 1 or 2 would be preferred from a Nature Conservation perspective.**

5.6 Geology and Soils

Route Options 1 and 3 have the least impact over the entirety of the scheme, as they stay close the current road alignment, utilizing the current road level and widening it westward of the carriageway. These routes also have the lowest cut volumes of all four route options.

Due to the ground conditions, and as rock is generally quite shallow in the study area, all four route options will have a greater impact on the solid geology, (albeit slight) than on the drift geology.

The receptor of highest sensitivity is Garabal Hill SSSI, north of Ardlui. The site will however experience a negligible impact, as it is distant from all route options.

There is generally very little contamination present on site, hence this is expected to be of generally negligible significance.

As there is no quarrying or mining in the area there is no loss of economic deposits/resources, meaning that the significance of the effects of a developed scheme will always be negligible in this respect.

Route Options 1 and 3 are very similar in the scale of their impacts, however, Route Option 3 incorporates the areas of shallowest peat within its design and therefore has a low impact on this resource. Using the preliminary data gathered at this stage, a tentative route option can be recommended; it is determined that **Route Option 3 is preferable from a Geology and Soils point of view**.

5.7 Materials and Waste

Each of the route options will have an adverse effect with regard to the use of materials and the generation of waste when compared to a 'Do Minimum' scenario.

The engineering information currently available for the each route option has facilitated the completion of a qualitative assessment, based on a comparison of the proposed options.

The quantity of materials used and wastes generated by each route option is likely to be positively correlated to construction value. This assumption is validated by various resource efficiency benchmarks published by WRAP and BRE for completed roads projects. The most expensive route option is therefore likely to result in the greatest 'materials' impact (i.e. potentially resulting in the largest material requirements, embodied carbon emissions and waste generation).

Consequently, Route Option 1, as the cheapest option, is likely to result in the lowest potential 'materials' impact. This is due to it offering the lowest percentage of off line sections, requiring a comparatively small number of structures and providing the optimum cut / fill balance.

Where impacts have been identified, these will be addressed through ensuring that the construction of the scheme responds to legislative requirements, policies and plans and identified mitigation measures.

Route Option 1 is the preferred route option from a Materials and Waste perspective.

5.8 Noise and Vibration

The assessment of construction (temporary) impacts is based on indicative noise calculations and without considering any mitigation measures in place. This has shown that noise levels associated with the key activities to be conducted during the construction of any of the four proposed route options are all expected to exceed the daytime noise trigger level of 75 dB at sensitive receptors within 50 m of any of the proposed route options.

The assessment of daytime and night-time operational road traffic noise (permanent) impacts has demonstrated that the majority of residential dwellings are expected to experience a negligible increase in noise levels in the short term and long term scenarios with any of the proposed route options.

Predicted increases in road traffic noise are due to predicted increases in traffic speeds in all route options and also the physical movement of road traffic closer to receptors in some locations, depending on the route option.

Nevertheless, the magnitude of the impact is expected to be greater with some route options, depending on how close the proposed route alignment is from the sensitive receptors.

Ground-borne vibration levels predicted at the closest residential premises, located between 8 m and 10 m from the proposed routes, range between 0.72 and 0.86 mm/s. Levels of such magnitudes would be just noticeable and below the level likely to cause complaint.

Based on the operational road traffic noise assessment, in terms of the least adverse noise impacts expected at the assessed sensitive receptors, the preferred route option is Route Option 1. This is likely to be due to the fact that Route Option 1 is the route option most similar to the existing A82 route alignment, hence the change in noise levels at the assessed areas are not as significant as those resulting from the other route options.

5.9 Effects on All Travellers

Due to the presence of a number of Core Paths, a National Cycle Network route and Tourist Walks, the sensitivity of the study area for all four route options for NMUs is high.

Due to the predominately on-line nature of Route Option 1, it is predicted that this route option would have the least overall benefit from the perspective of all travellers experience of the route.

Specifically, it is considered at this stage that Route Option 4 is the best route option due to the amount of potential NMU enhancement opportunities, which results in predicted residual Major Beneficial effects.

When considering the future vehicle travellers along the route, it is predicted at this stage that Route Options 2, 3 and 4 would reduce driver stress levels more so than Route Option 1.

When considering the route options against the driver experience in terms of views from the road, it is predicted at this stage that Route Option 4 would be the preferred route option and Route Option 1 would be the least preferred route option. Route Option 4 is also considered to provide the most opportunity to enhance views of the LLTNP from the road.

Taking into account the predicted effects and differences between the four route options, **Route Option 4 is the preferred route option from an all traveller perspective.**

5.10 Community and Private Assets

In terms of the effects on private property, all route options involve severance to and land take of private property. A number of buildings may be affected (potentially requiring demolition) as part of each route option, with the majority being non-residential.

For Route Option 1, approximately 213 land parcels will lose a small amount of land, and five buildings (non-residential) may be affected.

For Route Option 2, approximately 221 land parcels will lose a small amount of land, and three buildings (non-residential) may be affected.

For Route Option 3, approximately 200 land parcels will lose a small-medium amount of land, and three buildings (non-residential) may be affected.

For Route Option 4, approximately 215 land parcels will lose a small-medium amount of land, and six buildings may be affected, including one residential property which would be compulsory purchased.

Route Option 1 affects the fewest areas of community land out of all four route options. This is due to the largely on-line nature of the route.

Once the road is constructed, access to private property, community facilities and community land will be improved.

There will be broadly similar quantities of agricultural land take as a result of all four route options; this will sever access to land and the loss of low quality agricultural land.

The route options are designed to minimise impacts to local features, reduce land take to a minimum and include the installation of access tracks to provide continued connectivity to those areas affected by the new road alignment.

Land owners will also be compensated for the value of land lost, taking into account the reduced income and viability from their land.

From a Community and Private Assets perspective, Route Option 3 has been identified as the preferred route, due to it impacting the fewest number of private properties.

5.11 Road Drainage and the Water Environment

The water risk assessment has concluded that the inclusion of appropriate mitigation measures will lead to a general improvement of the water quality, fluvial geomorphology and flood risk in the surface water bodies for all route options.

The significance of impacts of the construction and operational activities with mitigation in place have been identified as either beneficial or neutral on all receptors, except on the fluvial geomorphology of all surface water bodies during construction and the River Falloch during operation where slight adverse impacts have been identified. This is as a result of channel re-alignments, watercourse crossings and loch shore works.

All route options offer scope for beneficial improvement to the water environment when compared to the existing situation.

Route Option 1 is the preferred route option from a Road Drainage and the Water Environment perspective, due to the opportunities to maximise improvements or remove existing pressures and the potential to avoid and mitigate new pressures on the water environment.

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6. Traffic and Economic Assessment

6.1 Introduction

The quantitative assessment of the transport economic efficiency and road safety aspects of a proposed road improvement requires the development and application of various computer models.

In the case of the DMRB Stage 2 A82 Tarbet to Inverarnan appraisal, this has involved the development of a NESA (Network Evaluation from Surveys and Assignment) model supported by a QUADRO (Queues and Delays at Roadworks) model.

The NESA model was developed to compare the costs and road user benefits of the proposed improvements; and the QUADRO model was developed to examine the delays and costs associated with the construction works and future road maintenance requirements.

Full details of the traffic and economic models developed to support the assessment of the four route options considered as part of the DMRB Stage 2 Scheme Assessment can be found in the DMRB Stage 2: Traffic and Economic Appraisal Report, dated March 2015.

6.2 Base Model

The NESA Base model was developed as part of the DMRB Stage 1 assessment to reasonably represent existing conditions on the A82 between Tarbet and Inverarnan. The model is based on information collected as part of a detailed programme of traffic surveys and data collection in 2013, which included obtaining details of:

- traffic volumes through automatic traffic count data
- turning movements from vehicle classified junction counts
- traffic patterns via automatic number plate recognition surveys
- journey times
- accidents numbers and their severity

Details regarding the development of the Base model can be found in the CFJV DMRB Stage 1: Traffic and Economic Appraisal Report, dated March 2014.

6.3 Future Conditions

6.3.1 Reference Case

A Reference Case provides the baseline conditions against which, proposed improvements to the trunk road network are assessed. The NESA Reference Case model used in the DMRB Stage 2 traffic and economic appraisal is based on that developed at Stage 1, which includes the improvement at Pulpit Rock (which is not in the Base model).

For the purpose of the Stage 2 appraisal, the model has been updated to incorporate the latest available 5-years of local accident data (covering the period 2009 to 2013 inclusive), separating out accidents that occurred on links and at junctions.

Details of the Reference Case can be found in the CFJV DMRB Stage 1: Traffic and Economic Appraisal Report, dated March 2014.

6.3.2 Traffic Forecasts

As Transport Scotland's Transport Model for Scotland (TMfS) forecasts reflect current land use plans and, accordingly, potential changes of demand in the corridor, it is considered to provide the most suitable evidence base on which to predict forecasts of traffic on the A82.

The forecast of traffic growth on the A82 from TMfS is shown in **Figure 6.1** based on output flows, from version 12A of the model, for the 2012, 2017, 2022, 2027 and 2032 model years Forecast Years.

Using 2013 as the base year, the traffic growth forecast from TMfS is presented alongside National Road Traffic Forecasts (NRTF (1997)) projections, embedded as default growth scenarios within the NESA program and (considered during the DMRB Stage 1 assessment), in **Figure 6.2**.

Figure 6.1: TMfS traffic growth forecast for A82

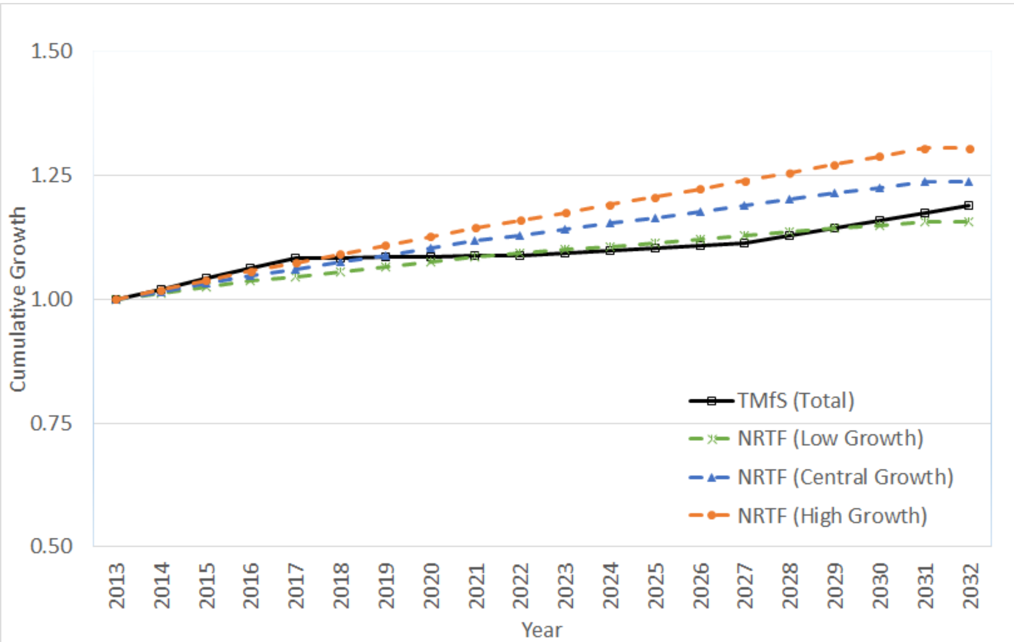

Figure 6.2: TMfS vs. NRTF (1997) Growth (2013 to 2032)

6.3.3 Forecast Years

Forecast years are taken to be the predicted year of opening (2020) for the Tarbet to Inverarnan Upgrade and the design year of fifteen years after opening (2035).

Cumulative traffic growth factors derived from the TMfS traffic forecasts are shown for key years in **Table 6.1**.

Table 6.1: TMfS traffic growth factors

Year	Cumulative growth factor
2013	1.00
2020	1.09
2032	1.19
2033 to 2080	1.19

Traffic flows for the Reference Case network in the 2013 base year, 2020 and 2035, under TMfS traffic forecasts, are shown in **Figure 6.3**. For the purpose of the Stage 2 assessment, flows on the A82 between Tarbet and Inverarnan are forecast to range from 3,400 to 3,600 vehicles in 2020, increasing to between 3,700 and 4,000 in 2035.

6.3.4 Journey Times

Examination of the NESA Reference Case model indicates that:

- trips between Tarbet and Inverarnan would take just under 17 minutes in 2020, with a slight increase in 2035
- of the 17 minutes, just over 11 minutes is attributable to the section of the A82 between Tarbet and Pulpit Rock(nodes 100 to 140), with just over 5 minutes associated with the section between Pulpit Rock and Inverarnan (nodes 145 to 205)

6.3.5 Network Capacity

Examination of the model results indicates that none of the modelled links in the Reference Case would exceed capacity under the TMfS traffic growth scenario by the year 2035.

6.3.6 Road Safety

The location and severity of accidents on the A82 between Tarbet and Inverarnan (excluding the Pulpit Rock improvement section), during the period from 2009 to 2013 inclusive, are shown in **Figure 6.4**. During this period, 56 personal injury accidents (PIAs) occurred on this section of the route, of which 15 were ‘serious’ PIAs and 41 were ‘slight’ PIAs.

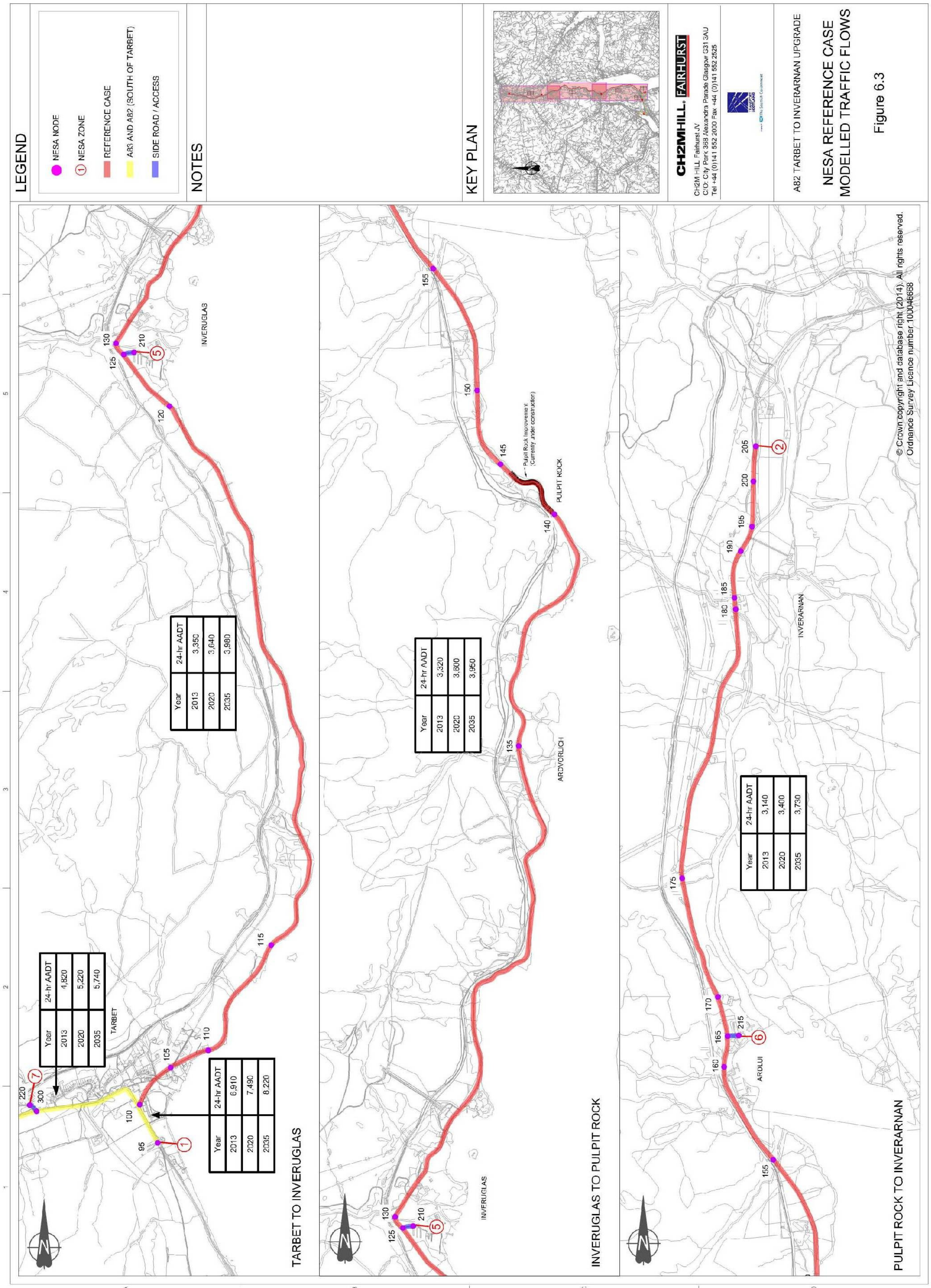

Figure 6.3: NESA reference case, Modelled traffic flows

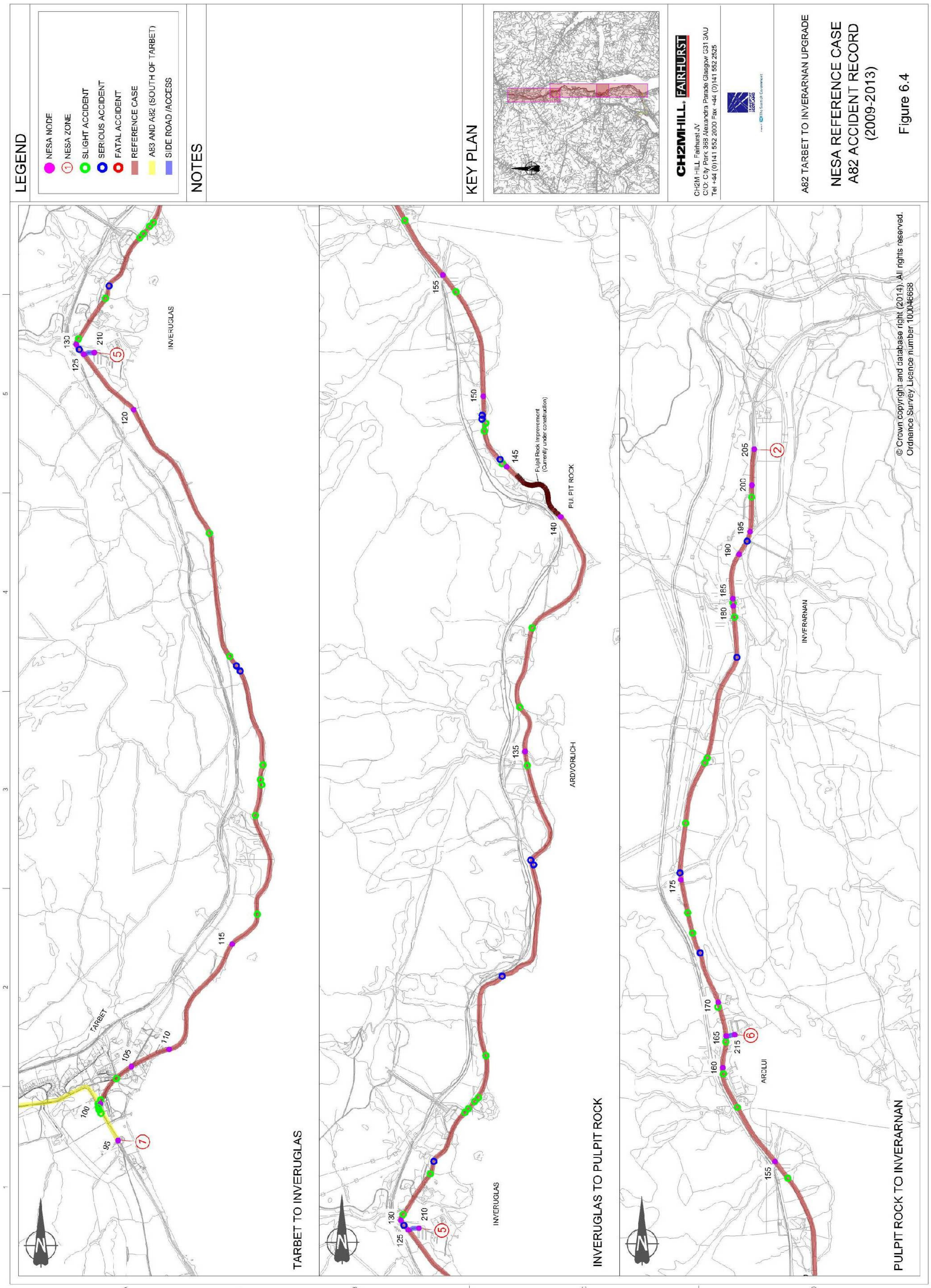

Figure 6.4: NESA reference case, Accident record (2009-2013)

6.4 Effect of Route Options

6.4.1 Introduction

Savings in journey time are likely to be the most significant benefits resulting from the provision of the A82 Tarbet to Inverarnan upgrade. Significant benefits are also expected from improving safety.

6.4.2 Traffic Flows

The 2-way 24-hour AADT traffic flows in the 2020 opening year and 2035 design year for the route options, under traffic growth forecasts from TMfS are presented in **Figures 6.5a** to **6.5d**. The flows are consistent with the Reference Case, ranging from 3,400 to 3,600 vehicles in 2020 and increasing to between 3,700 and 4,000 in 2035.

6.4.3 Journey Time Savings

Trips between Tarbet and Inverarnan via each of the route options could be between approximately 13.5 to 14 minutes in the opening year (2020) and design year (2035), providing a journey time saving of up to around 3.5 minutes when compared to the respective Reference Case times.

Of the 3.5 minute saving, approximately 2.5 minutes is attributable to the upgrade of the A82 between Tarbet and Pulpit Rock (south of the improvement), with just under 1 minute associated with the upgrade between Pulpit Rock (north of the improvement) and Inverarnan.

Whilst there is little difference in journey times between the route options, Route Option 4 is predicted to provide the shortest journey times (13 minutes and 22 seconds in 2020 and 13 minutes 26 seconds in 2035). This is expected to deliver savings of approximately 3 minutes 26 seconds in 2020 and 3 minutes 28 seconds in 2035 when compared against the Reference Case.

6.4.4 Road Safety

The results of the NESA analysis indicate that, whilst there is little difference between the route options in terms of their impact on safety, Route Option 4 would provide the greatest level of accident savings, followed by Route Options 2 and 3, then Route Option 1.

Over the 60 year economic life of the upgrade, the projected savings of the four route options range between 408 and 413 personal injury accidents.

In addition to reducing the number of personal injury accidents, the upgrade is also expected to reduce their severity.

6.4.5 Network Capacity

As the upgrade will generally improve link capacity, none of the modelled links in the route option models are likely to exceed capacity under the TMfS traffic growth forecast by 2035.

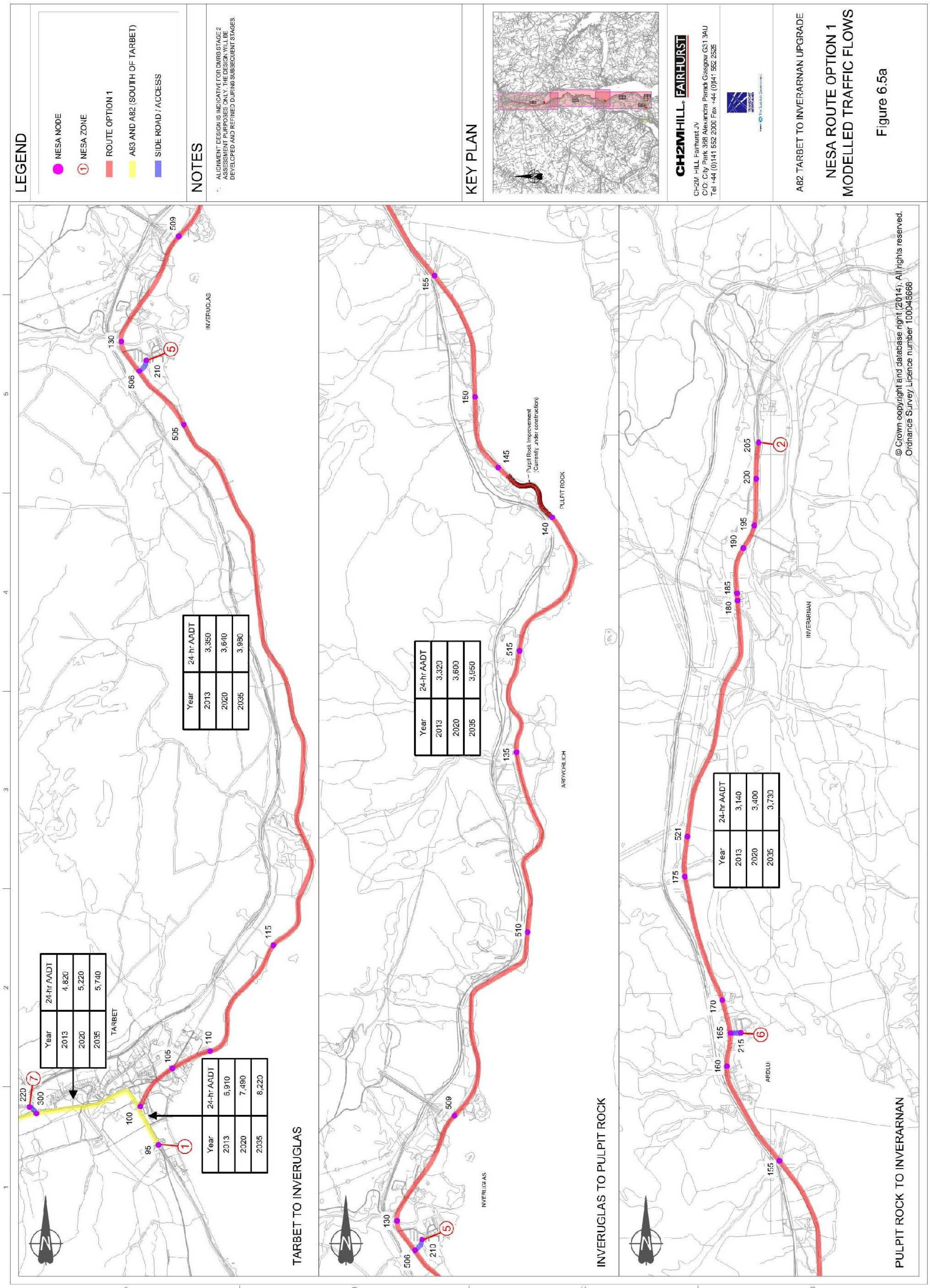

Figure 6.5a: NESA Route Option 1, Modelled traffic flows

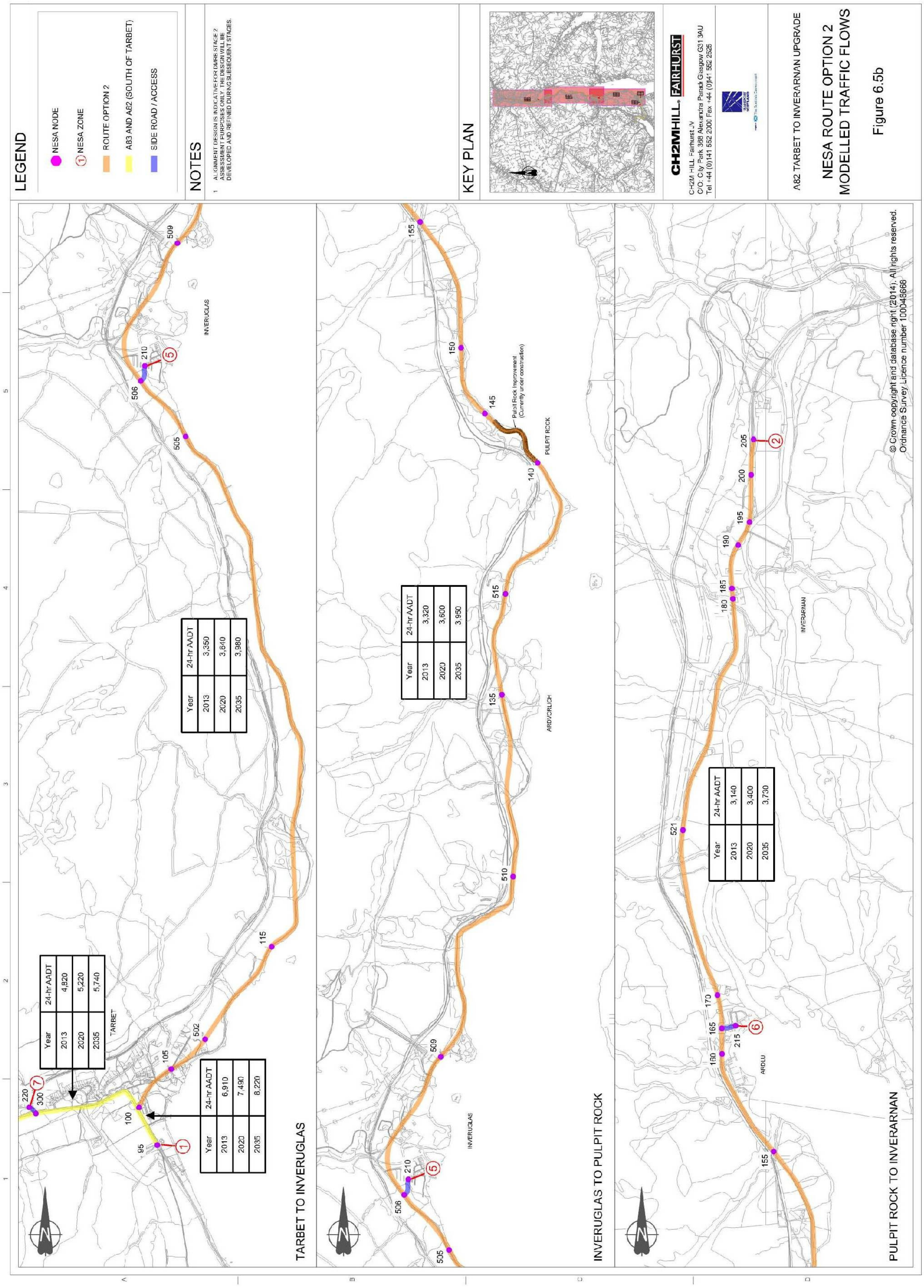

Figure 6.5b: NESA Route Option 2, Modelled traffic flows

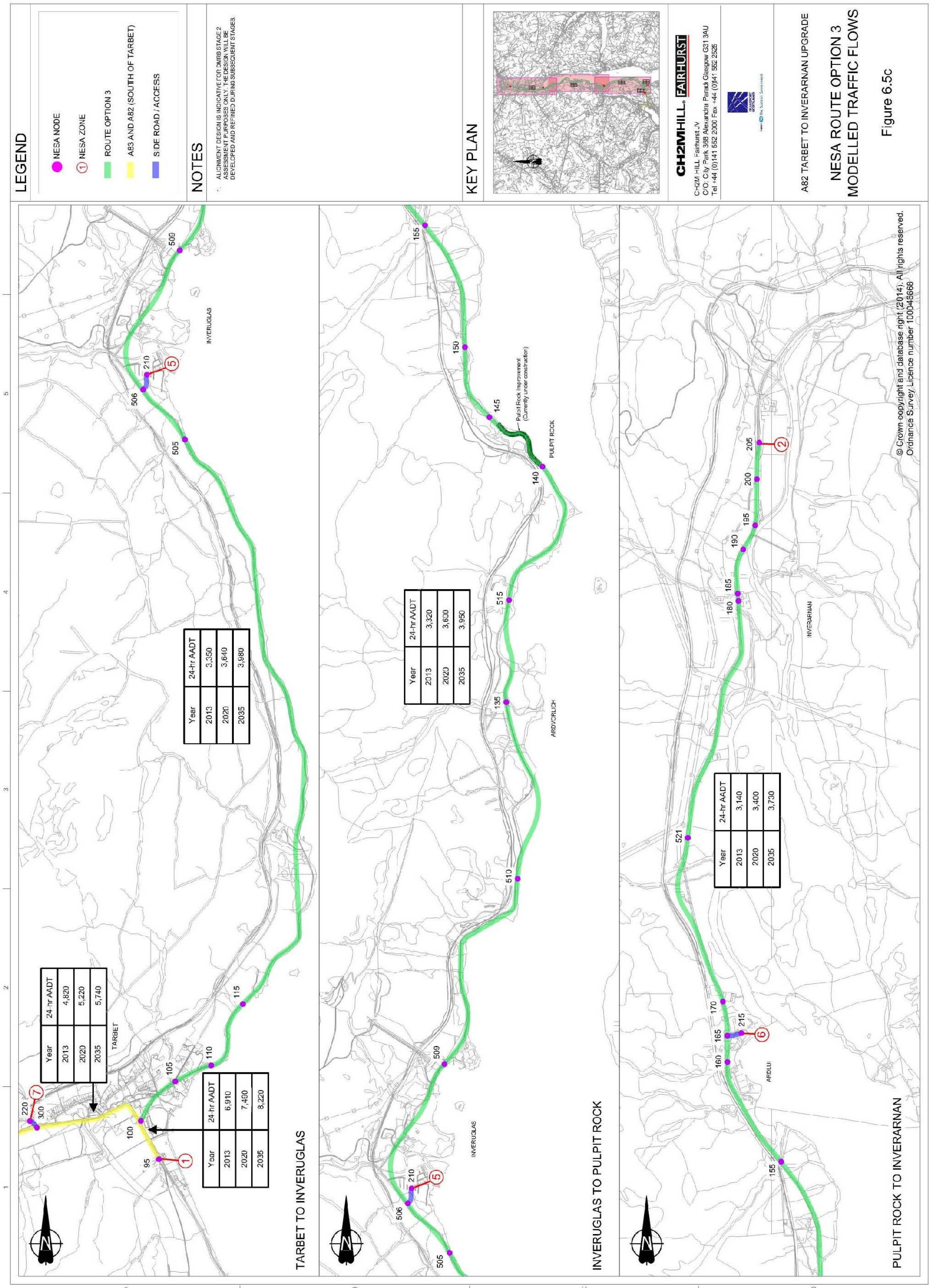

Figure 6.5c: NESA Route Option 3, Modelled traffic flows

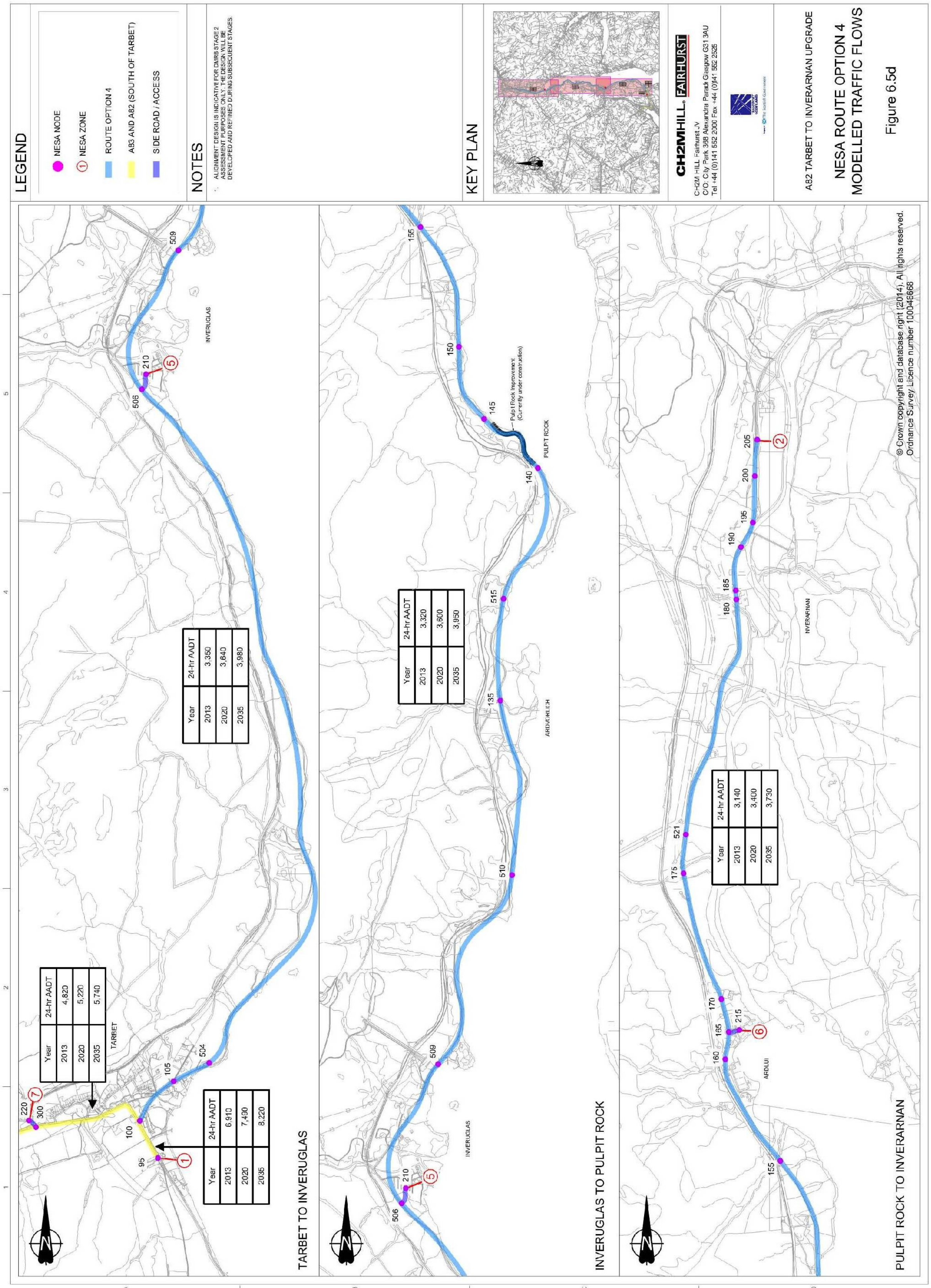

Figure 6.5d: NESA Route Option 4, Modelled traffic flows

6.5 Economic Performance of Route Options

6.5.1 Introduction

The NESA assessment for the A82 Tarbet to Inverarnan upgrade is based on the latest version of the program, version NESA14, which was released on behalf of Transport Scotland in June 2014. This version incorporates current national road traffic forecasts; a mid-2010 price base; and an annual discount rate of 3.5 % for the first 30 years, and 3.0 % for the remainder of the 60 year appraisal period.

The QUADRO assessment for the A82 Tarbet to Inverarnan upgrade is based on Release 12 of the QUADRO4 program to provide results that are consistent with the NESA assessment.

6.5.2 Scheme Costs

Preliminary cost estimates, based on measured quantities and assumed rates from industry standard road price books, supplemented with costs from similar schemes, have been used in the NESA assessment. Refer to Section 3.10.

The Total Scheme Costs include Preparation and Supervision Costs, which are considered to be 9 % and 5 % respectively of the combined Construction, Land and Property Costs, in accordance with DMRB 15.1.6.8.

The preliminary cost estimates for the route options have been increased for optimism bias, taking cognisance of the values in Table 6/8/2 of DMRB 15.1.6.8, to reflect the appraisers' tendency to be overly optimistic. For the purpose of the DMRB Stage 2 appraisal, an optimism bias of 44 %, which is typically associated with a Stage 1 assessment for road projects has been used to take cognisance of the numerous constraints of the route corridor, the particular construction requirements (including working within water) and residual uncertainties.

The estimated cost of typical alignments for each of the proposed route options, used in the NESA assessment, is summarised in **Table 6.2**. An inflation allowance for construction cost changes[3] relative to the general price level[4] has been accounted for in the preparation of total scheme cost inputs to NESA, in line with the guidance set out in DMRB 15.1.6.9.

At this early stage of design development an estimated construction period of three years has been assumed along with the following construction cost profile, in line with DMRB 15.1.6.8, Table 6/8/2:

- 2017 - 30 % of costs
- 2018 - 34 % of costs
- 2019 - 33 % of costs
- 2020 - 3 % of costs in the proposed year of opening

For the purpose of the economic appraisal, the construction cost profile input to NESA is 2017 - 29 %, 2018 - 34 %, 2019 - 34 % and 2020 - 3 % to account for the effects of inflation.

[3] Annual increase in construction cost assumed to be 4.4 % based on a review of Building Cost Information Service (BCIS) indices.

[4] General price level assumed to increase in line with the Bank of England's inflation target of 2 %.

Table 6.2: Preliminary scheme cost estimates (Quarter 2 2014 prices, excluding VAT)

Cost item	Cost (£m)			
	Option 1	Option 2	Option 3	Option 4
Construction*	123.03	157.87	164.20	281.50
Preparation	11.07	14.21	14.78	25.33
Supervision	6.15	7.89	8.21	14.07
Sub Total	140.26	179.97	187.19	320.91
Optimism Bias (@ 44 %)	61.71	79.19	82.36	141.20
Sub Total	201.97	259.16	269.56	462.11
Inflation Allowance	20.20	25.92	26.96	46.22
Total Scheme Cost	222.17	285.08	296.52	508.33

*Note: *includes Land & Property Costs*

6.5.3 NESA Assessment

The results of the NESA assessment for the route options are presented in **Table 6.3**.

Table 6.3: NESA assessment results

	Route Option			
	Option 1	Option 2	Option 3	Option 4
TEE Impact				
Greenhouse Gases (Emissions)	0.00	0.12	0.07	0.16
Accident Benefits	23.47	23.74	23.62	23.86
Non-Business User Benefits: Commuting	3.90	4.46	4.22	4.80
Non-Business User Benefits: Other	13.09	14.86	14.08	15.96
Business Users & Provider Benefits	16.45	18.77	17.76	20.15
Wider Public Finances (Indirect Tax Revenues)	0.00	-0.31	-0.17	-0.42
Present Value of Benefits (PVB)	56.91	61.65	59.57	64.51
Government Funding				
Broad Transport Budget	178.83	229.42	238.65	409.13
Present Value of Costs (PVC)	178.83	229.42	238.65	409.13
Total Impact				
Net Present Value (NPV)	-121.92	-167.78	-179.08	-344.62
Benefit to Cost Ratio (BCR)	0.32	0.27	0.25	0.16

Monetary values are expressed in £m (2010 prices, discounted to 2010 at 3.5 % for the first 30 years and 3.0 % for the remainder of the 60-year appraisal period).

The overall results of the NESA assessment indicate that the route options will deliver economic returns of between -£121.92 m and -£344.62 m, with BCRs ranging from 0.32 to 0.16.

Whilst the route options are not expected to provide transport economic efficiencies that offset Government Funding, the upgrade of the A82 between Tarbet and Inverarnan is predicted to provide journey time, vehicle operating cost, accident and emission benefits. The total benefits (PVB) range from £56.91 m to £64.51 m.

The principal benefits of the upgrade are expected to be as a result of traffic experiencing improved travel times, with total user benefits (i.e. Non-Business User Benefits: Commuting, Non-Business User Benefits: Other, and Business Users & Provider Benefits) ranging from £33.44 m to £40.91 m. Significant benefits are also expected from improving safety with accident savings of between £23.47 m and £23.86 m. Route Option 4 provides the most direct route between Tarbet and Inverarnan of the four options and, as such, is predicted to provide the greatest level of benefits to road users (£64.51 m), including the greatest level of accident benefits (£23.86 m). However, the funding expected to be required for this option (£409.13 m), which includes an allowance for the construction of a route generally to DMRB standard, is such that it provides the poorest NPV (-£344.62 m) and BCR (0.16) of the four options.

Route Option 2 provides the second highest level of benefits. The funding expected to be required for this option (£229.42 m), is such that it provides an economic return in terms of NPV of -£167.78 m and BCR of 0.27.

Route Option 3 provides the third highest level of benefits. The funding expected to be required for this option (£238.65 m), is such that it is expected to provide an economic return in terms of NPV of -£179.08 m and BCR of 0.25.

With an NPV of -£121.92 m and a BCR of 0.32, Route Option 1 delivers the best economic return of the four options, although it delivers the lowest benefit. While Option 1 is the longest of the four routes, it compares favourably against the other options due to the predicted delivery of significant benefits to road users (£56.91 m) for the lowest level of expected funding (£178.83 m).

6.5.4 QUADRO Assessment

To provide a more complete assessment of the economic impact of the route options over a 60-year period, the following have been assessed using the QUADRO program:

- The road user costs associated with construction of the route options.
- The works costs and road user costs associated with undertaking a programme of future maintenance for both the Reference Case and route option scenarios.

The results of the QUADRO assessments for construction and future maintenance are presented in **Tables 6.4** and **6.5** respectively.

Table 6.4: QUADRO assessment results (£m) – construction

	Route Option			
	Option 1	Option 2	Option 3	Option 4
Net Consumer Impact	8.13	7.13	7.27	6.32
Net Business Impact	6.15	5.39	5.49	4.78
Accident Costs	1.83	1.60	1.63	1.42
Fuel Carbon Emission Costs	0.12	0.11	0.11	0.09
Maintenance Works Costs	0.00	0.00	0.00	0.00
Indirect Tax Revenues	-0.05	-0.04	-0.04	-0.04
Total Impact	16.19	14.20	14.47	12.59

Monetary values are expressed in £m (2010 prices, discounted to 2010 at 3.5 % for the first 30 years and 3.0 % for the remainder of the 60-year appraisal period).

Table 6.5: QUADRO assessment results (£m) – future maintenance

	Reference Case	Route Option			
		Option 1	Option 2	Option 3	Option 4
Net Consumer Impact	2.89	0.03	0.03	0.03	0.03
Net Business Impact	1.97	0.02	0.02	0.02	0.02
Accident Costs	0.93	0.01	0.01	0.01	0.01
Fuel Carbon Emission Costs	0.23	0.00	0.00	0.00	0.00
Maintenance Works Costs	12.53	3.54	3.58	3.60	3.46
Indirect Tax Revenues	-0.06	0.00	0.00	0.00	0.00
Total Impact	18.48	3.60	3.64	3.67	3.52

Monetary values are expressed in £m (2010 prices, discounted to 2010 at 3.5 % for the first 30 years and 3.0 % for the remainder of the 60-year appraisal period).

The overall impact of the QUADRO assessment is presented in **Table 6.6**.

Table 6.6: QUADRO assessment results – overall impact

	Route Option			
	Option 1	Option 2	Option 3	Option 4
Present Value of Benefits (PVB)	-10.30	-8.30	-8.57	-6.69
Present Value of Costs (PVC)	-8.99	-8.95	-8.93	-9.07
Net Present Value (NPV)	-1.30	0.65	0.36	2.38

Monetary values are expressed in £m (2010 prices, discounted to 2010 at 3.5 % for the first 30 years and 3.0 % for the remainder of the 60-year appraisal period)

Examination of the QUADRO results in **Table 6.4** indicates that the road user impact of upgrading the A82 between Tarbet and Inverarnan could equate to between £12.59 m (Route Option 4) and £16.19 m (Route Option 1). Route Option 4 is expected to have the least impact on road users of the four options due to it requiring the lowest level of on-line construction. Conversely, Route Option 1 is expected to have the greatest impact on road users due to being largely constructed on-line.

It can be seen from the QUADRO results presented in **Table 6.5** that the impact of future maintenance for the route options (of approximately £3.6 m) is significantly less than that for the Reference Case (at approximately £18.5 m). This is principally as a result of the less intensive maintenance regime likely to be required following the upgrade.

The impact of future maintenance takes into consideration works costs and road user costs, the latter comprising: consumer and business impacts; accident costs; fuel carbon emission costs; and indirect tax revenues (ITRs).

Examination of the values in **Table 6.5** indicates that the works costs is £3.5 m to £3.6 m across the route options, compared with £12.5 m for the Reference Case, which leads to cost savings of around £8.9 m. The road user impact during future maintenance activities is less than £0.1 m for all route options, compared with £6.0 m for the Reference Case, and this leads to road user benefits of over £5.9 m.

In operation terms, analysis of the QUADRO outputs indicate that the route options could reduce vehicle delays, of 40 to 50 minutes in the Reference Case, to under 5 minutes (for all route options) during future maintenance activities.

The overall results from the QUADRO models, presented in **Table 6.5**, indicate that an NPV of between -£1.30 m and £2.38 m may be achieved under the modelled construction and future maintenance programme.

To take cognisance of a potential optimism bias towards underestimating the duration of construction and future maintenance work costs, the outputs from QUADRO have been increased by the following:

- Consumer and business impacts, accident costs, fuel carbon emission costs and ITRs during construction - 20 %
- Future maintenance works costs for the Reference Case and route options - 44 %

These uplifts are consistent with the optimism bias levels typically associated with a Stage 1 assessment (presented in Table 6/8/2 of DMRB 15.1.6.8) and reflect the uncertainties associated with carrying out works along the corridor (including working within water). The overall impact of the QUADRO assessment, including optimism bias is presented in **Table 6.6**.

The results of the QUADRO assessment, adjusted to include optimism bias, indicates that an NPV of between -£0.58 m and £3.85 m may be achieved under the modelled construction and future maintenance programme.

Table 6.6: QUADRO assessment results – overall impact (incl. optimism bias)

	Route Option			
	Option 1	Option 2	Option 3	Option 4
Present Value of Benefits (PVB)	-13.53	-11.14	-11.46	-9.21
Present Value of Costs (PVC)	-12.95	-12.89	-12.86	-13.07
Net Present Value (NPV)	-0.58	1.75	1.40	3.85

Monetary values are expressed in £m (2010 prices, discounted to 2010 at 3.5 % for the first 30 years and 3.0 % for the remainder of the 60-year appraisal period)

Table 6.7: Combined NESA and QUADRO assessment results

	Route Option			
	Option 1	Option 2	Option 3	Option 4
Present Value of Benefits (PVB)	43.38	50.51	48.11	55.30
Present Value of Costs (PVC)	165.88	216.53	225.79	396.06
Net Present Value (NPV)	-122.50	-166.02	-177.68	-340.76
Benefit to Cost Ratio (BCR)	0.26	0.23	0.21	0.14

Monetary values are expressed in £m (2010 prices, discounted to 2010 at 3.5 % for the first 30 years and 3.0 % for the remainder of the 60-year appraisal period)

The combined results of the NESA and QUADRO assessments presented in Tables 6.3 and 6.6 are summarised in **Table 6.7**.

The combined NESA and QUADRO results indicate that the route options will deliver economic returns of between -£340.76 m and -£122.50 m, with BCRs ranging from 0.14 to 0.26. Whilst the route options are not expected to provide transport economic efficiencies that offset their costs, the upgrade of the A82 between Tarbet and Inverarnan is predicted to provide benefits to road users (PVB), which range from £43.38 m to £55.30 m.

With an NPV of -£122.50 m and a BCR of 0.26 Route Option 1 is predicted to deliver the best economic return of the four route options.

6.5.5 Economic Activity and Location Impacts

The findings of stakeholder discussions, business survey fieldwork and the analysis of wider economic benefits indicates little difference between the route options. Potential impacts at local level will be more apparent as the project moves to detailed design at DMRB Stage 3. For businesses and the economy in the wider area, journey time and reliability improvements are consistent across all route options.

The upgrading of the A82 between Tarbet and Inverarnan is expected to:

- Increase reliability of market access
- Improve the use of the A82 as the principal road access to the Central Belt from Argyll and the West Highlands.
- Improve journey time reliability on the A82 generating benefits to businesses along its length, while also generating positive impacts for communities (particularly those reliant on tourism) on linked routes such as the A85.
- Reduce perceived market remoteness, with benefits to inward investment, staff recruitment and retention.
- Increase of employment in tourism and related sectors in the communities accessed by the road.

Analysis of Business Survey findings indicate that the improved section could lead to a 10.4 % increase in annual turnover, generating an additional £15.6 m per annum in the economy, and potentially employing a further 300 to 440 staff in the tourism sector.

Taking this into consideration, the benefits of the upgrade could potentially offset the scheme cost within 20 years of the scheme opening for Route Option 1 and within 30 years for both Route Option 2 and Route Option 3. Based on the available information, it seems unlikely that the scheme cost of Route Option 4 would be offset within the 60-year appraisal period.

6.5.6 Risk and Uncertainty

Risk and uncertainty analysis has been used to test the sensitivity of the NESA assessment results and provide a greater level of confidence in the conclusions of the appraisal.

The risks and uncertainties relating to the traffic and economic appraisal of the A82 Tarbet to Inverarnan Upgrade mainly surround the following:

- Scheme costs
- Traffic forecasts
- Safety impacts
- A82 speed limit reduction
- Random operational delays

- Wider economic impacts

Seven uncertainty tests have been carried on the results of the main NESA assessment to assess the impact of:

- Low, central and high traffic growth projections
- Rebasing traffic levels from 2013 to 2014
- Applying default accident rates rather than local
- Introducing a 50 mph speed limit on the A82 in the Reference Case
- Random operational delays resulting in increased journey time in the Reference Case

A comparison between the results of the NESA uncertainty tests and the main assessment, presented in terms of NPV and BCR in **Figure 6.6a** and **Figure 6.6b** respectively, indicate that the ranking of route options within each of the tests remains consistent with the main NESA assessment, with Route Option 1 performing best throughout, followed, in order, by Route Options 2, 3 and 4.

Figure 6.6a: Comparison between NESA uncertainty tests and main assessment NPVs (£m)

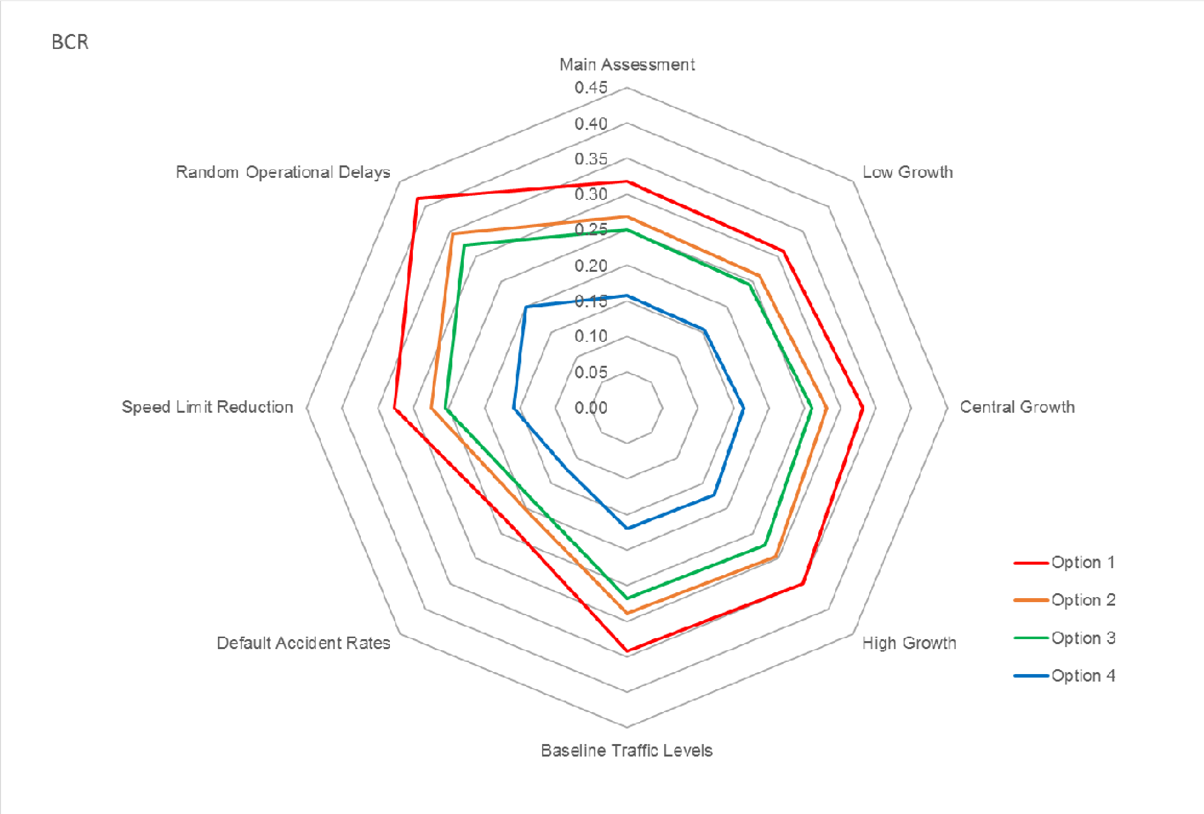

Figure 6.6b: Comparison between NESA uncertainty tests and main assessment BCRs

7. Summary of Comparative Assessment

7.1 Introduction

This section of the report makes a comparative assessment of the Stage 2 report route options, with a view to identifying a preferred route.

The Stage 2 Report aims to identify the main advantages and disadvantages in terms of engineering, economics and traffic. The following sections detail the comparative assessments that have been undertaken for each of the key elements.

7.2 Engineering Assessment

Each of the route options have been designed to rural all purpose road standard with a 6 m carriageway and 1 m hardstrips and with a Design Speed of 85B kph. The key distinctions between the route options in terms of alignment and geometry have been discussed in Section 4 of this report. A comparative assessment of the engineering topics is provided below.

Departures from Standard

Each route option has been separately assessed for compliance with design standards relating to geometry and SSD, and anticipated Departures from Standard have been identified. It should be noted that during the DMRB Stage 3 it is likely that these Departures would be removed or mitigated as the design of the preferred route option is developed.

The total number of Departures from Standard have been summarised in **Table 7.1**.

Table 7.1: Summary of Departures from Standard

Route Option	Departures			
	Horizontal	Vertical	SSD	Total
1	26	3	44	73
2	15	6	45	66
3	19	4	38	61
4	2	0	8	10

In terms of Departures from Standard, Route Option 4 is preferred as it has the least number.

Junctions & Accesses

All route options are considered similar in terms of junctions, but with the exception of the A82/A83 Tarbet junction, the results from the junction turning counts, environmental appraisal and analysis of accidents (amongst other factors) will inform whether the junctions shown in each route option should be considered as accesses during Stage 3.

To inform the assessment, a number of the accesses considered significant, and common to all route options, have been subjected to a preliminary Engineering assessment. This will be taken forward during the next Stage when accesses will be detailed as part of the design of the preferred route option.

All route options are considered to be similar in terms of junctions and accesses, so there is no preference of route option.

Laybys & Rest Areas

In carrying out the DMRB Stage 2 assessment a number of laybys have been proposed for all route options. The potential reuse of discontinued sections of the existing A82 is to be considered during Stage 3.

A number of local businesses located within the route corridor could be considered to provide amenities associated with a rest area. These businesses include the Home on the Loch Cafe, Inveruglas Visitor Centre, Ardlui Hotel and Drovers Inn. These are supplemented by amenities located in communities including Tarbet, Crianlarich, Luss and Arrochar.

In terms of laybys and rest areas all route options are considered to be similar, so there is no preference of route option.

Structures

All route options will require retaining walls, structures and viaducts in various combinations and to differing degrees.

Route Option 4 stands out as being more challenging with viaducts of up to 730 m running along the side of Loch Lomond. Route Option 3 also requires viaduct structures crossing over loch bays. Further investigation work will be required to confirm foundation works should these route options progress to the preferred route.

A new structure to bypass the existing constraint at the 'Seven Bends/Sisters' at Creag an Arnain is proposed in all route options, along with a large retaining wall structure supporting the road at Coire Nan Each.

Further consideration of the location and form of retaining walls will also be required in terms of visual impact and affects on the loch shore habitat. In places there may be an opportunity to provide embankments instead.

All route options have their own particular engineering challenges. Route Option 4 requires the most structures with an extensive requirement of 'over loch' construction. Route Options 1, 2 and 3 have comparable structure requirements, although Route Options 3 larger crossing of the Loch, may require deep piling into the loch bed. **In terms of structures Route Options 1 and 2 are preferred**.

Hydrology, Hydrogeology and Drainage

The Hydrology, Hydrogeology and Drainage assessment of the four route options indicate that all have a similar extent of engineering works.

Route Option 4 has the least impact on the water environment due to having the lowest number of drainage outfalls, the lowest number of watercourse crossings and affects the lowest number of watercourses. However, Route Option 4 also has the lowest percentage of road length achieving two levels of SuDS treatment to surface runoff prior to discharge to the loch or receiving watercourse (based on conceptual design). A substantially greater length of Route Option 4 is located on 'in-loch' structures and not on land.

Engineering works and provision of SuDS treatment associated with Route Options 1, 2 and 3 are similar, but Route Option 1 has least impact on the water environment due to having the lowest number of outfalls discharging to watercourses and affecting the lowest number of watercourses in terms of vertical alignment change.

In terms of hydrology, hydrogeology and drainage Route Option 1 has the least impact on the water environment and is therefore considered as the preferred route option for the scheme based on the assessment undertaken.

Geology, Geomorphology and Ground Conditions

The topography and geomorphology and the issues they present are broadly similar across all route options. The more significant earthworks proposed in Route Options 2 and 4 will be influenced by the topography, with an increased earthworks footprint being required that may impact on existing infrastructure, particularly the West Highland Line.

For structure foundations, subject to confirmation of ground conditions at individual locations and apart from structures located in the loch, spread foundations seem likely in most cases. Piled foundations are anticipated for structures in the loch there with a likely requirement for piles to bear on the rock in the bed of the loch.

Compared to Route Options 1 and 2 there will be an increased requirement for the use of piled foundations to support the longer length of proposed structures in the loch in Route Options 3 and 4.

Route Option 4 has the largest cut and fill volume of all the route options, with a substantial surplus of cut material expected.

Route Option 2 is similar to Route Option 4, albeit with reductions in volume of cut, fill and surplus.

Route Option 3 may be the route option that is closest to achieving an overall balance of cut and fill materials.

Although Route Option 1 has a closer balance of cut and fill quantities than Route Option 3, a deficit of fill material could result unless a very high proportion of excavated materials are acceptable for re-use.

Buildability is an issue for all the route options examined, due to the constrained nature of the corridor. Route Options 1 and 2 are expected to be the most difficult in this regard, followed by Route Options 3 and 4.

In summary all of the route options have advantages and disadvantages from a Geology, Geomorphology and Ground Conditions perspective, and it is difficult to pick a preferred route option on this basis. This appraisal will need to be considered along with the other scheme assessment issues to reach an overall conclusion on route option selection.

Non Motorised Users

A non motorised user route, situated to the east side of the new A82, is proposed for all route options.

In terms of non motorised users there is no preference of route options.

Public Utilities

All route options affect utilities to some degree. Route Option 4 may impact less due to the increased amount of 'in loch' works. Further investigation will be required for all route options to determine the precise location of an existing telecoms line in the loch, which may have an influence on the works. **In terms of Public Utilities, all routes are consistent although further investigation at Stage 3 will be required**.

Buildability

Buildability needs to consider the practicality of the engineering challenge involved, the impact on the people constructing the scheme and those living adjacent to it or passing through it, and most importantly, the safety of all.

The route corridor is particularly constrained by the topography, West Highland Line and individual properties and hamlets. As a consequence of these constraints, the four route options all have sections where construction would be required on the same line as the existing road.

Construction of on-line sections should ensure disruption to residents, businesses, road users and also to the visitors to the LLTNP is minimised. Accesses to properties and businesses adjacent to the construction should be maintained for locals, visitors and emergency services, as well as keeping the A82 open for strategic traffic.

In simple terms, the route option with the least amount of on-line construction could be considered as the least disruptive to both the road users and those involved in building it. The engineering challenges involved in the off-line construction, however, include working over water and additional blasting works, which do not necessarily assist buildability or safety.

In terms of Buildability all route options have their own particular engineering challenges and issues. Further consideration during Stage 3 will be required to identify issues and reduce impacts.

Engineering Assessment Summary

Each topic assessment has concluded with a recommendation of a preferred route option, as identified in **Table 7.2** and outlined in the following sections.

Table 7.2: Engineering Route Option Preference

Engineering Assessment	Route Option Preference
Departures from Standard	4
Junctions & Accesses	No preference
Laybys & Rest Areas	No preference
Structures	1 & 2
Hydrology, Hydrogeology and Drainage	1
Geology, Geomorphology and Ground Conditions	No preference
Non Motorised Users	No preference
Public Utilities	No preference
Buildability	No preference

7.3 Scheme Cost Estimates

Scheme cost estimates, as detailed in Chapter 3, have been prepared at Q2 2014 prices for the purposes of identifying significant cost differences between the route options. As the preferred option is developed, the estimate will be refined as assumptions become clarified through further development and investigations. The estimates to date, however, are considered to give a robust evaluation of the scheme rankings and a reasonable estimate of the order of costs anticipated.

Route Option 1 is the least expensive route option considered, with an estimated cost range of £217.12m to £285.68 m and consequently would be favoured in terms of capital cost. Route Option 2 is ranked second (£278.60 m to £366.57 m), Route Option 3 is third (£289.77 m to £381.28 m) and Route Option 4 is fourth (£496.77 m to 653.64 m).

With assumed inflation of 4.4 % per annum these cost would increase by approx 19.0 % by the anticipated year opening of 2020.

7.4 Environmental Assessment

Environmental assessment of all route options has been undertaken in accordance with topic specific methodologies detailed in DMRB Volume 11, Section 3, as summarised in Chapter 5 of this report. Each topic assessment has concluded with a recommendation of a preferred route option, as identified in **Table 7.3**.

Table 7.3: Environmental Route Option Preference

Environmental Topic	Route Option Preference
Air Quality	No preference
Cultural Heritage	1
Landscape	1
Nature Conservation	1 or 2
Geology and Soils	3
Materials and Waste	1
Noise and Vibration	1
Effects on All Travellers	4
Community and Private Assets	3
Road Drainage and the Water Environment	1

Six of the ten environmental topics state a preference for Route Option 1, with Air Quality stating no preference.

Geology and Soils states a preference for Route Option 3 as a result of its potential lesser impact on peat deposits.

Effects on All Travellers states a preference for Route Option 4, primarily due to the scale of NMU enhancement opportunities associated with the potential re-use of sections of the existing A82. Community and Private Assets states a preference for Route Option 3 due to it being the route option with the least impacts on private properties/private land.

The overall preferred route option from an environmental perspective, is for Route Option 1 to be progressed.

As the project progresses to Stage 3, to address the issues identified above, detailed design of the preferred route option will aim to minimise impacts to areas of peat and private property/private land and to maximise enhancement opportunities for NMUs.

7.5 Traffic and Economic Assessment

The combined NESA and QUADRO results indicate that the route options will deliver economic returns of between -£340.76 m and -£122.50 m, with BCRs ranging from 0.14 to 0.26. Whilst the route options are not expected to provide transport economic efficiency and road safety benefits that offset their capital costs, the upgrade of the A82 between Tarbet and Inverarnan is predicted to provide benefits to road users, which range from £43.38 m to £55.30 m.

With an NPV of -£122.50 m and a BCR of 0.26 **Route Option 1 is predicted to deliver the best economic return of the four route options**.

7.6 Value for Money Workshop

7.6.1 Introduction

A VfM workshop was held on 21st April 2015 at which the findings of the Stage 2 study were presented to Transport Scotland stakeholders.

The purpose of the VfM Workshop was to:

- Present the route options
- Review, modify where necessary and agree the criteria for a comparative assessment of the route options.
- Undertake an assessment of the route options against objectives and criteria including weighting to test the sensitivity as required
- Review the list of identified delivery risks and undertake a route options risk assessment.
- Take into account the outputs from the comparative assessment, capital costs, NPV, BCR and risk assessment and reach consensus on the preferred route for the upgrade.

7.6.2 Assessment

Route Options 1 and 2 scored higher than Route Options 3 and 4 in terms of Environment and Sustainability. Route Option 1 was scored highest in consideration of minimising of environmental impact both during construction and upon completion and also scored highest in ensuring that the qualities of the National Park are respected. Route Option 4 scored the lowest against these topics. All options however scored equally in terms of maximising opportunities for the development of environmental enhancements and benefits.

In consideration of Accessibility and Social Inclusion, all route options scored highly in terms of their provision of appropriate stopping opportunities and for providing opportunities for enhanced access by sustainable modes of travel.

For safety, all route options again scored highly in terms of improved motorised and non-motorised safety.

All options scored high against integration with local plans and policies and integration with public transport facilities with Route Option 4 scoring fractionally lower.

Route Option 4 scored highest in regard to reducing impact on road user during construction due to its offline routing, with Route Options 2 and 3 being lower.

Route Option 4 was however deemed to offer less operational resilience due to the amount of structures it required.

Finally, in consideration of economy, all route options scored highly for their improvements in journey time with Route Option 4 being fractionally improved.

A separate assessment of project risk was carried out which identified Route Option 1 as having the least risk to cost with Route Option 2, 3 and 4 ranked 2nd 3rd and 4th respectively.

7.6.3 VFM conclusion

In consideration of the scored objectives and weighting, the risks associated with the route options and the economics appraisal, Route Option 1 was found to be ranked 1st. Route Options 2, 3 and 4 were ranked 2nd, 3rd and 4th respectively.

The workshop concluded that Route Option 1 was preferred, although there may be elements of Route Option 2 which could be incorporated in order to further refine the design.

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8. Recommendations

All route options are expected to meet the transport planning objectives set for the project, providing improvements in average journey time, a reduction in personal injury accidents, appropriate stopping opportunities and improved accessibility with a new cycle/pedestrian path adjacent to the route. The improved carriageway cross sections will also improve the ability to carry out maintenance activities.

Route Option 4 requires the greater number of large structures as well as 'in loch' work. The option will also have the lowest percentage of carriageway receiving two levels of water treatment, has the greatest volume of earthworks and is not overall preferred from an environmental viewpoint. The option is also expected to be the most expensive and provide the worst economic return of the four route options proposed.

Route Options 2 and 3 provide improvements in benefits over Route Option 4 in terms of nature conservation, community and private assets.

Route Option 1 is the preferred option from an environmental perspective in particular when considering cultural heritage, landscape, materials and waste, nature conservation and the water environment. Route Option 1 is also the least expensive and is predicted to provide the best economic return of the four.

Route Option 1 has the greater number of Departures, however these will be reviewed as the design develops and any design going forward will be provided to a safe standard.

On the basis of engineering challenges, environmental impacts, traffic benefits and value for money it is recommended that Route Option 1 is progressed as the Preferred Scheme, with the following additional recommendations:

- Further consideration should be given to combining some off-line sections from Route Option 2, where there is limited environmental impact.
- Further consideration should be given to adjusting the alignment of the road to improve buildability.
- Further consideration should be given to reduce/avoid direct impact on properties and requirements for demolition.
- The benefits and disbenefits of either a 6.0 m or 7.3 m wide carriageway (both with 1 m hardstrips) should also be considered.
- Further consideration of the A82/A83 Tarbet Junction options will be required subject to further traffic surveys and consideration of the LLTNPA masterplan.

The Stage 3 assessment will focus on the refinement of the route alignment identifying cross-section, landtake, geotechnical, structural and drainage solutions, in consultation with stakeholders and landowners.

An Environmental Assessment will also be carried out for the preferred alignment to inform the mitigation required.

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Appendix A

Existing Infrastructure

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Table A.1: Existing junctions and accesses

Approximate Chainage	Access Reference	Type	Direction (NB / SB)	Description
0	J001	Major Junction	NB & SB	A82 / A83 Junction
60	AC01	Business / Commercial	NB	Tarbet Hotel Car Park
65	AC02	Car Park	SB	Cruise Loch Lomond
175	AC03	Residential	NB	Still Braes
210	AC04	Residential	NB	Access to Bemersyde Road
210	AC05	School	SB	Arrochar Primary School
300	AC06	School	SB	Arrochar Primary School
310	AC07	Field	NB	Playing Field Access
330	AC08	Business / Commercial	SB	
330	AC09	Residential	NB	Old Military Road
365	AC10	Business / Commercial	SB	Cruise Loch Lomond Ltd Boatyard
395	AC11	Residential	NB	Loch Lomond View Country House B&B
395	AC12	Business / Commercial	SB	Disused Service Station
500	AC13	Residential	NB	Ben Cruach Lodge
530	AC14	Residential	NB	Clattochbeg Cottage
1140	AC15	Business / Commercial	NB	Tarbet Isle Viewpoint
2090	AC16	Business / Commercial	NB	Home on the Loch (Inverhoulin)
2150	AC17	Residential	NB	Blairannaich
2150	AC18	Business / Commercial	SB	Jetty
3800	AC19	Business / Commercial	NB	Forestry Commission
5270	AC20	Business / Commercial	SB	Loch Lomond Holiday Park
5570	AC21	Business / Commercial	NB	Access to Loch Sloy
5650	AC22	Business / Commercial	NB	Accessed to disused camp site
5660	AC23	Residential	SB	Inveruglas Farm
5740	AC24	Business / Commercial	SB	Farm Access (Inveruglas Farm)
5770	AC25	Business / Commercial	NB	Farm Access
5770	AC26	Field	SB	Field Access
6040	AC27	Field	SB	Field Access
6070	AC28	Residential	NB	Inveruglas Cottage
6100	AC29	Residential	NB	Inveruglas Cottage
6110	AC30	Business / Commercial	NB	Loch Sloy Power Station
6270	AC31	Business / Commercial	NB	Loch Sloy Power Station
6360	AC32	Business / Commercial	SB	Inveruglas Visitor Centre
6450	AC33	Business / Commercial	SB	Inveruglas Visitor Centre
8700	AC34	Field	NB	Field Access
8700	AC35	Field	SB	Field Access
8770	AC36	Business / Commercial	NB	Ardvorlich House B&B (Ardvorlich Farm)
8800	AC37	Residential	NB	Ardvorlich Cottage West
8810	AC38	Field	SB	Field Access
10820	AC39	Field	NB	Field Access
11630	AC40	Field	NB	Field Access
11730	AC41	Field	SB	Field Access
11730	AC42	Field	NB	Field Access
11790	AC43	Business / Commercial	NB	Stuckindroin Farm
11830	AC44	Field	SB	Field Access
11980	AC45	Field	SB	Field Access
12000	AC46	Field	NB	Field Access

Approximate Chainage	Access Reference	Type	Direction (NB / SB)	Description
12170	AC47	Residential	NB	Burnside Cottage & Ardleish Cottage
12180	AC48	Field	SB	Field Access
12420	AC49	Field	NB	Sheep underpass below railway
12570	AC50	Business / Commercial	SB	Ardlui Retreat
12650	AC51	Business / Commercial	NB	Garristuck
12790	RA	Rail	NB	Ardlui Rail Station
12840	AC52	Residential	NB	Station Cottage
12930	AC53	Field	SB	Field Access
12940	AC54	Residential	NB	Station House
13030	AC55	Business / Commercial	SB	Ardlui Hotel
13090	AC56	Business / Commercial	SB	Ardlui Marina Holiday Park
13100	AC57	Business / Commercial	NB	
13170	AC58	Field	NB	Field Access
13340	AC59	Business / Commercial	SB	Loch Lomond Outdoor Centre
13940	AC60	Business / Commercial	NB	Ardlui Church Self Catering
14460	AC61	Field	NB	Field Access
14870	AC62	Business / Commercial	SB	Sheep Pen/Fold
14990	AC63	Field	SB	Field Access
14990	AC64	Field	NB	Field Access
15030	AC65	Field	SB	Field Access
15740	AC66	Residential	NB	Falls View Cottage
15740	AC67	Field	SB	Field Access
15810	AC68	Field	SB	Field Access
15850	AC69	Business / Commercial	NB	Drovers Lodge Car Park
15900	AC70	Business / Commercial	SB	Drovers Inn
15940	AC71	Residential	NB	
15990	AC72	Residential	NB	Rose Cottage B&B
16000	AC73	Field	SB	Field Access
16270	AC74	Business / Commercial	SB	Beinglas Camp Site
16630	AC75	Residential	NB	Glenfalloch Lodge & The Bothy

Table A.2: Existing parking areas and laybys

Approximate Chainage	Type	Direction (NB / SB)	Description
4402	Parking Lay-by	SB	1 no. Space
4575	Parking Lay-by	SB	1-2 no. Spaces
4596	Parking Lay-by	SB	3 no. Spaces
6424	Parking Area	SB	Formal Signed Facility Access B
6517	Parking Area	SB	Formal Signed Facility Access A
10104	Parking Lay-by	SB	2 no. Spaces
10830	Parking Lay-by	NB	1 no. Space
11396	Segregated Parking Lay-by	SB	Signed Exit Only
11502	Segregated Parking Lay-by	SB	Signed Entrance Only
12895	Parking Lay-by	SB	Opp. Ardlui Station, 1-2 no. spaces, phone box
13213	Parking Area/Possible Bus Stop	NB	5 no. spaces, small masonry building
13956	Parking Lay-by	NB	Signed, 8 no. Spaces
14315	Parking Lay-by	NB	1 no. Space
15184	Parking Lay-by	NB	2 no. Spaces

Table A.3: Existing A82 Bridge Structures

Approximate Chainage	Structure Number/ Name	Form of Construction	Principle Dimensions
200	A82 380 Tarbet Smithy	Masonry arch	Span: 4.8 m Width: 6.0 m
200	A82 381F Footbridge (south side)	Timber	Span: assumed 4.8 m Width: 2.3 m
200	Footbridge (north side)	Unknown, possible steel	No records
310	Unknown	Masonry arch	No records
310	A82 382F Footbridge	Timber	Span: 7.0 m Width: 2.25 m
5500	A82 390 Inveruglas Water	Masonry arch	Span: 1 m x13.1 m Width: 9.1 m
6200	A82 400 Sloy Tail Race	Reinforced concrete arch	Span: 2x12.2 m Width: 15.5 m
8760	A82 410 Ardvorlich North	Masonry arch	Span: 3.7 m Width: 6.4 m
12225	A82 420 Stuckindroin	Reinforced concrete: arch extended with concrete slab	Span: 11.1 m Width: 6.5 m
14060	A82 430 Strath Dubh-Uisge South	Masonry arch extended and strengthened with concrete arch	Span: 5.9 m Width: 6.5 m
14135	A82 440 Strath Dubh Uisge North	Masonry arch extended and strengthened with concrete arch	Span: 6.3 m Width: 6.2 m
15790	A82 450 Inverarnan	Concrete slab	Span: Single span 8.0 m Width: 12.0 m

Table A.4: Existing Retaining Walls

Approximate Chainage	Structure Name	Location	Form of Construction	Principle Dimensions
	A82 380 W6		Masonry, gravity	Max Height: 2.3 m Length: 73 m
880	A82 380 W12	Waterfront Below road	Masonry, gravity	Max.Height: 3.3 m Length: 12 m
890	A82 380 W13	Waterfront Below road	Masonry, gravity	Max.Height: 2.9 m Length: 14 m
1030	A82 380 W15	Waterfront Below road	Masonry, gravity	Max.Height: 1.5 m Length: 11 m
1136	A82 380 W17	Waterfront Below road	Masonry, gravity	Max.Height: 3.7 m Length: 40 m
1333	A82 380 W21	Waterfront Below road	Masonry, gravity	Max.Height: 1.6 m Length: 37 m
1422	A82 380 W23	Waterfront Below road	Masonry, gravity	Max.Height: 1.26 m Length: 36 m
1498	A82 380 W24	Waterfront Below road	Masonry, gravity	Max.Height: 1.6 m Length: 25 m
1660	A82 380 W27	Waterfront Below road	Masonry, gravity	Max.Height: 1.8 m Length: 31 m
1720	A82 380 W29	Waterfront Below road	Masonry, gravity	Max.Height: 2.1 m Length: 68 m
1780	A82 380 W30	Waterfront Below road	Masonry, gravity	Max.Height: 1.08 m Length: 18 m
2470	A82 380 W42	Waterfront Below road	Masonry, gravity	Max.Height: 2.25 m Length: 52 m
2550	A82 380 W43	Waterfront Below road	Masonry, gravity	Max.Height: 2.9 m Length: 15 m
2575	A82 380 W44	Waterfront Below road	Masonry, gravity	Max.Height: 2.2 m Length: 14 m
2760	A82 380 W48	Waterfront Below road	Masonry, gravity	Max.Height: 2.8 m Length: 42 m
2920	A82 380 W50	Waterfront Below road	Masonry, gravity	Max.Height: 1.6 m Length: 250 m
3270	A82 380 W57	Waterfront Below road	Masonry, gravity	Max.Height: 1.7 m Length: 79 m
3360	A82 380 W59	Waterfront Below road	Masonry, gravity	Max.Height: 2.7 m Length: 176 m
4200	A82 380 W76	Waterfront Below road	Masonry, gravity	Max.Height: 1.43 m Length: 126 m
4800	A82 380 W87	Waterfront Below road	Masonry, gravity	Max.Height: 1.31 m Length: 224 m
7310	A82 400 W39	Waterfront Below road	Masonry, gravity	Max.Height: 2.1 m Length: 45 m
7174	No reference	Waterfront Below road	Masonry, gravity	Not given
7190	No reference Possible Network Rail Structure	Above NB carriageway	Masonry, gravity	Not given
7400	A82 380 W43	Waterfront Below road	Masonry, gravity	Max.Height: 5.5 m Length: 11.5 m

Approximate Chainage	Structure Name	Location	Form of Construction	Principle Dimensions
7470	No reference Possible Network Rail Structure	Above NB carriageway	Masonry, gravity	Not given
7698	A82 400 W54	Waterfront Below road	Masonry, gravity	Max.Height: 1.8 m Length: 14 m
7740	A82 400 W56	Waterfront Below road	Masonry, gravity	Max.Height: 2.0 m Length: 14 m
7960	A82 400 W63	Waterfront Below road	Masonry, gravity	Max.Height: 2.5 m Length: 9 m
8390	A82 400 W80	Waterfront Below road	Masonry, gravity	Max.Height: 1.26 m Length: 25 m
10450	A82 410 W49	Waterfront Below road	Masonry, gravity	Max.Height: 2.1 m Length: 27 m
10740	A82 410 W58	Waterfront Below road	Masonry, gravity	Max.Height: 2.1 m Length: 45 m
10785	A82 380 W39	Waterfront Below road	Masonry, gravity	Max.Height: 2.25 m Length: 73 m
11071	A82 380 W39	Waterfront Below road	Masonry, gravity	Max.Height: 1.95 m Length: 38 m

Table A.5: Existing A82 Culverts

Approx Chainage	Culvert Reference	Type	Principle Dimensions (mm)	Cover Depth (mm)	NB Offset (m)	SB Offset (m)	Length (m)	Headwall Type
634	C1	Concrete Pipe	500 dia.	1000	2.6	4.6	12.8	Stone Masonry
744	C2	Concrete Pipe	500 dia.	900	2.5	4.4	13.8	Stone Masonry
833	C3	Concrete Pipe	400 dia.	1400	2.1	4.4	13.8	Stone Masonry
980	C4	Concrete Pipe	900 dia.	1500	2.7	4.5	11.8	Concrete
1120	C5	Concrete Pipe	500 dia.	1000	2.6	3.7	13.8	Concrete Masonry
1254	C6	Concrete Pipe	900 dia.	1200	3.2	4.8	14.3	Masonry
1360	C7	Pipe / Box	300 dia. (inlet) Breadth: 500 (outlet) Depth: 500 (outlet)	1400	2.4	0.6	10.8	Stone Masonry
1385	C8	Pipe / Box	300 dia. (inlet) Breadth: 500 (outlet) Depth: 450 (outlet)	900 (inlet) 1000(outlet)	2.1	1.9	10.6	Stone Masonry
1440	C9	Pipe	300 dia.	800 (inlet) 3000(outlet)	2.2	6.3	1.5	Stone Masonry
	C10	Concrete Pipe	1 m x 1.4 m					
1895	C11	Box	Breadth: 450 Depth: 600	500 (inlet) 2000(outlet)	1.0	2.3	8.0	Stone Masonry
2067	C12	Box / Pipe	150 dia. (outlet) Breadth: 430 (inlet) Depth: 400 (inlet)	3000	3.6	5.6	9.0	None
2141	C13	Pipe	3 no. 1300 dia.	700	1.4	3.5	10.3	Stone Masonry
2260	C14	Pipe	300 dia.	1000	1.2	6.4	11.8	None

Table A.5: Existing A82 Culverts (Cont)

Approx Chainage	Culvert Reference	Type	Principle Dimensions (mm)	Cover Depth (mm)	NB Offset (m)	SB Offset (m)	Length (m)	Headwall Type
2405	C15	Pipe	225 dia. (outlet)			0.7	6.8	N/A
2470	C16	Box / Pipe	300 dia. (outlet) Breadth: 600 (inlet) Depth: 400 (inlet)	1000	0.9	7.6	14.1	N/A
2480	C17	Clay Pipe	300 dia. (outlet)		0.9	6.3	13.0	N/A
2535	C18		Breadth: 300 (outlet) Depth: 200 (outlet)		1.1	0.6	7.5	N/A
2865	C19	Box	Breadth: 450 (inlet) 500(outlet) Depth: 450 (inlet) 700 (outlet)	1100 (inlet) 1200 (outlet)	0.9	0.2	7.2	Stone Masonry
2880	C20	Box / Pipe	225 dia. (outlet) Breadth: 300 (inlet) Depth: 400 (inlet)	300	0.9	3.7	8.5	None
2965	C21	Pipe / Box	200 dia. (inlet) Breadth: 250 (outlet) Depth: 600 (outlet)	300	1.0	5.1	11.5	N/A
2985	C22	Pipe	225 dia. (outlet)	1400 (outlet)	0.4	4.1	9.6	N/A
3065	C23	Box / Pipe	225 dia. (outlet) Breadth: 250 (inlet) Depth: 600 (inlet)	300 (inlet) 1000 (outlet)	0.3	5.0	11.0	N/A
3126	C24	Pipe	600 dia.	1200 (inlet) 1000 (outlet)	0.9	2.7	9.7	N/A

Table A.5: Existing A82 Culverts (Cont)

Approx Chainage	Culvert Reference	Type	Principle Dimensions (mm)	Cover Depth (mm)	NB Offset (m)	SB Offset (m)	Length (m)	Headwall Type
3233	C25	Pipe	375 dia. (outlet) Breadth: 400 (inlet) Depth: 600 (inlet)	200	0.7	3.2		
3255	C26	Pipe	375 dia. (outlet) Breadth: 300 (inlet) Depth: 700 (inlet)	200	0.7	5.0	12.2	Stone
3270	C27	Pipe	150 dia.	200	0.7	5.0	9.9	N/A
3342	C28	Pipe	300 dia.	400		4.0	10.0	None
3351	C29	Pipe	450 dia.		0.5	5.8	13.4	
3399	C30	Box	Breadth: 300 (inlet) 500(outlet) Depth: 600 (inlet) 400 (outlet)	300	0.6	0.7	7.6	Stone
3419	C31	Box	Breadth: 500 (outlet) Depth: 350 (outlet)		0.6	0.8	7.7	Stone
3465	C32	Box / Pipe	225 dia. (outlet) Breadth: submerged Depth: submerged		0.9	6.2	13.7	Stone
3572	C33	Box	Breadth: 400 Depth: 500	250	0.5	1.3	7.6	Stone
3610	C34	Box / Pipe	225 dia. (outlet) Breadth: 500 (inlet) Depth: 800 (inlet)	150	0.5	1.0	8.6	Stone
3744	C35	Pipe	600 dia.	700			9.6	Stone

Table A.5: Existing A82 Culverts (Cont)

Approx Chainage	Culvert Reference	Type	Principle Dimensions (mm)	Cover Depth (mm)	NB Offset (m)	SB Offset (m)	Length (m)	Headwall Type
3770	C36	Box / Pipe	400 dia. (outlet) Breadth: 300 (inlet) Depth: 300 (inlet)	800	1.2	3.5	10.5	Stone
3880	C37	Pipe	500 dia. (inlet)	500	1.5	0.3	7.8	Stone
3916	C38	Box / Pipe	300 dia. (outlet) Breadth: 400 (inlet) Depth: 400 (inlet)		1.0	0.9	7.7	Stone
3949	C39	Box / Pipe	400 dia. (outlet) Breadth: 500 (inlet) Depth: 600 (inlet)	300	0.7	4.7	11.4	Stone
3975	C40	Pipe	225 dia. (inlet)	300	0.4	4.0	11.2	Concrete
4060	C41	Pipe	450 dia.	700	1.2	7.2	15.4	Concrete
4170	C42	Pipe	450 dia.	300		3.0	9.9	Stone Masonry
4265	C43	Box	Breadth: 250 Depth: 300	300	1.2	1.3	7.8	Stone
4360	C44	Pipe	225 dia.	500	1.0	3.5	10.1	Stone Masonry
4387	C45	Pipe	150 dia. (outlet)		0.9	3.0	9.3	
4420	C46	Pipe	225 dia. (outlet)		0.9	3.0	9.3	
4520	C47	Pipe	300 dia.	300	0.6	2.1	8.5	Stone
4572	C48	Plastic Pipe	600 dia.	200	0.9	1.8	8.8	Masonry
4606	C49	Box / Pipe	150dia. (outlet) Breadth: 400 (inlet) Depth: 300 (inlet)	300	1.0	3.0	10.4	Stone

Table A.5: Existing A82 Culverts (Cont)

Approx Chainage	Culvert Reference	Type	Principle Dimensions (mm)	Cover Depth (mm)	NB Offset (m)	SB Offset (m)	Length (m)	Headwall Type
4631	C50	Pipe / Box	300 dia. (inlet) Breadth: 400 (outlet) Depth: 400 (outlet)	225	1.7	2.2		Stone Masonry
4670	C51	Pipe	300 dia. (inlet) 450dia. (outlet)	600	1.3	1.2	12.0	Stone Masonry
4831	C52	Box	400 dia. (outlet) Breadth: 500 (inlet) Depth: 300 (inlet)	200	2.8	0.6	12.0	N/A
4912	C53	Box	Breadth: 400 (inlet) 400(outlet) Depth: 700 (inlet) 400 (outlet)	800	0.6	1.8	8.3	Stone
4946	C54	Box / Pipe	400 dia. (outlet) Breadth: 300 (inlet) Depth: 500 (inlet)	400	0.9	2.5	10.0	Stone
5078	C55	Pipe	300 dia.		0.9	3.0	10.0	N/A
5143	C56	Pipe	900 dia.	900	1.5	6.2	13.5	Brick / Stone
5205	C57	Box	Breadth: 600 (inlet) Depth: 500 (inlet)	350	0.9	1.4	7.4	None
5225	C58	Pipe / Box	225 dia. (inlet) Breadth: 400 (outlet) Depth: 300 (outlet)	700	0.6	1.5	10.7	Stone

Table A.5: Existing A82 Culverts (Cont)

Approx Chainage	Culvert Reference	Type	Principle Dimensions (mm)	Cover Depth (mm)	NB Offset (m)	SB Offset (m)	Length (m)	Headwall Type
5323	C59	Pipe / Box	225 dia. (inlet) Breadth: 350 (outlet) Depth: 500 (outlet)	350	0.5	1.1	7.0	N/A
5335	C60	Pipe / Box	300 dia. (inlet) Breadth: 300 (inlet) 400(outlet) Depth: 500 (inlet) 500 (outlet)	500	0.6	0.9	6.7	Stone Masonry
5386	C61	Box	Breadth: 600 Depth: 500	500	1.2	1.8	8.2	N/A
5454	C62	Pipe	300 dia.	800	0.7	39.0	35.0	Stone
5494	C63	Pipe	300 dia.	500	1.1	5.6	12.0	
5595	C64	Pipe	1600 dia.	1300			14.2	Stone Masonry (11.3 x 2.0)
6117	C65	Pipe	300 dia.	400				
6653	C66	Pipe / Box	300 dia. (inlet) Breadth: 350 (outlet) Depth: 350 (outlet)	2000	1.9	1.4	8.0	None
6733	C67	Pipe	225 dia. (outlet)	2000	0.2	2.5	8.0	None
6770	C68	Pipe	225 dia.	400	0.6	3.2	9.4	None
6829	C69	Pipe	300 dia. (inlet) 400 dia. (outlet)	250	0.9	2.5	8.7	None

Table A.5: Existing A82 Culverts (Cont)

Approx Chainage	Culvert Reference	Type	Principle Dimensions (mm)	Cover Depth (mm)	NB Offset (m)	SB Offset (m)	Length (m)	Headwall Type
6942	C70	Box	Breadth: 500 (inlet) 450(outlet) Depth: 500 (inlet) 600 (outlet)	500	1.1	2.1	9.0	Stone Masonry
7049	C71	Pipe	1500 dia.	600	2.1	2.0	10.6	Concrete
7118	C72	Pipe	1200 dia.	2000 (inlet) 1500 (outlet)	3.5	4.8	14.5	Concrete
7165	C73	Arch	Breadth: 1100 Depth: 1000	3000 (inlet)	0.5	0.5	6.4	Stone Masonry
7344	C74	Pipe	450 dia.	1500	1.3	3.9	11.5	N/A
7470	C75	Pipe	225 dia. (outlet)		1.2	2.2	9.5	N/A
7660	C76	Pipe / Box	225 dia. (inlet) Breadth: 400 (outlet) Depth: 400 (outlet)	600	0.7	1.8	8.7	N/A
7785	C77	Box	Breadth: 500 Depth: 400	900	1.3	0.9	8.5	Concrete
7942	C78	Pipe	300 dia.	400 (inlet) 700 (outlet)	0.5	3.4	9.2	Stone Masonry
7970	C79	Box	Breadth: 400 Depth: 450	800	1.6		7.9	N/A
8080	C80	Box	300 dia. (outlet) Breadth: 900 (inlet) Depth: 800 (inlet)	300	1.0	2.8	9.7	N/A
8170	C81	Pipe	1000 dia.	1400	3.2	3.2	13.0	Concrete
8300	C82	Pipe	600 dia. (outlet)		1.0	7.3	14.3	Concrete (outlet)
8365	C83	Pipe	225 dia. (outlet)	200	0.2	1.3	7.7	N/A

Table A.5: Existing A82 Culverts (Cont)

Approx Chainage	Culvert Reference	Type	Principle Dimensions (mm)	Cover Depth (mm)	NB Offset (m)	SB Offset (m)	Length (m)	Headwall Type
8475	C84	Pipe	300 dia. (outlet)	200	0.8	0.2	7.4	N/A
8567	C85	Pipe	1000 dia.	700	4.7	7.0	19.7	Masonry (3 m wide x 2 m high)
8941	C86	Pipe	225 dia.	400	0.8	1.6	8.0	Stone
9000	C87	Pipe						
9153	C88	Pipe	300 dia.	1000	1.8	1.5	9.0	
9175	C89	Box	Breadth: 300 (outlet) Depth: 400 (outlet)	500	0.6	1.6	8.1	N/A
9242	C90	Pipe	225 dia. (outlet)		0.4	0.2	6.6	
9327	C91	Pipe	300 dia. (outlet)	500	1.9	0.9	9.1	Stone
9354	C92	Pipe	150 dia. (outlet)		0.1	1.6	7.5	N/A
9475	C93	Pipe	400 dia.	700	1.3	2.3	9.2	N/A
9506	C94	Pipe / Box	2 no. 650 dia. (inlet) Breadth: 2 no. 500 (outlet) Depth: 2 no. 400 (outlet)	500	0.5	2.6	9.1	N/A
9517	C95	Pipe / Box	300 dia. (inlet) Breadth: 400 (outlet) Depth: 400 (outlet)	500	0.4	2.6	9.1	
9646	C96	Pipe	1100 dia. (inlet)	600	3.9	3.0	12.8	
9770	C97	Pipe	225 dia. (outlet)		0.6	2.3	9.3	N/A
9821	C98	Box / Pipe	225 dia. (outlet) Breadth: 200 (inlet) Depth: 600 (inlet)	200	0.6	1.2	7.8	N/A
9901	C99	Pipe	225 dia.	600	0.6	0.5	7.0	N/A

Table A.5: Existing A82 Culverts (Cont)

Approx Chainage	Culvert Reference	Type	Principle Dimensions (mm)	Cover Depth (mm)	NB Offset (m)	SB Offset (m)	Length (m)	Headwall Type
10116	C100	Pipe	225 dia. (outlet)		0.6	1.5	8.0	N/A
10153	C101	Box / Pipe	225 dia. (outlet) Breadth: 200 (inlet) Depth: 500 (inlet)	300	1.3	1.8	8.9	N/A
10326	C102	Pipe / Box	400 dia. (inlet) Breadth: 200 (outlet) Depth: 400 (outlet)	750	0.9	6.5	12.0	N/A
10401	C103	Pipe	300 dia.	800	0.9	1.5	7.5	Masonry
10526	C104	Pipe	450 dia.	800	0.5	1.5	8.0	N/A
10860	C105	Pipe	225 dia. (outlet)		0.2	1.8	9.7	N/A
10873	C106	Pipe	600 dia. (outlet)	5000	5.0	7.0	18.5	N/A
10933	C107	Box / Pipe	225 dia. (outlet) Breadth: 250 (inlet) Depth: 700 (inlet)	700	0.6	1.6	7.3	Masonry
11071	C107A	Box / Pipe	300 dia. (outlet) Breadth: 300 (inlet) Depth: 500 (inlet)					
11143	C108	Pipe	300 dia. (inlet)	400	0.3	2.0	7.8	N/A
11270	C109	Box	Breadth: 400 (outlet) Depth: 200 (outlet)	400	0.8	2.0	8.5	Stone
11292	C110	Pipe	300 dia. (outlet)					N/A

Table A.5: Existing A82 Culverts (Cont)

Approx Chainage	Culvert Reference	Type	Principle Dimensions (mm)	Cover Depth (mm)	NB Offset (m)	SB Offset (m)	Length (m)	Headwall Type
11375	C111	Pipe / Box	800 dia. (inlet) Breadth: 1600 (inlet) Depth: 500 (inlet)	800	0.8	2.5	9.0	N/A
11575	C112	Concrete Pipe	600 dia. (inlet) 900 dia. (outlet)	1400	4.4	7.8	21.0	Masonry
11707	C113	Concrete Pipe	1000 dia.	800	7.0	8.6	25.0	Masonry
12416	C114	Box	Breadth: 1500 (outlet) Depth: 1500 (outlet)		3.3	11.6	22.9	Concrete
12517	C115	Concrete Pipe	450 dia. (outlet)		1.6	4.2	12.6	Concrete
12565	C116	Plastic Pipe / Box	500 dia. (inlet) Breadth: 900 (outlet) Depth: 550 (outlet)	800	0.6	3.0	14.5	Brick
12755	C117	Arch	Breadth: 1500 Depth: 1000	1000	0.4	0.4	6.5	
12960	C118	Plastic Pipe	525 dia. (inlet) 250 dia. (inlet)		0.9	1.0	7.3	
13304	C119	Concrete Pipe	3 no. 450 dia.	550	4.0	3.0	12.7	Concrete
13417	C120	Concrete Pipe	900 dia.	1500	3.9	6.3	16.5	Concrete
13523	C121	Pipe	450 dia. (outlet)	1400	2.0	5.2	15.4	
13598	C122	Pipe / Box	225 dia. (inlet) Breadth: 300 (outlet) Depth: 450 (outlet)	1400 (inlet) 1800 (outlet)	7.0	1.9	13.0	

Table A.5: Existing A82 Culverts (Cont)

Approx Chainage	Culvert Reference	Type	Principle Dimensions (mm)	Cover Depth (mm)	NB Offset (m)	SB Offset (m)	Length (m)	Headwall Type
13733	C123	Pipe	450 dia. (outlet)		2.7	2.7	13.0	Concrete
13846	C124	Pipe	2 no. 300 dia.	650	2.4	2.8	12.4	Concrete
14004	C125	Pipe	300 dia.	1000	2.6	2.5	11.6	Concrete
14027	C126	Concrete Pipe	850 dia.	900	5.0	4.1	15.5	Concrete
14405	C127	Box	Breadth: 350 Depth: 700		0.6	1.8	8.3	Brick
14430	C128	Box / Pipe	300 dia. (outlet) Breadth: collapsed Depth: collapsed	8.5	0.8	1.8	8.5	N/A
14460	C129	Box	Breadth: 200 Depth: 250					
14550	C130	Pipe	375 dia.					
14605	C131	Plastic Pipe	500 dia.	300			9.1	Stone Masonry
14670	C132	Box	Breadth: 300 (outlet) Depth: 300 (outlet)		2.0	2.4	11.6	None
14723	C133	Plastic Pipe	225 dia. 150 dia. 300 dia.	300 (inlet) 900 (outlet)	1.3	0.9	8.7	Stone Masonry
14900	C134	Pipe	300 dia. (inlet)	900	0.45	1.6	8.1	N/A
15033	C135	Box	Breadth: 400 Depth: 300	600	0.8	1.9	8.5	N/A
15123	C136	Box	Breadth: 950 Depth: 400	300	1.8	0.8	7.6	Stone
15294	C137	Clay Pipe / Box	300 dia. (inlet) Breadth: 400 (outlet) Depth: 300 (outlet)	1200 (inlet) 1300 (outlet)	2.1	1.8	9.7	None

Table A.5: Existing A82 Culverts (Cont)

Approx Chainage	Culvert Reference	Type	Principle Dimensions (mm)	Cover Depth (mm)	NB Offset (m)	SB Offset (m)	Length (m)	Headwall Type
15380	C138	Plastic Pipe	950 dia.	200 (inlet) 400 (outlet)	1.4	1.3	8.6	Stone / Concrete
	C139	Box	Breadth: 350 Depth: 400	1000	1.2	1.8	8.3	None
15460	C140	Clay Pipe	400 dia.	700	1.8	1.3	8.7	Stone
15723	C141	Plastic Pipe	225 dia.	400	0.6	14.0	21.0	None
15775	C142	Concrete Pipe	1000 dia.	950	2.5	2.7	12.5	Concrete
16237	C143	Box	Breadth: 2000 Depth: 1000	1000	1.7	4.4	14.2	Masonry
16297	C144	Box / Plastic Pipe	225 dia. (outlet) Breadth: 400 (inlet) Depth: 500 (inlet)	550	0.9	5.3	13.6	
16375	C145	Pipe	225 dia. (outlet)		1.1	3.2	11.8	N/A
16493	C146	Pipe	1200 dia. (inlet)		0.65	3.6	8.9	Concrete
16632	C147	Box / Steel Pipe	400 dia. (outlet) Breadth: 600 (inlet) Depth: 600 (inlet)	2000	0.65	3.6	12.2	N/A
16707	C148	Box	Breadth: 400 (inlet) Depth: 200 (inlet)		10.0	2.2	18.2	N/A
16805	C149	Concrete Pipe	600 dia. (inlet)	800	1.7	0.7	8.1	Masonry

Table A.5: Existing A82 Culverts (Cont)

Approx Chainage	Culvert Reference	Type	Principle Dimensions (mm)	Cover Depth (mm)	NB Offset (m)	SB Offset (m)	Length (m)	Headwall Type
16837	C150	Concrete Pipe / Box	375 dia. Breadth: 550 (inlet) 500 (outlet) Depth: 600 (inlet) 400 (outlet)	300	1.5	1.6	8.7	Brick
16855	C151	Concrete Pipes	2 no. 225 dia. Breadth: 550 (inlet) Depth: 450 (inlet)	150	3.3	3.1	8.7	Brick
16936	C153	Concrete Pipes	750 dia. Breadth: 700 (inlet) Depth: 650 (inlet)	1000	6.2	7.1	21.6	

Appendix B

Relaxations and Departures from Standards

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Table B.1: Route Option 1 summary of Relaxations and Departures from Standard associated with vertical and horizontal alignment, and Stopping Sight Distance

Relaxations are indicated in black text, and Departures are indicated in red text on a shaded background.

Route Option	Chainage		Vertical / Horizontal / SSD	Description		
	From	To				
1	485.024	577.384	Horizontal	1 Step below	R =	360.0
1	570.000	590.000	SSD	2 Steps below. NB	Distance =	111.4
1	577.384	752.471	Horizontal	4 Steps below	R =	127.0
1	590.000	590.000	SSD	1 Step below. NB	Distance =	122.3
1	690.000	820.000	SSD	1 Step below. SB	Distance =	127.7
1	850.552	891.118	Horizontal	5 Steps below	R =	90.0
1	921.327	1006.432	Horizontal	2 Steps below	R =	255.0
1	1133.230	1250.678	Horizontal	1 Step below	R =	360.0
1	1140.000	1170.000	SSD	1 Step below. NB	Distance =	154.4
1	1328.947	1445.606	Horizontal	3 Steps below	R =	190.0
1	1440.000	1450.000	SSD	1 Step below. NB	Distance =	159.5
1	1445.606	1493.344	Horizontal	3 Steps below	R =	180.0
1	1530.000	1540.000	SSD	1 Step below. NB	Distance =	159.9
1	1533.246	1611.101	Horizontal	5 Steps below	R =	90.0
1	1689.794	1730.244	Horizontal	5 Steps below	R =	90.0
1	1760.000	1770.000	SSD	1 Step below. SB	Distance =	158.9
1	1925.216	2009.989	Horizontal	3 Steps below	R =	180.0
1	2090.000	2100.000	SSD	1 Step below. NB	Distance =	159.7
1	2120.000	2130.000	SSD	1 Step below. SB	Distance =	159.5
1	2226.594	2278.471	Horizontal	4 Steps below	R =	127.0
1	2280.000	2310.000	SSD	1 Step below. NB	Distance =	145.2
1	2325.637	2345.548	Horizontal	3 Steps below	R =	180.0
1	2718.056	2746.047	Horizontal	3 Steps below	R =	180.0
1	2850.000	2860.000	SSD	1 Step below. SB	Distance =	159.3
1	2886.776	2925.312	Horizontal	2 Steps below	R =	255.0
1	3080.000	3120.000	SSD	1 Step below. NB	Distance =	154.2
1	3104.997	3170.860	Horizontal	1 Step below	R =	360.0
1	3339.287	3398.841	Horizontal	2 Steps below	R =	255.0
1	3943.458	3972.950	Horizontal	1 Step below	R =	360.0
1	3991.956	4128.908	Horizontal	2 Steps below	R =	255.0
1	4049.512	4079.512	Vertical	1 Step below	K =	-30.0
1	4079.512	4825.987	Vertical	Gradient < 0.5 %		
1	4167.682	4202.516	Horizontal	1 Step below	R =	360.0
1	4571.443	4652.179	Horizontal	2 Steps below	R =	255.0

Table B.1: Route Option 1 summary of Relaxations and Departures from Standard associated with vertical and horizontal alignment, and Stopping Sight Distance (Cont)

Relaxations are indicated in black text, and Departures are indicated in red text on a shaded background.

Route Option	Chainage		Vertical / Horizontal / SSD	Description		
	From	To				
1	4710.066	4730.085	Horizontal	5 Steps below	R =	90.0
1	4984.805	5044.806	Vertical	1 Step below	K =	-30.0
1	5149.815	5191.578	Horizontal	3 Steps below	R =	180.0
1	5330.150	5380.000	SSD	6 Steps below. SB	Distance =	19.8
1	5350.000	5360.000	SSD	1 Step below. NB	Distance =	158.6
1	5370.000	5490.000	SSD	1 Step below. NB	Distance =	133.0
1	5380.000	5400.000	SSD	4 Steps below. SB	Distance =	59.8
1	5400.000	5420.000	SSD	3 Steps below. SB	Distance =	79.8
1	5420.000	5450.000	SSD	2 Steps below. SB	Distance =	99.8
1	5434.870	5579.249	Horizontal	4 Steps below	R =	127.0
1	5450.000	5490.000	SSD	1 Step below. SB	Distance =	129.8
1	5510.000	5660.000	SSD	1 Step below. SB	Distance =	122.3
1	5670.000	5680.000	SSD	1 Step below. SB	Distance =	158.5
1	6107.776	6185.845	Horizontal	2 Steps below	R =	255.0
1	6398.168	6449.779	Horizontal	2 Steps below	R =	255.0
1	6476.574	6575.884	Horizontal	1 Step Below	R =	394.0
1	6500.000	6530.000	SSD	1 Step below. NB	Distance =	158.6
1	6635.806	6683.888	Horizontal	2 Steps below	R =	255.0
1	6750.000	6760.000	SSD	1 Step below. SB	Distance =	159.7
1	6910.000	6950.000	SSD	1 Step below. NB	Distance =	127.0
1	6950.000	7050.000	SSD	2 Steps below. NB	Distance =	90.5
1	7008.511	7101.286	Horizontal	5 Steps below	R =	90.0
1	7050.000	7060.000	SSD	2 Steps below. SB	Distance =	105.5
1	7060.000	7140.000	SSD	3 Steps below. SB	Distance =	78.3
1	7130.000	7170.000	SSD	2 Steps below. SB	Distance =	94.2
1	7170.000	7210.000	SSD	1 Step below. SB	Distance =	126.7
1	7260.000	7290.000	SSD	1 Step below. NB	Distance =	124.6
1	7290.000	7330.000	SSD	2 Steps below. NB	Distance =	97.3
1	7330.000	7380.000	SSD	3 Steps below. NB	Distance =	72.0
1	7382.558	7468.320	Horizontal	5 Steps below	R =	90.0
1	7387.347	7481.88	Vertical	2 Steps below	K =	-20.0
1	7380.000	7430.000	SSD	4 Steps below. NB	Distance =	66.4
1	7420.000	7450.000	SSD	2 Steps below. SB	Distance =	93.0
1	7430.000	7440.000	SSD	2 Steps below. SB	Distance =	100.2

Table B.1: Route Option 1 summary of Relaxations and Departures from Standard associated with vertical and horizontal alignment, and Stopping Sight Distance (Cont)

Relaxations are indicated in black text, and Departures are indicated in red text on a shaded background.

Route Option	Chainage		Vertical / Horizontal / SSD	Description		
	From	To				
1	7450.000	7510.000	SSD	3 Steps below. SB	Distance =	82.3
1	7510.000	7550.000	SSD	2 Steps below. SB	Distance =	95.8
1	7550.000	7580.000	SSD	1 Step below. SB	Distance =	128.6
1	7773.673	7860.278	Horizontal	2 Steps below	R =	255.0
1	7860.000	7880.000	SSD	1 Step below. NB	Distance =	159.9
1	7900.000	7930.000	SSD	1 Step below. NB	Distance =	125.5
1	7930.000	7970.000	SSD	2 Steps below. NB	Distance =	93.0
1	7970.000	8020.000	SSD	3 Steps below. NB	Distance =	79.2
1	8007.383	8071.487	Horizontal	6 Steps below	R =	60.0
1	8020.000	8030.000	SSD	2 Steps below. NB	Distance =	95.5
1	8040.000	8050.000	SSD	2 Steps below. SB	Distance =	113.6
1	8050.000	8110.000	SSD	3 Steps below. SB	Distance =	70.5
1	8070.000	8220.000	SSD	1 Step below. NB	Distance =	126.4
1	8110.000	8160.000	SSD	2 Steps below. SB	Distance =	96.1
1	8127.066	8304.973	Horizontal	4 Steps below	R =	127.0
1	8160.000	8190.000	SSD	1 Step below. SB	Distance =	128.0
1	8230.000	8360.000	SSD	1 Step below. SB	Distance =	136.7
1	8400.000	8410.000	SSD	1 Step below. SB	Distance =	159.6
1	8757.281	8907.955	Horizontal	2 Steps below	R =	255.0
1	8770.000	8790.000	SSD	1 Step below. NB	Distance =	150.4
1	8840.000	8930.000	SSD	1 Step below. NB	Distance =	121.4
1	8907.955	9017.704	Horizontal	5 Steps below	R =	90.0
1	8990.000	9150.000	SSD	1 Step below. NB	Distance =	133.9
1	9000.000	9070.000	SSD	1 Step below. SB	Distance =	130.8
1	9017.704	9259.734	Horizontal	3 Steps below	R =	180.0
1	9100.000	9110.000	SSD	1 Step below. SB	Distance =	156.5
1	9130.000	9310.000	SSD	1 Step below. SB	Distance =	120.2
1	9220.000	9260.000	SSD	1 Step below. NB	Distance =	147.0
1	9259.734	9329.392	Horizontal	3 Steps below	R =	180.0
1	9480.000	9590.000	SSD	1 Step below. NB	Distance =	139.8
1	9529.515	9686.526	Horizontal	3 Steps below	R =	180.0
1	9600.000	9760.000	SSD	1 Step below. SB	Distance =	124.2
1	9740.000	9480.000	SSD	1 Step below. NB	Distance =	144.5
1	9788.977	9970.572	Vertical	1 Step below	K =	-30.0
1	9802.583	9999.403	Horizontal	2 Steps below	R =	255.0

Table B.1: Route Option 1 summary of Relaxations and Departures from Standard associated with vertical and horizontal alignment, and Stopping Sight Distance (Cont)

Relaxations are indicated in black text, and Departures are indicated in red text on a shaded background.

Route Option	Chainage		Vertical / Horizontal / SSD	Description		
	From	To				
1	9910.000	9980.000	SSD	1 Step below. SB	R =	155.2
1	10078.944	10174.142	Horizontal	4 Steps below	R =	127.0
1	10270.000	10330.000	SSD	1 Step below. NB	Distance =	122.7
1	10270.000	10280.000	SSD	1 Step below. SB	Distance =	159.6
1	10390.921	10450.505	Horizontal	2 Steps below	R =	255.0
1	10450.000	10490.000	SSD	1 Step below. SB	Distance =	147.3
1	10460.000	10690.000	SSD	6 Steps below. NB	Distance =	19.8
1	10719.751	10773.674	Horizontal	5 Steps below	R =	90.0
1	10740.000	10820.000	SSD	3 Steps below. SB	Distance =	78.3
1	10740.000	10750.000	SSD	1 Step below. NB	Distance =	135.2
1	10820.000	10910.000	SSD	2 Steps below. SB	Distance =	91.1
1	10854.816	11193.688	Vertical	Gradient < 0.5 %		
1	10870.000	10910.000	SSD	1 Step below. SB	Distance =	121.1
1	11045.295	11164.434	Horizontal	2 Steps below	R =	255.0
1	11705.080	11790.977	Horizontal	1 Step below	R =	360.0
1	11973.168	11991.633	Horizontal	1 Step below	R =	360.0
1	12470.000	12490.000	SSD	1 Step below. NB	Distance =	157.7
1	12500.000	12540.000	SSD	1 Step below. NB	Distance =	132.0
1	12740.000	12750.000	SSD	1 Step below. NB	Distance =	158.6
1	12793.186	12817.145	Horizontal	3 Steps below	R =	180.0
1	12899.846	12969.370	Horizontal	2 Steps below	R =	255.0
1	12900.000	12930.000	SSD	1 Step below. NB	Distance =	133.0
1	12969.370	13128.968	Horizontal	1 Step below	R =	360.0
1	13080.000	13140.000	SSD	1 Step below. SB	Distance =	137.3
1	13220.000	13230.000	SSD	1 Step below. SB	Distance =	159.9
1	14115.581	14173.279	Horizontal	1 Step below	R =	360.0
1	14328.821	14774.695	Vertical	Gradient < 0.5 %		
1	15291.815	15331.837	Horizontal	2 Steps below	R =	255.0
1	15472.565	15531.398	Horizontal	3 Steps below	R =	180.0
1	16038.620	16128.204	Horizontal	2 Steps below	R =	255.0
1	16279.668	16344.686	Horizontal	2 Steps below	R =	255.0

Table B.2: Route Option 2 summary of Relaxations and Departures from Standard associated with vertical and horizontal alignment, and Stopping Sight Distance

Relaxations are indicated in black text, and Departures are indicated in red text on a shaded background.

Ref.	Chainage		Vertical / Horizontal / SSD	Description		
	From	To				
2	370.000	450.000	SSD	1 Step below. NB	Distance =	157.0
2	1080.000	1110.000	SSD	1 Step below. NB	Distance =	155.5
2	1109.893	1238.151	Horizontal	1 Step below	R =	360.0
2	1267.577	1384.342	Horizontal	3 Steps below	R =	190.0
2	1380.000	1390.000	SSD	1 Step below. NB	Distance =	159.8
2	1384.342	1432.106	Horizontal	3 Steps below	R =	180.0
2	1472.008	1549.863	Horizontal	5 Steps below	R =	90.0
2	2236.056	2316.779	Horizontal	3 Steps below	R =	180.0
2	2624.365	2717.368	Horizontal	3 Steps below	R =	180.0
2	2750.000	2760.000	SSD	1 Step below. SB	Distance =	159.1
2	2793.100	2831.638	Horizontal	2 Steps below	R =	255.0
2	2910.000	2930.000	SSD	1 Step below. NB	Distance =	157.7
2	2990.000	3020.000	SSD	1 Step below. NB	Distance =	157.0
2	3011.329	3169.887	Horizontal	1 Step below	R =	360.0
2	3245.619	3380.904	Horizontal	2 Steps below	R =	255.0
2	3330.000	3400.000	SSD	1 Step below. SB	Distance =	147.0
2	3849.790	3879.281	Horizontal	1 Step below	R =	360.0
2	3880.000	3940.000	SSD	1 Step below. NB	Distance =	158.3
2	3898.287	4074.014	Horizontal	2 Steps below	R =	255.0
2	3955.822	3985.822	Vertical	1 Step below	K =	-30.0
2	4040.000	4050.000	SSD	1 Step below. SB	Distance =	158.5
2	4074.014	4108.848	Horizontal	1 Step below	R =	360.0
2	4477.774	4558.511	Horizontal	2 Steps below	R =	255.0
2	4616.398	4636.416	Horizontal	5 Steps below	R =	90.0
2	5056.145	5097.908	Horizontal	3 Steps below	R =	180.0
2	5120.000	5150.000	SSD	1 Step below. NB	Distance =	156.1
2	5230.000	5400.000	SSD	1 Step below. NB	Distance =	122.0
2	5256.426	5563.654	Horizontal	2 Steps below	R =	255.0
2	5430.000	5460.000	SSD	1 Step below. SB	Distance =	122.7
2	5460.000	5490.000	SSD	2 Steps below. SB	Distance =	116.7
2	5490.000	5510.000	SSD	1 Step below. SB	Distance =	120.0
2	5510.000	5530.000	SSD	2 Steps below. SB	Distance =	116.7
2	5530.000	5540.000	SSD	1 Step below. SB	Distance =	120.5
2	5540.000	5560.000	SSD	2 Steps below. SB	Distance =	111.7
2	5540.000	5570.000	SSD	1 Step below. NB	Distance =	123.3

Table B.2: Route Option 2 summary of Relaxations and Departures from Standard associated with vertical and horizontal alignment, and Stopping Sight Distance (Cont)

Relaxations are indicated in black text, and Departures are indicated in red text on a shaded background.

Ref.	Chainage		Vertical / Horizontal / SSD	Description		
	From	To				
2	5560.000	5580.000	SSD	1 Step below. SB	Distance =	131.4
2	5570.000	5610.000	SSD	2 Steps below. NB	Distance =	90.8
2	5610.000	5630.000	SSD	3 Step below. NB	Distance =	87.7
2	5625.655	5704.867	Vertical	2 Steps below	K =	-17.0
2	5630.000	5640.000	SSD	2 Steps below. NB	Distance =	97.3
2	5640.000	5650.000	SSD	1 Step below. NB	Distance =	131.7
2	5700.000	5710.000	SSD	1 Step below. SB	Distance =	152.7
2	5710.000	5770.000	SSD	2 Step below. SB	Distance =	96.1
2	5720.000	5750.000	SSD	1 Step below. NB	Distance =	158.3
2	5770.000	5820.000	SSD	1 Step below. SB	Distance =	125.2
2	6027.737	6073.284	Horizontal	2 Steps below	R =	255.0
2	6071.764	6160.680	Vertical	Gradient < 0.5 %		
2	6284.746	6335.991	Horizontal	2 Steps below	R =	255.0
2	6362.787	6463.048	Horizontal	1 Step below	R =	394.6
2	6390.000	6420.000	SSD	1 Step below. NB	Distance =	158.9
2	6522.970	6571.051	Horizontal	2 Steps below	R =	255.0
2	6630.000	6640.000	SSD	1 Step below. SB	Distance =	159.6
2	6800.000	6830.000	SSD	1 Step below. NB	Distance =	124.5
2	6830.000	6940.000	SSD	2 Steps below. NB	Distance =	90.5
2	6895.674	6988.450	Horizontal	5 Steps below	R =	90.0
2	6930.000	6940.000	SSD	1 Step below. NB	Distance =	129.2
2	6940.000	6950.000	SSD	2 Steps below. SB	Distance =	95.8
2	6950.000	7020.000	SSD	3 Steps below. SB	Distance =	78.3
2	7020.000	7050.000	SSD	2 Steps below. SB	Distance =	95.8
2	7050.000	7100.000	SSD	1 Step below. SB	Distance =	120.5
2	7160.000	7200.000	SSD	1 Step below. NB	Distance =	124.2
2	7200.000	7230.000	SSD	2 Steps below. NB	Distance =	90.5
2	7230.000	7310.000	SSD	3 Steps below. NB	Distance =	73.3
2	7310.000	7320.000	SSD	2 Steps below. NB	Distance =	116.1
2	7269.721	7355.483	Horizontal	5 Steps below	R =	90.0
2	7274.454	7369.017	Vertical	2 Steps below	K =	-20.0
2	7281.410	7370.000	SSD	3 Steps below. SB	Distance =	86.4
2	7310.000	7320.000	SSD	2 Steps below. NB	Distance =	116.1
2	7320.000	7340.000	SSD	2 Steps below. SB	Distance =	90.8
2	7340.000	7370.000	SSD	3 Steps below. SB	Distance =	88.6

Table B.2: Route Option 2 summary of Relaxations and Departures from Standard associated with vertical and horizontal alignment, and Stopping Sight Distance (Cont)

Relaxations are indicated in black text, and Departures are indicated in red text on a shaded background.

Ref.	Chainage		Vertical / Horizontal / SSD	Description	
	From	To			
2	7370.000	7410.000	SSD	2 Steps below. SB	Distance = 92.3
2	7410.000	7460.000	SSD	1 Step below. SB	Distance = 120.5
2	7620.000	7640.000	SSD	1 Step below. NB	Distance = 157.0
2	7660.836	7747.441	Horizontal	2 Steps below	R = 255.0
2	7840.291	7857.187	Vertical	Gradient < 0.5 %	
2	7860.000	7870.000	SSD	1 Step below. NB	Distance = 159.9
2	7940.000	8010.000	SSD	1 Step below. NB	Distance = 121.7
2	7972.223	8284.170	Vertical	1 Step below	K = -30.0
2	8010.000	8050.000	SSD	2 Steps below. NB	Distance = 118.3
2	8050.000	8170.000	SSD	1 Step below. NB	Distance = 121.4
2	8090.000	8200.000	SSD	1 Step below. SB	Distance = 121.1
2	8200.000	8270.000	SSD	2 Steps below. SB	Distance = 117.3
2	8270.000	8330.000	SSD	1 Step below. SB	Distance = 121.1
2	8500.000	8510.000	SSD	1 Step below. NB	Distance = 158.6
2	8880.000	8950.000	SSD	1 Step below. NB	Distance = 140.5
2	8980.000	9050.000	SSD	1 Step below. SB	Distance = 122.0
2	9020.000	9060.000	SSD	1 Step below. NB	Distance = 133.0
2	9050.000	9080.000	SSD	2 Steps below. SB	Distance = 116.1
2	9053.039	9064.958	Horizontal	3 Steps below	R = 180.0
2	9090.000	9120.000	SSD	1 Step below. SB	Distance = 123.9
2	9260.000	9390.000	SSD	1 Step below. NB	Distance = 135.8
2	9334.740	9491.751	Horizontal	3 Steps below	R = 180.0
2	9400.000	9410.000	SSD	1 Step below. SB	Distance = 126.1
2	9410.000	9450.000	SSD	2 Steps below. SB	Distance = 115.2
2	9440.000	9610.000	SSD	1 Step below. NB	Distance = 126.1
2	9450.000	9560.000	SSD	1 Step below. SB	Distance = 121.7
2	9522.407	9704.013	Vertical	1 Step below	K = -30.0
2	9570.000	9610.000	SSD	1 Step below. NB	Distance = 157.7
2	9607.807	9804.628	Horizontal	2 Steps below	R = 255.0
2	9610.000	9620.000	SSD	1 Step below. SB	Distance = 125.2
2	9620.000	9680.000	SSD	2 Steps below. SB	Distance = 114.8
2	9680.000	9740.000	SSD	1 Step below. SB	Distance = 122.7
2	9820.000	9880.000	SSD	1 Step below. NB	Distance = 143.6
2	9884.168	9979.366	Horizontal	4 Steps below	R = 127.0
2	9990.000	10010.000	SSD	1 Step below. SB	Distance = 159.2

Table B.2: Route Option 2 summary of Relaxations and Departures from Standard associated with vertical and horizontal alignment, and Stopping Sight Distance (Cont)

Relaxations are indicated in black text, and Departures are indicated in red text on a shaded background.

Ref.	Chainage		Vertical / Horizontal / SSD	Description	
	From	To			
2	10070.000	10080.000	SSD	1 Step below. SB	Distance = 159.4
2	10080.000	10160.000	SSD	1 Step below. NB	Distance = 120.2
2	10194.615	10204.454	Horizontal	2 Steps below	R = 255.0
2	10455.393	10541.830	Vertical	1 Step below	K = -30.0
2	10511.889	10624.960	Horizontal	5 Steps below	R = 90.0
2	10660.094	10998.966	Vertical	Gradient < 0.5 %	
2	10680.000	10710.000	SSD	1 Step below. NB	Distance = 125.2
2	10850.491	11045.434	Horizontal	2 Steps below	R = 255.0
2	11510.373	11596.268	Horizontal	1 Step below	R = 360.0
2	11778.458	11796.923	Horizontal	1 Step below	R = 360.0
2	12170.000	12310.000	SSD	1 Step below. NB	Distance = 148.3
2	12350.000	12430.000	SSD	1 Step below. SB	Distance = 145.5
2	12598.476	12622.533	Horizontal	3 Steps below	R = 180.0
2	12960.000	13020.000	SSD	1 Step below. SB	Distance = 142.7
2	13160.961	13668.226	Vertical	Gradient < 0.5 %	
2	13780.000	13900.000	SSD	1 Step below. NB	Distance = 143.9
2	13950.000	14050.000	SSD	1 Step below. SB	Distance = 146.7
2	14124.590	14597.782	Vertical	Gradient < 0.5 %	
2	15086.231	15126.252	Horizontal	2 Steps below	R = 255.0
2	15170.000	15210.000	SSD	1 Step below. NB	Distance = 155.0
2	15266.981	15325.814	Horizontal	3 Steps below	R = 180.0
2	15660.000	15680.000	SSD	1 Step below. NB	Distance = 156.7
2	15690.000	15730.000	SSD	1 Step below. NB	Distance = 146.4
2	15810.000	15930.000	SSD	1 Step below. SB	Distance = 129.5
2	15833.035	15922.620	Horizontal	2 Steps below	R = 255.0
2	16074.083	16139.102	Horizontal	2 Steps below	R = 255.0

Table B.3: Route Option 3 summary of Relaxations and Departures from Standard associated with vertical and horizontal alignment, and Stopping Sight Distance

Relaxations are indicated in black text, and Departures are indicated in red text on a shaded background.

Ref.	Chainage		Vertical / Horizontal / SSD	Description	
	From	To			
3	485.025	577.384	Horizontal	1 Step below	R =360.0
3	577.384	752.471	Horizontal	6 Steps below	R =19.8
3	580.000	590.000	SSD	2 Steps below. NB	Distance =117.0
3	590.000	690.000	SSD	1 Step below. NB	Distance =122.3
3	850.552	891.118	Horizontal	5 Steps below	R =90.0
3	921.327	1006.433	Horizontal	2 Steps below	R =255.0
3	1133.230	1250.678	Horizontal	1 Step below	R =360.0
3	1140.000	1170.000	SSD	1 Step below. NB	Distance =154.5
3	1328.947	1445.606	Horizontal	3 Steps below	R =190.0
3	1440.000	1450.000	SSD	1 Step below. NB	Distance =159.5
3	1445.606	1493.344	Horizontal	3 Steps below	R =180.0
3	1533.246	1611.101	Horizontal	5 Steps below	R =90.0
3	2250.000	2260.000	SSD	1 Step below. NB	Distance =159.8
3	2297.294	2313.020	Horizontal	3 Steps below	R =180.0
3	2685.603	2713.609	Horizontal	3 Steps below	R =180.0
3	2810.000	2820.000	SSD	1 Step below. SB	Distance =159.0
3	2854.338	2892.875	Horizontal	2 Steps below	R =255.0
3	2970.000	2990.000	SSD	1 Step below. NB	Distance =158.3
3	3050.000	3080.000	SSD	1 Step below. NB	Distance =156.1
3	3072.567	3138.430	Horizontal	1 Step below	R =360.0
3	3306.857	3366.410	Horizontal	2 Steps below	R =255.0
3	3390.000	3460.000	SSD	1 Step below. SB	Distance = 147.0
3	3911.027	3940.519	Horizontal	1 Step below	R =360.0
3	3940.000	3980.000	SSD	1 Step below. NB	Distance =158.0
3	3959.525	4096.477	Horizontal	2 Steps below	R =255.0
3	3990.000	4000.000	SSD	1 Step below. NB	Distance =158.9
3	4017.082	4047.082	Vertical	1 Step below	K =-30.0
3	4047.082	4793.567	Vertical	Gradient < 0.5 %	
3	4100.000	4110.000	SSD	1 Step below. SB	Distance =158.5
3	4135.252	4170.086	Horizontal	1 Step below	R =360.0
3	4539.012	4619.748	Horizontal	2 Steps below	R =255.0
3	4677.636	4697.654	Horizontal	5 Steps below	R =90.0
3	5117.383	5159.146	Horizontal	3 Steps below	R =180.0
3	5180.000	5210.000	SSD	1 Step below. NB	Distance =156.4
3	5290.000	5460.000	SSD	1 Step below. NB	Distance =122.0

Table B.3: Route Option 3 summary of Relaxations and Departures from Standard associated with vertical and horizontal alignment, and Stopping Sight Distance (Cont)

Relaxations are indicated in black text, and Departures are indicated in red text on a shaded background.

Ref.	Chainage		Vertical / Horizontal / SSD	Description	
	From	To			
3	5317.664	5624.892	Horizontal	2 Steps below	R =255.0
3	5490.000	5520.000	SSD	1 Step below. SB	Distance =123.9
3	5520.000	5550.000	SSD	2 Steps below. SB	Distance =118.9
3	5550.000	5650.000	SSD	1 Step below. SB	Distance =120.2
3	5600.000	5630.000	SSD	1 Step below. NB	Distance =124.8
3	5630.000	5670.000	SSD	2 Steps below. NB	Distance =91.4
3	5670.000	5690.000	SSD	3 Steps below. NB	Distance =88.3
3	5686.915	5766.127	Vertical	2 Steps below	K =-17.0
3	5690.000	5710.000	SSD	2 Steps below. NB	Distance =90.5
3	5780.000	5810.000	SSD	1 Step below. NB	Distance =158.3
3	5780.000	5830.000	SSD	2 Steps below. SB	Distance =98.3
3	5830.000	5880.000	SSD	1 Step below. SB	Distance =124.8
3	6088.975	6134.472	Horizontal	2 Steps below	R =255.0
3	6133.132	6221.884	Vertical	Gradient < 0.5 %	
3	6345.984	6397.228	Horizontal	2 Steps below	R =255.0
3	6424.024	6524.286	Horizontal	1 Step below	R =394.4
3	6450.000	6480.000	SSD	1 Step below. NB	Distance =158.9
3	6584.207	6632.289	Horizontal	2 Steps below	R =255.0
3	6700.000	6710.000	SSD	1 Step below. SB	Distance =159.7
3	6860.000	6890.000	SSD	1 Step below. NB	Distance =125.8
3	6890.000	7000.000	SSD	2 Steps below. NB	Distance =90.5
3	6956.912	7049.687	Horizontal	5 Steps below	R =90.0
3	6990.000	7000.000	SSD	1 Step below. NB	Distance =123.6
3	7000.000	7010.000	SSD	2 Steps below. SB	Distance =99.5
3	7010.000	7080.000	SSD	3 Steps below. SB	Distance =78.3
3	7080.000	7120.000	SSD	2 Steps below. SB	Distance =95.2
3	7120.000	7160.000	SSD	1 Step below. SB	Distance =128.3
3	7210.000	7240.000	SSD	1 Step below. NB	Distance =123.0
3	7240.000	7270.000	SSD	2 Steps below. NB	Distance =96.1
3	7270.000	7330.000	SSD	3 Steps below. NB	Distance = 71.7
3	7330.000	7370.000	SSD	4 Steps below. NB	Distance =66.7
3	7330.959	7416.456	Horizontal	5 Steps below	R =90.0
3	7335.681	7430.245	Vertical	2 Steps below	K =-20.0
3	7370.000	7380.000	SSD	3 Steps below. NB	Distance =71.4
3	7370.000	7390.000	SSD	2 Steps below. SB	Distance =98.9

Table B.3: Route Option 3 summary of Relaxations and Departures from Standard associated with vertical and horizontal alignment, and Stopping Sight Distance (Cont)

Relaxations are indicated in black text, and Departures are indicated in red text on a shaded background.

Ref.	Chainage		Vertical / Horizontal / SSD	Description	
	From	To			
3	7380.000	7390.000	SSD	1 Step below. NB	Distance = 92.0
3	7390.000	7440.000	SSD	3 Steps below. SB	Distance = 82.3
3	7440.000	7480.000	SSD	2 Steps below. SB	Distance =90.5
3	7480.000	7530.000	SSD	1 Step below. SB	Distance =121.4
3	7760.000	7850.000	SSD	1 Step below. SB	Distance =136.1
3	7810.000	8130.000	SSD	1 Step below. NB	Distance =123.0
3	7931.770	8226.232	Horizontal	1 Step below	R =360.0
3	8020.000	8140.000	SSD	1 Step below. SB	Distance =153.6
3	8200.000	8210.000	SSD	1 Step below. SB	Distance =159.4
3	8640.000	8700.000	SSD	1 Step below. NB	Distance =120.5
3	8700.000	8720.000	SSD	2 Steps below. NB	Distance =116.7
3	8720.000	8730.000	SSD	1 Step below. NB	Distance =127.7
3	8727.166	8798.828	Horizontal	4 Steps below	R =127.0
3	8770.000	8850.000	SSD	1 Step below. NB	Distance =120.5
3	8780.000	8850.000	SSD	2 Steps below. SB	Distance =95.8
3	8833.379	9018.126	Horizontal	2 Steps below	R =255.0
3	8850.000	8940.000	SSD	2 Steps below. NB	Distance =101.7
3	8850.000	8890.000	SSD	1 Step below. SB	Distance =124.8
3	8940.000	9070.000	SSD	1 Step below. SB	Distance =127.7
3	9020.000	9030.000	SSD	1 Step below. NB	Distance =159.8
3	9090.000	9100.000	SSD	1 Step below. SB	Distance =159.8
3	9130.000	9160.000	SSD	1 Step below. NB	Distance =135.5
3	9160.000	9290.000	SSD	1 Step below. SB	Distance =157.0
3	9370.000	9500.000	SSD	1 Step below. NB	Distance =135.5
3	9438.060	9595.071	Horizontal	3 Steps below	R =180.0
3	9500.000	9510.000	SSD	1 Step below. SB	Distance =134.2
3	9510.000	9550.000	SSD	2 Steps below. SB	Distance =115.2
3	9550.000	9670.000	SSD	1 Step below. SB	Distance =120.8
3	9660.000	9780.000	SSD	1 Step below. NB	Distance =144.5
3	9711.127	9907.948	Horizontal	2 Steps below	R =255.0
3	9721.959	9903.556	Vertical	1 Step below	K =-30.0
3	9830.000	9920.000	SSD	1 Step below. SB	Distance =148.9
3	9920.000	9980.000	SSD	1 Step below. NB	Distance =143.9
3	9987.489	10082.686	Horizontal	4 Steps below	R = 127.0
3	10090.000	10110.000	SSD	1 Step below. SB	Distance =159.2

Table B.3: Route Option 3 summary of Relaxations and Departures from Standard associated with vertical and horizontal alignment, and Stopping Sight Distance (Cont)

Relaxations are indicated in black text, and Departures are indicated in red text on a shaded background.

Ref.	Chainage		Vertical / Horizontal / SSD	Description	
	From	To			
3	10180.000	10290.000	SSD	1 Step below. NB	Distance =121.1
3	10180.000	10190.000	SSD	1 Step below. SB	Distance =159.6
3	10305.245	10350.064	Horizontal	2 Steps below	R =255.0
3	10550.344	10641.646	Vertical	1 Step below	K = -30.0
3	10615.345	10682.067	Horizontal	5 Steps below	R = 90.0
3	10620.000	10650.000	SSD	1 Step below. NB	Distance = 92.7
3	10650.000	10660.000	SSD	1 Step below. NB	Distance = 143.9
3	10730.000	10770.000	SSD	2 Steps below. SB	Distance =92.0
3	10763.547	11102.420	Vertical	Gradient < 0.5 %	
3	10770.000	10820.000	SSD	1 Step below. SB	Distance =122.0
3	10953.946	11073.158	Horizontal	2 Steps below	R =255.0
3	11613.828	11699.724	Horizontal	1 Step below	R =360.0
3	11881.913	11900.378	Horizontal	1 Step below	R =360.0
3	12350.000	12380.000	SSD	1 Step below. NB	Distance =120.8
3	12380.000	12410.000	SSD	2 Steps below. NB	Distance =90.8
3	12410.000	12430.000	SSD	3 Steps below. NB	Distance =70.8
3	12430.000	12460.000	SSD	4 Steps below. NB	Distance =50.8
3	12490.000	12540.000	SSD	1 Step below. SB	Distance =157.3
3	12701.931	12725.988	Horizontal	3 Steps below	R =180.0
3	12900.000	12920.000	SSD	1 Step below. NB	Distance =153.6
3	13690.000	13710.000	SSD	1 Step below. NB	Distance =142.3
3	13760.000	13770.000	SSD	1 Step below. NB	Distance =159.5
3	13790.000	13800.000	SSD	1 Step below. NB	Distance =158.8
3	13856.914	14000.555	Horizontal	2 Steps below	R =255.0
3	13900.000	13980.000	SSD	1 Step below. SB	Distance =124.5
3	14070.000	14090.000	SSD	1 Step below. NB	Distance =158.9
3	14246.101	14710.255	Vertical	Gradient < 0.5 %	
3	15221.119	15261.140	Horizontal	2 Steps below	R =255.0
3	15270.000	15360.000	SSD	1 Step below. SB	Distance =136.1
3	15401.869	15460.702	Horizontal	3 Steps below	R =180.0
3	15900.000	15980.000	SSD	1 Step below. SB	Distance =132.7
3	15967.924	16057.508	Horizontal	2 Steps below	R =255.0
3	15990.000	16010.000	SSD	1 Step below. SB	Distance =154.5
3	16208.971	16273.990	Horizontal	2 Steps below	R =255.0

Table B.4: Route Option 4 summary of Relaxations and Departures from Standard associated with vertical and horizontal alignment, and Stopping Sight Distance

Relaxations are indicated in black text, and Departures are indicated in red text on a shaded background.

Ref.	Chainage		Vertical / Horizontal / SSD	Description		
	From	To				
4	525.398	720.834	Horizontal	2 Steps below	R =	255.0
4	872.297	940.267	Horizontal	2 Steps below	R =	255.0
4	1652.469	1682.469	Vertical	1 Step below	K =	-30.0
4	1850.000	1870.000	SSD	1 Step below. NB	Distance =	159.8
4	1980.000	1990.000	SSD	1 Step below. SB	Distance =	159.8
4	2090.000	2100.000	SSD	1 Step below. NB	Distance =	159.5
4	2156.636	2217.964	Horizontal	1 Step below	R =	360.0
4	3120.000	3200.000	SSD	1 Step below. NB	Distance =	127.7
4	3201.119	3291.119	Vertical	1 Step below	K =	-30.0
4	3280.000	3380.0	SSD	1 Step below. SB	Distance =	120.8
4	3399.163	3410.767	Horizontal	2 Steps below	R =	255.0
4	4010.679	4048.179	Vertical	1 Step below	K =	-30.0
4	4048.179	4699.162	Vertical	Gradient < 5 %		
4	5070.000	5120.000	SSD	1 Step below. NB	Distance =	122.3
4	5120.000	5190.000	SSD	2 Steps below. NB	Distance =	98.0
4	5190.000	5200.000	SSD	1 Step below. NB	Distance =	141.4
4	5191.130	5632.258	Horizontal	1 Step below	R =	360.0
4	5200.000	5250.000	SSD	6 Steps below. SB	Distance =	28.9
4	5250.000	5270.000	SSD	4 Steps below. SB	Distance =	53.3
4	5270.000	5290.000	SSD	3 Steps below. SB	Distance =	72.0
4	5270.000	5280.000	SSD	1 Step below. NB	Distance =	159.4
4	5290.000	5320.000	SSD	2 Steps below. SB	Distance =	91.7
4	5320.000	5360.000	SSD	1 Step below. SB	Distance =	121.1
4	6056.618	6084.857	Horizontal	2 Steps below	R =	255.0
4	6240.000	6280.000	SSD	1 Step below. SB	Distance =	129.8
4	6297.893	6349.349	Horizontal	2 Steps below	R =	255.0
4	6716.843	7112.781	Horizontal	1 Step below	R =	360.0
4	7000.000	7020.000	SSD	1 Step below. NB	Distance =	158.6
4	7130.000	7170.000	SSD	1 Step below. SB	Distance =	132.7
4	7205.477	7398.768	Horizontal	1 Step below	R =	360.0
4	7790.266	7890.248	Vertical	Gradient < 5 %		
4	8180.000	8190.000	SSD	1 Step below. SB	Distance =	159.8
4	10000.000	10010.000	SSD	1 Step below. SB	Distance =	159.7

Table B.4: Route Option 4 summary of Relaxations and Departures from Standard associated with vertical and horizontal alignment, and Stopping Sight Distance (Cont)

Relaxations are indicated in black text, and Departures are indicated in red text on a shaded background.

Ref.	Chainage		Vertical / Horizontal / SSD	Description		
	From	To				
4	10060.368	10101.463	Horizontal	3 Steps below	R =	200.0
4	10140.000	10170.000	SSD	1 Step below. SB	Distance =	136.7
4	10363.475	10465.717	Horizontal	4 Steps below	R =	127.0
4	10460.000	10590.000	SSD	1 Step below. SB	Distance =	128.0
4	12130.000	12160.000	SSD	1 Step below. NB	Distance =	157.7
4	12400.000	12410.000	SSD	1 Step below. NB	Distance =	158.5
4	12570.000	12610.000	SSD	1 Step below. NB	Distance =	128.3
4	12610.000	12660.000	SSD	2 Step below. NB	Distance =	103.0
4	12790.000	12900.000	SSD	1 Step below. NB	Distance =	130.5
4	12850.000	12900.000	SSD	1 Step below. NB	Distance =	122.3
4	12900.000	12930.000	SSD	2 Step below. NB	Distance =	113.0
4	12930.000	12940.000	SSD	1 Step below. NB	Distance =	133.0
4	10556.866	10840.415	Vertical	Gradient < 5 %		
4	10721.936	10825.586	Horizontal	2 Steps below	R =	255.0
4	11366.267	11452.161	Horizontal	1 Step below	R =	360.0
4	11634.351	11652.816	Horizontal	1 Step below	R =	360.0
4	12400.000	12410.000	SSD	1 Step below. NB	Distance =	158.5
4	12454.369	12478.328	Horizontal	3 Steps below	R =	180.0
4	12561.028	12630.553	Horizontal	2 Steps below	R =	255.0
4	12630.553	12790.151	Horizontal	1 Step below	R =	360.0
4	12880.000	12890.000	SSD	1 Step below. SB	Distance =	159.9
4	13776.764	13834.462	Horizontal	1 Step below	R =	360.0
4	13990.047	14435.921	Vertical	Gradient < 0.5 %		
4	14952.998	14993.020	Horizontal	2 Steps below	R =	255.0
4	15133.748	15192.581	Horizontal	3 Steps below	R =	180.0
4	15699.803	15789.387	Horizontal	2 Steps below	R =	255.0
4	15940.850	16005.869	Horizontal	2 Steps below	R =	255.0

Appendix C

Earthworks Volumes

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Table C.1: Route Option 1 Earthworks Volumes

Chainage		Cut			Fill		Totals				
From	To	(a) Bulk (m^3)	(b) Subsoil + Topsoil (m^3)	(c) Rock Cut (m^3)	(d) Bulk (m^3)	(e) Bulk + Topsoil (m^3)	(a-b)+(e-d) Topsoil Strip (m^3)	(c) Rock Cut (m^3)	(c-b) Other Cut (m^3)	(e) Fill Subsoil + Topsoil (m^3)	(e)-(c+(b-c) Surplus (Cut -) (Fill +) (m^3)
0	350	0	0	0	0	0	0	0	0	0	0
350	570	0	0	0	0	0	0	0	0	0	0
570	1000	3887	3318	2518	12874	15235	2930	2518	800	15235	11917
1000	1150	1027	577	28	714	1229	965	28	549	1229	652
1150	1700	7269	5752	930	21604	25331	5244	930	4822	25331	19579
1700	1990	37619	34797	19596	3630	4115	3307	19596	15201	4115	-30682
1990	2400	9410	7888	5372	8509	10872	3885	5372	2516	10872	2984
2400	2990	92525	85784	71307	4065	566	8343	71307	14477	5667	-80117
2990	3990	17523	14742	3764	9529	13219	6471	3764	10978	13219	-1523
3990	4990	8383	6782	2212	26362	31892	7131	2212	4570	31892	25110
4990	5200	2709	2094	94	1838	2612	1389	94	2000	2612	518
5200	5440	1425	889	0	15991	18939	3484	0	889	18939	18050
5520	5750	289	151	0	10658	12415	1895	0	151	12415	12264
5750	6100	974	703	3	8929	11118	2460	3	700	11118	10415
6100	6190	75	2	0	770	1214	517	0	2	1214	1212
6250	6480	6882	6150	3547	795	1753	1690	3547	2603	1753	-4397
6480	6900	6230	5019	1388	3778	5571	3004	1388	3631	5571	552
6900	7000	203	116	0	1195	1717	609	0	116	1717	1601
7000	7110	0	0	0	7988	8820	832	0	0	8820	8820
7380	7450	26800	24837	20597	855	1100	2208	20597	4240	1100	-23737
7450	7750	7864	7344	6240	26961	30009	3568	6240	1104	30009	22665
7750	8000	10815	9653	7426	2453	3403	2112	7426	2227	3403	-6250
8000	8650	45082	41485	27727	4856	7444	6185	27727	13758	7444	-34041
8650	9000	3743	3083	821	4587	6801	2874	821	2262	6801	3718
9000	9400	2258	1677	1375	10986	13483	3078	1375	302	13483	11806
9400	10000	38867	35813	34079	4255	6708	5507	34079	1734	6708	-29105
10000	10200	46275	43280	32911	1156	1707	3546	32911	10369	1707	-41573
10200	10470	10776	9688	6059	3515	4551	2124	6059	3629	4551	-5137
10470	10700	0	0	0	0	0	0	0	0	0	0
10700	10710	0	0	0	0	0	0	0	0	0	0
10710	11010	14331	12900	8520	1739	2354	2046	8520	4380	2354	-10546
11010	11050	5617	5250	3597	0	5	372	3597	1653	5	-5245
11050	11200	1598	1365	575	3537	4407	1103	575	790	4407	3042
11200	11400	3546	2780	582	409	793	1150	582	2198	793	-1987
11400	11550	412	259	17	2678	3496	971	17	242	3496	3237

Table C.1: Route Option 1 Earthworks Volumes (Cont)

Chainage		Cut			Fill		Totals				
From	To	(a) Bulk (m^3)	(b) Subsoil + Topsoil (m^3)	(c) Rock Cut (m^3)	(d) Bulk (m^3)	(e) Bulk + Topsoil (m^3)	(a-b)+(e-d) Topsoil Strip (m^3)	(c) Rock Cut (m^3)	(c-b) Other Cut (m^3)	(e) Fill Subsoil + Topsoil (m^3)	(e)-(c+(b-c) Surplus (Cut -) (Fill +) (m^3)
11550	12000	279	35	0	2452	4899	2691	0	35	4899	4864
12000	12100	86	17	0	141	502	430	0	17	502	485
12100	12900	995	650	44	12870	17874	5349	44	606	17874	17224
12900	13010	1412	901	50	79	312	744	50	851	312	-589
13010	13400	1209	701	0	3576	5591	2523	0	701	5591	4890
13400	13800	5414	4281	211	6554	8325	2904	211	4070	8325	4044
13800	14010	90	19	0	2521	3704	1254	0	19	3704	3685
14010	14300	422	68	0	2383	3710	1681	0	68	3710	3642
14300	15010	1123	680	0	8193	12084	4334	0	680	12084	11404
15010	15600	3945	3001	226	9488	12901	4357	226	2775	12901	9900
15600	16010	847	292	0	3482	5474	2547	0	292	5474	5182
16010	16850	3123	2186	10	22415	28399	6921	10	2176	28399	26213
						Totals	126735	261826	125183	361755	-25254

Table C.2: Route Option 2 Earthworks Volumes

Chainage		Cut			Fill		Totals				
From	To	(a) Bulk (m^3)	(b) Subsoil + Topsoil (m^3)	(c) Rock Cut (m^3)	(d) Bulk (m^3)	(e) Bulk + Topsoil (m^3)	(a-b)+(e-d) Topsoil Strip (m^3)	(c) Rock Cut (m^3)	(c-b) Other Cut (m^3)	(e) Fill Subsoil + Topsoil (m^3)	(e)-(c+(b-c) Surplus (Cut -) (Fill +) (m^3)
0	350	0	0	0	0	0	0	0	0	0	0
350	380	0	0	0	0	0	0	0	0	0	0
380	940	75571	72017	66432	11548	13275	5281	66432	5585	13275	-58742
940	1000	340	183	10	203	301	255	10	173	301	118
1000	1090	679	413	40	462	810	614	40	373	810	397
1090	1640	7546	6001	1268	16231	19679	4993	1268	4733	19679	13678
1640	2000	86981	83248	64866	1321	1650	4062	64866	18382	1650	-81598
2000	2300	10989	9569	6686	731	1209	1898	6686	2883	1209	-8360
2300	3000	97600	90375	75014	5346	7341	9220	75014	15361	7341	-83034
3000	4000	21595	18495	5138	8663	12286	6723	5138	13357	12286	-6209
4000	5000	8567	6736	1293	29008	34466	7289	1293	5443	34466	27730
5000	5100	1014	660	4	1098	1464	720	4	656	1464	804
5100	5350	1565	948	0	15121	18010	3506	0	948	18010	17062
5350	5640	377	194	0	24170	26187	2200	0	194	26187	25993
5640	5990	1652	831	4	2112	3604	2313	4	827	3604	2773
5990	6080	14	0	0	697	1149	466	0	0	1149	1149
							0	0	0	0	0
6080	6135	0	0	0	0	0	0	0	0	0	0
6135	6140	0	0	0	0	0	0	0	0	0	0
6140	6380	7017	6254	3556	889	1895	1769	3556	2698	1895	-4359
6380	6780	6551	5385	1656	3578	5249	2837	1656	3729	5249	-136
6780	7000	304	195	15	9915	1146	-8660	15	180	1146	951
7000	7270	0	0	0	0	0	0	0	0	0	0
7270	7335	25299	23431	19406	622	821	2067	19406	4025	821	-22610
7335	7640	9374	8747	7418	24274	27278	3631	7418	1329	27278	18531
7640	8000	11258	9942	7469	4582	6076	2810	7469	2473	6076	-3866
8000	8470	126952	122068	99377	7786	9207	6305	99377	22691	9207	-112861
8470	9000	46675	43593	30544	2380	3851	4553	30544	13049	3851	-39742
9000	9200	394	227	394	3748	4894	1313	394	-167	4894	4667
9200	10000	92862	86987	92862	11397	14670	9148	92862	-5875	14670	-72317
10000	10010	1598	1468	1201	0	9	139	1201	267	9	-1459
10010	10290	18317	16776	13439	5385	6537	2693	13439	3337	6537	-10239
10290	10510	0	0	0	0	0	0	0	0	0	0
10510	10850	19718	17933	12364	1741	2373	2417	12364	5569	2373	-15560
10850	10990	1604	1393	762	3703	4505	1013	762	631	4505	3112
10990	11000	17	7	0	119	174	65	0	7	174	167

Table C.2: Route Option 2 Earthworks Volumes (Cont)

Chainage		Cut			Fill		Totals				
From	To	(a) Bulk (m^3)	(b) Subsoil + Topsoil (m^3)	(c) Rock Cut (m^3)	(d) Bulk (m^3)	(e) Bulk + Topsoil (m^3)	(a-b)+(e-d) Topsoil Strip (m^3)	(c) Rock Cut (m^3)	(c-b) Other Cut (m^3)	(e) Fill Subsoil + Topsoil (m^3)	(e)-(c+(b-c) Surplus (Cut -) (Fill +) (m^3)
11000	11200	3450	2695	600	488	882	1149	600	2095	882	-1813
11200	11350	392	250	18	2795	3633	980	18	232	3633	3383
11350	11900	303	49	0	2793	5660	3121	0	49	5660	5611
11900	11990	25	14	0	915	1472	568	0	14	1472	1458
11990	12700	950	600	0	12676	17096	4770	0	600	17096	16496
12700	12990	8147	6414	0	68	263	1928	0	6414	263	-6151
12990	13200	705	377	0	1511	2472	1289	0	377	2472	2095
13200	13600	1790	1509	4	11217	13628	2692	4	1505	13628	12119
13600	13990	321	141	0	10346	12719	2553	0	141	12719	12578
13990	14100	9	3	0	1981	2690	715	0	3	2690	2687
14100	14990	1017	691	0	15475	20900	5751	0	691	20900	20209
14990	15400	5624	4259	922	4685	6377	3057	922	3337	6377	2118
15400	15990	848	349	0	11704	15382	4177	0	349	15382	15033
15990	16645	4532	3216	48	15085	19067	5298	48	3168	19067	15851
16645	16650	32	7	0	96	138	67	0	7	138	131
						Totals	119755	512810	141840	352495	-302155

Table C.3: Route Option 3 Earthworks Volumes

Chainage		Cut			Fill		Totals				
From	To	(a) Bulk (m^3)	(b) Subsoil + Topsoil (m^3)	(c) Rock Cut (m^3)	(d) Bulk (m^3)	(e) Bulk + Topsoil (m^3)	(a-b)+(e-d) Topsoil Strip (m^3)	(c) Rock Cut (m^3)	(c-b) Other Cut (m^3)	(e) Fill Subsoil + Topsoil (m^3)	(e)-(c+(b-c) Surplus (Cut -) (Fill +) (m^3)
0	350						0	0	0	0	0
350	570						0	0	0	0	0
570	1000	4075	3467	2614	13045	15463	3026	2614	853	15463	11996
1000	1150	1026	576	28	881	1463	1032	28	548	1463	887
1150	1700	7207	5699	929	16470	19939	4977	929	4770	19939	14240
1700	2000	86477	82957	62069	1356	1591	3755	62069	20888	1591	-81366
2000	2360	11682	10052	6933	549	1138	2219	6933	3119	1138	-8914
2360	3000	98590	91331	75856	4474	6236	9021	75856	15475	6236	-85095
3000	4000	19726	16750	4604	9484	13203	6695	4604	12146	13203	-3547
4000	5000	7517	5824	1212	29145	34732	7280	1212	4612	34732	28908
5000	5160	4035	3278	392	1338	1817	1236	392	2886	1817	-1461
5160	5410	1518	929	0	14906	17890	3573	0	929	17890	16961
5410	5480						0	0	0	0	0
5480	5690	443	221	0	10305	11870	1787	0	221	11870	11649
5690	6000	1395	709	5	1622	2868	1932	5	704	2868	2159
6000	6040	115	31	0	370	543	257	0	31	543	512
6040	6135	21	3	0	851	1400	567	0	3	1400	1397
							0	0	0	0	0
6135	6190						0	0	0	0	0
6190	6200						0	0	0	0	0
6200	6440	7017	6254	3556	889	1895	1769	3556	2698	1895	-4359
6440	6840	6013	4855	1374	3620	5318	2856	1374	3481	5318	463
6840	7000	285	177	6	3196	4138	1050	6	171	4138	3961
7000	7390	26640	24907	21097	34491	36260	3502	21097	3810	36260	11353
7390	7690	8929	8281	6931	25173	28037	3512	6931	1350	28037	19756
7690	7700						0	0	0	0	0
7700	8220						0	0	0	0	0
8220	8570	2767	1761	67	2457	4047	2596	67	1694	4047	2286
8570	8690	162	74	0	788	1422	722	0	74	1422	1348
8690	9300						0	0	0	0	0
9300	9370						0	0	0	0	0
9370	10000	58887	54371	58887	4902	7031	6645	58887	-4516	7031	-47340
10000	10100	17937	16499	17937	10	67	1495	17937	-1438	67	-16432
10100	10385	20872	19132	20872	3671	4761	2830	20872	-1740	4761	-14371
							0	0	0	0	0
10385	10600						0	0	0	0	0
10600	10620						0	0	0	0	0

Table C.3: Route Option 3 Earthworks Volumes (Cont)

Chainage		Cut			Fill		Totals				
From	To	(a) Bulk (m^3)	(b) Subsoil + Topsoil (m^3)	(c) Rock Cut (m^3)	(d) Bulk (m^3)	(e) Bulk + Topsoil (m^3)	(a-b)+(e-d) Topsoil Strip (m^3)	(c) Rock Cut (m^3)	(c-b) Other Cut (m^3)	(e) Fill Subsoil + Topsoil (m^3)	(e)-(c+(b-c) Surplus (Cut -) (Fill +) (m^3)
10620	10950	18537	16852	11566	1742	2378	2321	11566	5286	2378	-14474
10950	11000	2714	2437	1544	520	703	460	1544	893	703	-1734
11000	11100	48	26	0	3192	3820	650	0	26	3820	3794
11100	11300	3182	2479	554	607	1054	1150	554	1925	1054	-1425
11300	11450	684	479	67	2476	3227	956	67	412	3227	2748
11450	12000	278	35	0	3099	6031	3175	0	35	6031	5996
12000	12800	1232	617	2	11587	16172	5200	2	615	16172	15555
12800	13000	2278	1635	105	488	919	1074	105	1530	919	-716
13000	13300	1526	871	0	1696	2769	1728	0	871	2769	1898
13300	13700	4623	3980	247	6924	8875	2594	247	3733	8875	4895
13700	14000	16285	14691	145	1984	2666	2276	145	14546	2666	-12025
14000	14230	3243	2530	0	687	1343	1369	0	2530	1343	-1187
14230	15000	1092	695	0	9329	13480	4548	0	695	13480	12785
15000	15530	4474	3459	315	6707	9373	3681	315	3144	9373	5914
15530	16000	713	242	0	5213	7751	3009	0	242	7751	7509
16000	16770	3654	2606	25	21668	26974	6354	25	2581	26974	24368
16770	16790	17	4	0	276	422	159	0	4	422	418
						Totals	115038	299939	111837	331086	-80690

Table C.4: Route Option 4 Earthworks Volumes

Chainage		Cut			Fill		Totals				
From	To	(a) Bulk (m³)	(b) Subsoil + Topsoil (m³)	(c) Rock Cut (m³)	(d) Bulk (m³)	(e) Bulk + Topsoil (m³)	(a-b)+(e-d) Topsoil Strip (m³)	(c) Rock Cut (m³)	(c-b) Other Cut (m³)	(e) Fill Subsoil + Topsoil (m³)	(e)-(c+(b-c) Surplus (Cut -) (Fill +) (m³)
0	350						0	0	0	0	0
350	510						0	0	0	0	0
510	970	35095	32983	29694	10818	12454	3748	29694	3289	12454	-20529
970	1000	15	0	0	471	631	175	0	0	631	631
1000	1120	917	519	4	549	989	838	4	515	989	470
1120	1210	907	607	3	1384	2106	1022	3	604	2106	1499
1210	1685						0	0	0	0	0
1685	1910						0	0	0	0	0
1910	2000	776	524	0	2065	2402	589	0	524	2402	1878
2000	2380	5524	4668	3310	10780	12869	2945	3310	1358	12869	8201
2380	3000	229330	220596	200944	15290	16786	10230	200944	19652	16786	-203810
3000	4000	40868	38190	23887	58321	63244	7601	23887	14303	63244	25054
4000	5000	39955	36919	23992	35200	39367	7203	23992	12927	39367	2448
5000	5130	687	477	0	2994	3629	845	0	477	3629	3152
5130	5370	1039	557	0	20972	24151	3661	0	557	24151	23594
5370	5450						0	0	0	0	0
5450	5650	101	42	0	26821	28959	2197	0	42	28959	28917
5650	5990	1321	809	4	1781	3249	1980	4	805	3249	2440
5990	6000	9	0	0	57	105	57	0	0	105	105
6000	6090	5	0	0	680	1135	460	0	0	1135	1135
							0	0	0	0	0
6090	6140						0	0	0	0	0
6140	6150						0	0	0	0	0
6150	6380	9386	8477	5153	778	1730	1861	5153	3324	1730	-6747
6380	6700	2286	1755	219	6300	7776	2007	219	1536	7776	6021
6700	6800						0	0	0	0	0
6800	7200						0	0	0	0	0
7200	7300	45497	44279	41581	688	805	1335	41581	2698	805	-43474
7300	7650	21028	19989	17767	8760	9963	2242	17767	2222	9963	-10026
7650	7785						0	0	0	0	0
7785	7950						0	0	0	0	0
7950	8000	5415	5022	4188	1	18	410	4188	834	18	-5004
8000	8430	70244	66899	53087	1366	2464	4443	53087	13812	2464	-64435
8430	8810	12715	11612	6908	2381	3667	2389	6908	4704	3667	-7945
8810	9070						0	0	0	0	0
9070	9150	0	0	0	2132	2636	504	0	0	2636	2636
9150	9850	338144	330057	338144	13001	15243	10329	338144	-8087	15243	-314814

Table C.4: Route Option 4 Earthworks Volumes (Cont)

Chainage		Cut			Fill		Totals				
From	To	(a) Bulk (m^3)	(b) Subsoil + Topsoil (m^3)	(c) Rock Cut (m^3)	(d) Bulk (m^3)	(e) Bulk + Topsoil (m^3)	(a-b)+(e-d) Topsoil Strip (m^3)	(c) Rock Cut (m^3)	(c-b) Other Cut (m^3)	(e) Fill Subsoil + Topsoil (m^3)	(e)-(c+(b-c) Surplus (Cut -) (Fill +) (m^3)
9850	10000	26511	24742	26511	1484	1714	1999	26511	-1769	1714	-23028
10000	10140	5	0	0	680	1135	460	0	0	1135	1135
							0	0	0	0	0
10140	10350						0	0	0	0	0
10350	10360						0	0	0	0	0
10360	10710	22899	20966	14599	4454	5439	2918	14599	6367	5439	-15527
10710	10860	1109	936	470	3681	4572	1064	470	466	4572	3636
10860	11000	1522	1105	267	356	698	759	267	838	698	-407
11000	11050	1896	1571	397	0	6	331	397	1174	6	-1565
11050	11210	527	346	30	2969	3868	1080	30	316	3868	3522
11210	11760	409	74	0	2275	4980	3040	0	74	4980	4906
11760	12000	45	9	0	4096	5913	1853	0	9	5913	5904
12000	12560	1190	812	0	8840	12021	3559	0	812	12021	11209
12560	13000	2314	1419	0	3331	5373	2937	0	1419	5373	3954
13000	13050	196	97	0	94	253	258	0	97	253	156
13050	13450	5160	4288	244	6389	8148	2631	244	4044	8148	3860
13450	13960	594	136	0	5121	7669	3006	0	136	7669	7533
13960	14000	111	38	0	507	761	327	0	38	761	723
14000	14740	4753	3465	508	16651	23679	8316	508	2957	23679	20214
14000	15260						0	0	0	0	0
15260	16000	1928	1034	5	12457	17048	5485	5	1029	17048	16014
16000	16515	2032	1423	0	14327	17794	4076	0	1423	17794	16371
						Totals	113170	791916	95526	377449	-509993

Appendix D

Route Option Junctions and Accesses

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Table D.1: Route Option Junctions/Accesses

Ref.	Route Option 1 Approx. Chainage	Route Option 2 Approx. Chainage	Route Option 3 Approx. Chainage	Route Option 4 Approx. Chainage	Type	Direction (NB / SB)	Description
J001	0	0	0	0	Major Junction	NB & SB	A82 / A83 Junction
AC01	60	60	60	60	Business / Commercial	NB	Tarbet Hotel Car Park
AC02	65	65	65	65	Car Park	SB	Cruise Loch Lomond
AC03	175	175	175	175	Residential	NB	Still Braes
AC04	210	210	210	210	Residential	NB	Access to Bemersyde Road
AC05	210	210	210	210	School	SB	Arrochar Primary School
AC06	300	300	300	300	School	SB	Arrochar Primary School
AC07	310	310	310	310	Field	NB	Playing Field Access
AC08	330	330	330	330	Business / Commercial	SB	
AC09	330	330	330	330	Residential	NB	Old Military Road
AC10	365	365	365	365	Business / Commercial	SB	Cruise Loch Lomond Ltd Boatyard
AC11	395	395	395	395	Residential	NB	Loch Lomond View Country House B&B
AC12	395	395	395	395	Business / Commercial	SB	Disused Service Station
AC13	500	500	500	500	Residential	NB	Ben Cruach Lodge
AC14	530	530	530	530	Residential	NB	Clattochbeg Cottage
AC15	1140	1070	1140	1100	Business / Commercial	NB	Tarbet Isle Viewpoint
AC16	2090	1970	2030	2070	Business / Commercial	NB	Home on the Loch (Inverhoulin)
AC17	2150	2030	2120	2120	Residential	NB	Blairannaich
AC18	2150	2030	2120	2120	Business / Commercial	SB	Jetty
AC19	3800	3700	3760	3750	Business / Commercial	NB	Forestry Commission
AC20	5270	5170	5240	5200	Business / Commercial	SB	Loch Lomond Holiday Park
AC21	5570	5460	5510	5470	Business / Commercial	NB	Access to Loch Sloy
AC22	5650	5540	5600	5550	Business / Commercial	NB	Accessed to disused camp site
AC23	5660	5550	5610	5560	Residential	SB	Inveruglas Farm
AC24	5740	5630	5690	5640	Business / Commercial	SB	Farm Access (Inveruglas Farm)
AC25	5770	5660	5730	5670	Business / Commercial	NB	Farm Access
AC26	5770	5660	5730	5670	Field	SB	
AC27	6040	5930	5990	5940	Field	SB	
AC28	6070	5960	6020	5970	Field	NB	
AC29	6100	5980	6040	5990	Residential	NB	
AC30	6110	6000	6060	6010	Business / Commercial	NB	Loch Sloy Power Station

Table D.1: Route Option Junctions/Accesses (Cont)

Ref.	Route Option 1 Approx. Chainage	Route Option 2 Approx. Chainage	Route Option 3 Approx. Chainage	Route Option 4 Approx. Chainage	Type	Direction (NB / SB)	Description
AC31	6270	6150	6220	6160	Business / Commercial	NB	Loch Sloy Power Station
AC32	6360	6250	6310	6260	Business / Commercial	SB	Inveruglas Visitor Centre
AC33	6450	6340	6400	6350	Business / Commercial	SB	Inveruglas Visitor Centre
AC34	8700	8520	8630	8480	Field	NB	
AC35	8700	8520	8630	8480	Field	SB	
AC36	8770	8590	8700	8550	Business / Commercial	NB	Ardvorlich House B&B (Ardvorlich Farm)
AC37	8800	8630	8740	8590	Residential	NB	Ardvorlich Cottage
AC38	8810	8630	8740	8590	Field	SB	
AC39	10820	10630	10740	10470	Field	NB	
AC40	11630	11440	11540	11290	Field	NB	
AC41	11730	11540	11640	11390	Field	SB	
AC42	11730	11540	11640	11390	Field	NB	
AC43	11790	11600	11700	11450	Business / Commercial	NB	Stuckindroin
AC44	18030	11630	11740	11490	Field	SB	
AC45	11980	11790	11900	11650	Field	SB	
AC46	12000	11800	11910	11660	Field	NB	
AC47	12170	11970	12030	11830	Residential	NB	Burnside Cottage
AC48	12180	11980	12040	11840	Field	SB	
AC49	12420	12230	12330	12090	Field	NB	Sheep underpass below railway
AC50	12570	12390	12490	12250	Business / Commercial	SB	Ardlui Retreat
AC51	12650	12450	12550	12300	Business / Commercial	NB	Garristuck
RA	12790	12590	12700	12450	Rail	NB	Ardlui Rail Station
AC52	12840	12640	12740	12500	Residential	NB	
AC53	12930	12730	12840	12590	Field	SB	
AC54	12940	12740	12850	12600	Residential	NB	
AC55	13030	12830	12940	12690	Business / Commercial	SB	Ardlui Hotel
AC56	13090	12880	12980	12740	Business / Commercial	SB	Ardlui Marina Holiday Park
AC57	13100	12890	13000	12760	Business / Commercial	NB	
AC58	13170	12990	13090	12850	Field	NB	
AC59	13340	13140	13250	13000	Business / Commercial	SB	Loch Lomond Outdoor Centre
AC60	13940	13730	13830	13600	Business / Commercial	NB	Ardlui Church Self Catering
AC61	14460	14250	14390	14120	Field	NB	
AC62	14870	14670	14800	14530	Business / Commercial	SB	Sheep Pen/Fold
AC63	14990	14770	14910	14650	Field	SB	
AC64	14990	14770	14910	14650	Field	NB	

Table D.1: Route Option Junctions/Accesses (Cont)

Ref.	Route Option 1 Approx. Chainage	Route Option 2 Approx. Chainage	Route Option 3 Approx. Chainage	Route Option 4 Approx. Chainage	Type	Direction (NB / SB)	Description
AC65	15030	14820	14950	14680	Field	SB	
AC66	15740	15540	15670	15400	Residential	NB	Falls View Cottage
AC67	15740	15540	15670	15400	Field	SB	
AC68	15810	15600	15740	15470	Field	SB	
AC69	15850	15650	15770	15510	Business / Commercial	NB	Drovers Lodge Car Park
AC70	15900	15690	15820	15550	Business / Commercial	SB	Drovers Inn
AC71	15940	15730	15860	15590	Residential	NB	
AC72	15990	15790	15920	15650	Residential	NB	Rose Cottage B&B
AC73	16000	15800	15940	15660	Field	SB	
AC74	16270	16070	16200	15940	Business / Commercial	SB	Beinglas Camp Site
AC75	16630	16420	16550	16290	Residential	NB	The Bothy

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