

# URS

## A890 Stromeferry Bypass

Online Option  
Buildability Study  
Technical Note

August 2014

Prepared for:  
The Highland Council

UNITED  
KINGDOM &  
IRELAND



<b>REVISION SCHEDULE</b>					
<b>Rev</b>	<b>Date</b>	<b>Details</b>	<b>Prepared by</b>	<b>Reviewed by</b>	<b>Approved by</b>
0	August 2014	Draft for review (Sent to Scottish Civil Engineering Contractor )	Kenneth Chisholm Project Engineer	David Taylor Commission Project Manager	David Taylor Commission Project Manager
1	September 2014	Revised in line with Scottish Civil Engineering Contractor	Kenneth Chisholm Project Engineer	David Taylor Commission Project Manager	David Taylor Commission Project Manager

URS  
6 Ardross Street  
Inverness  
IV3 5NN  
United Kingdom

Telephone: +44(0)141 354 6050

**Limitations**

URS Infrastructure & Environment UK Limited (“URS”) has prepared this Report for the sole use of **The Highland Council** (“Client”) in accordance with the Agreement under which our services were performed (refer to Client brief and Contract dated 10<sup>th</sup> October 2012). No other warranty, expressed or implied, is made as to the professional advice included in this Report or any other services provided by URS. This Report is confidential and may not be disclosed by the Client nor relied upon by any other party without the prior and express written agreement of URS.

The conclusions and recommendations contained in this Report are based upon information provided by others and upon the assumption that all relevant information has been provided by those parties from whom it has been requested and that such information is accurate. Information obtained by URS has not been independently verified by URS, unless otherwise stated in the Report.

The methodology adopted and the sources of information used by URS in providing its services are outlined in this Report. The work described in this Report was undertaken between November 2012 and April 2013 and is based on the conditions encountered and the information available during the said period of time. The scope of this Report and the services are accordingly factually limited by these circumstances.

Where assessments of works or costs identified in this Report are made, such assessments are based upon the information available at the time and where appropriate are subject to further investigations or information which may become available.

URS disclaim any undertaking or obligation to advise any person of any change in any matter affecting the Report, which may come or be brought to URS’ attention after the date of the Report.

Certain statements made in the Report that are not historical facts may constitute estimates, projections or other forward-looking statements and even though they are based on reasonable assumptions as of the date of the Report, such forward-looking statements by their nature involve risks and uncertainties that could cause actual results to differ materially from the results predicted. URS specifically does not guarantee or warrant any estimate or projections contained in this Report.

**Copyright**

© This Report is the copyright of URS Infrastructure & Environment UK Limited. Any unauthorised reproduction or usage by any person other than the addressee is strictly prohibited.

## Contents

1.	Introduction .....	1
2.	RAILWAY VIADUCT (OPTION 02).....	1
2.1	Stage 1 - Construction of the bridge piers .....	2
2.2	Stage 2a & 2b – Casting and Installation of viaduct crossheads.....	2
2.3	Stage 3 - Construction of the abutments.....	3
2.4	Stage 4 - Installation of the half-through deck: .....	3
2.5	Stage 5 - Railway Diversion: .....	4
2.6	Stage 6 - Removal of existing railway and construction of roadway to DMRB specification .	4
2.7	Stage 7 - Upgrading the existing road surface to DMRB specification .....	4
2.8	Stage 8 - Full opening of roadway.....	5
2.9	Conclusion Option 02 .....	5
3.	TUNNEL (OPTION 03) .....	6
3.1	Stage 1 - Drilling, blasting and construction of the embankment at the Eastern entrance: ..	6
3.2	Stage 2 - Drilling, blasting, rock cutting and construction of the embankment at the Western entrance: .....	7
3.3	Stage 3 - Drilling, Blasting and excavation of the tunnel: .....	8
3.4	Stage 4 - Lining of the tunnel walls and construction of portals: .....	8
3.5	Stage 5 – Installation/Construction of the escape passage separation wall: .....	9
3.6	Stage 6 - Construction of the roadway surface through the tunnel:.....	9
3.7	Stage 7 - Installation of the mechanical, electrical and ventilation systems:.....	10
3.8	Stage 8 - Tie in works to existing road: .....	10
3.9	Stage 9 - Full opening of roadway:.....	11
3.10	Conclusion for Option 03.....	11
4.	DEVELOPED AVALANCHE SHELTER (OPTION 07).....	12
4.1	Stage 1 - Construction of the avalanche shelter piers on the shore side of the railway line: 12	
4.2	Stage 2 - Construction of the avalanche shelter piers on the land side of the railway line:	13
4.3	Stage 3 - Installation of the avalanche shelter main support beams: .....	13
4.4	Stage 4 - Installation of cross bracing: .....	13
4.5	Stage 5a – Casting of concrete deck sections: .....	14
4.6	Stage 5b – Installation of concrete deck sections:.....	14
4.7	Stage 6 - Construction of the access ramps to the avalanche shelter deck: .....	14
4.8	Stage 7 – Installation of Bridge furniture:.....	15

4.9	Stage 8 – surfacing of bridge deck: .....	15
4.10	Stage 9 - Full opening of roadway:.....	16
4.11	Stage 10 – Installation of rockfall barrier:.....	16
4.12	Conclusion Option O7 .....	16
5.	CONCLUSIONS.....	17
6.	APPENDIX A.....	18

# A890 Stromeferry Bypass Online Option Buildability Study Technical Note

---

## 1. Introduction

Developing the existing road corridor has undoubted benefits particularly with regard to procurement, landscape and the environment but introduces significant construction difficulties. These are discussed in outline in section 4.8 of the DMRB Stage 2 Report.

These comments are based on more detailed work that is presented here. Final recommendations of an on-line route must also take into account the many discussions with stakeholder groups undertaken during the scheme development, in particular Scheme Objective No. 8, *to keep the A890 and peripheral road network open during construction*.

Whilst estimates of the programme and closures have been made in this report, items are based on the level of detail available at Stage 2. The findings have been reviewed by a major Scottish Civil Engineering contractor familiar with this type of work. Should an on-line option be taken forward, further refinement to provide more robust information will be undertaken.

## 2. RAILWAY VIADUCT (OPTION 02)

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

However, more detailed consideration of this option, and discussions with Network Rail, have resulted in an amended proposal, where the railway line is moved onto a new viaduct alongside the loch over a length of 1.6km past the rock fall area to west of the Cuddies' Point. The road would be re-aligned on the existing railway corridor, leaving a wide enough separation to the unstable rock faces, which would be further made safe by additional rock fall measures and rock trap ditches. This amendment also omits the requirement for two cross-overs of railway and road, and is therefore considered the more feasible and less expensive alternative. Refer drawing number 47065084-2-5205

In order to establish the disruption that will be caused to vehicular traffic by the construction of the viaduct, we require to establish the probable build programme and check what the possible issues are with each stage.

The following stages are as follows:

1. Construction of the bridge piers;
2. 2a & 2b – Casting and Installation of viaduct crossheads;
3. Construction of the abutments;
4. Installation of the half-through deck;
5. Railway diversion;
6. Removal of existing railway and construction of roadway to DMRB specification;
7. Upgrading the existing road surface to DMRB specification;
8. Full opening of roadway

## 2.1 Stage 1 - Construction of the bridge piers

### *Works:*

Piers will need to be installed at set intervals of 40m based on the design of the deck sections of the viaduct. In order to install them they will need to be piled to bedrock. As there is a large quantity of scree on the slopes of the loch, the piles will need to be installed using steel casings designed to construct a 2m diameter pile. Constructed on top of the 2m pile will be a 1.5m diameter reinforced concrete column on which the deck will sit.

### *Road Closure:*

The construction of the piers will not require any road closure as all works will be carried out from barges.

### *Timescale:*

It is estimated that 3 piers can be installed per month (piling and casting) requiring a total time for installation of 11 months dependant on weather, to install all 33 piers.

## 2.2 Stage 2a & 2b – Casting and Installation of viaduct crossheads

### *Works:*

The viaduct deck will be precast and shipped into the site using barges. Time required for the delivery of the sections may be reduced if casting is carried out at the Kishorn fabrication yard located in Loch Kishorn on the North side of Loch Carron. The precast crosshead will be installed on the piers and connected up to the abutments. Once the viaduct deck crosshead has been completed and fully fixed in place, the steel half-through deck will be installed on top.

### *Road Closure:*

The installation of the crossheads will not require any road closures as all works will be carried out from barges.

**Timescale:**

Assuming that 10 crossheads can be cast and installed per month, it is estimated that it will take **4 months** dependant on weather, to install all 33 crossheads.

## 2.3 Stage 3 - Construction of the abutments

**Works:**

In order to connect the viaduct to the shore, 2No abutments need to be constructed. This will involve the installation of a total of 220m of reinforced concrete contiguous piles installed along the face and sides and backfilling with either crushed rock. As with the other works, this can be carried out from the loch using barges. Once the abutments are fully backfilled, there will be a requirement to install the parapets on the loch side of the abutments to protect against the possibility of material, equipment or personnel falling into the loch.

**Road Closure:**

The construction of the abutments will not require any road closure as all works will either be carried out from barges or will require only the railway line to be closed while the works are underway.

**Timescale:**

Assuming that 15 piles can be constructed per month, and that piles are 1m diameter, it is estimated that it will take **15 months** dependant on weather, to install all the piles. Once each set of piling is complete it will take approx. **2 months** to backfill the abutments and surcharge the backfill to ensure settlement stays within railway tolerances once work is completed. It will then require an addition **2 months** per end to construct the abutments. Assuming that two teams can do the work, one on each abutment, the total time for the works could potentially be halved. This will mean that the works will take an estimated **11 months** to complete.

## 2.4 Stage 4 - Installation of the half-through deck:

**Works:**

The half-through deck will be of steel construction that can be prefabricated into sections at the Kishorn fabrication yard. At this location, the sections can be fabricated while the pile and crossheads are being installed. It also means that it will be possible to construct, transport and install the 40m span sections as single units eliminating the requirement for temporary supports to be installed between the permanent piers. These sections will be lifted into position and bolted both in place and to the adjoining sections.

**Road Closure:**

The installation of the half through deck will not require any road closures as all works will be carried out from barges.

**Timescale:**

Assuming that 6 spans can be constructed and installed per month, works would take approx. **6 months** to install all 34 sections of the deck, dependant on weather conditions.



## 2.5 Stage 5 - Railway Diversion:

### *Works:*

Once the deck is installed, the existing railway line will require to be diverted onto it. As the new deck will already have the railway line installed on it, it will require joining the existing line to the new line. Once the railway is diverted, all the communication and signalling equipment and control cables will need to be rerouted through the viaduct. Access will be needed from the road onto the railway line with enough space to store material and unload equipment.

### *Road Closure:*

As there will be cranes operating to unload the tracks for trailers and install them, there may be the requirement for the road to be controlled with the use of traffic lights during the lifting operations. Although this section of the works may not require a full road closure, it will require the railway line to be closed for the duration.

### *Timescale:*

Works would be expected to take approx. **4 months** to complete.

## 2.6 Stage 6 - Removal of existing railway and construction of roadway to DMRB specification

### *Works:*

At this point the existing road will be limited in size to 3m and the verges removed. This will give maximum space for the railway to be dismantled, loaded onto trailers and removed from site and the new section of the road to be constructed. Works will be completed to DMRB specification ensuring that the road is of single carriageway standard. Works will need to be done in stages of 200m-300m in order to keep the road open.

### *Road Closure:*

This stage should not require the closure of the road. However, due to the nature of the work, there most likely will be traffic lights set up during the works.

### *Timescale:*

As the work is to be done in stages, it will be expected that each stage would take approximately **1 month** to clear the railway and construct the road. Assuming that the works will be done in 8 sections so as to minimise the length of road with traffic lights on it, the works will take approx. **8 months** to complete.

## 2.7 Stage 7 - Upgrading the existing road surface to DMRB specification

### *Works:*

At this point the existing road will be blocked off and traffic will be diverted onto the newly constructed road. This will give the contractor the area between the cliff face and the new road. Works will be completed to DMRB specification ensuring that the road is of single carriageway standard. Works will need to be done in stages of 200m-300m in order to keep

the road open. This will also entail the construction of a rock catch ditch to ensure that any rockfall does not land on the road.

***Road Closure:***

This stage will require road close at the connection between the old section of road and the new surface. This may require upwards of 1 month per end to be closed.

***Timescale:***

As the work is to be done in stages, it will be expected that each stage would take approximately 1 month to clear the railway and construct the road. Assuming that the works will be done in 8 sections so as to minimise the length of road with traffic lights on it, the works will take approx. 8 months to complete. However, it may be possible to run this stage of the works in tandem with stage 6 with 2 sets of lights running keeping 600m of road between each stage.

Road will be closed for a total of 2 months during this stage of the works.

## 2.8 Stage 8 - Full opening of roadway

***Works:***

Full opening of the carriageway will commence.

## 2.9 Conclusion Option 02

In summary, it can be seen that for all the works as a whole, the total time that the works will take and the max length of time that the road will be closed is as follows:

**TOTAL TIME REQUIRED TO COMPLETE WORKS: 24 Months.**

**TOTAL TIME FOR ROAD CLOSURES: 2 Months**

### 3. TUNNEL (OPTION 03)

A possible option for the rerouting of the road is to create a road tunnel for a length of approx. 1.5km that will be cut through the rock face as per drawing number 47065084-2-5209.

An indicative profile has been developed based on the Mott MacDonald assessment carried out previously. The assessment showed the ground conditions at the tunnel location are anticipated to primarily consist of gneiss and schist. The assessment anticipates that, although the majority of the alignment will be constructed in competent rock there will be significant areas of faulting and fractured rock mass. The tunnel cross section is based on the following criteria:

- 3.00m width per lane (2 lanes)
- 0.65m hard strips both sides
- Single 1.00m wide footway within vehicle compartment for emergency use
- 5.4m total headroom (see TD27/05)
- Lateral kinematic clearance 0.6m
- 3.00m wide pedestrian/ escape passage (assumed, subject to traffic requirement)

The tunnel will require to be constructed using the drill and blast method of excavation as tunnelling by Tunnel Boring Machine (TBM) will not be cost effective.

In order to establish the disruption that will be caused to vehicular traffic by the construction of the tunnel, we require to establish the probable build programme and check what the possible issues are with each stage.

The following stages are as follows:

1. Drilling, blasting and construction of the embankment of the Eastern entrance;
2. Drilling, blasting, rock cutting and construction of the embankment at the Western entrance;
3. Drilling, blasting and excavation of the tunnel;
4. Lining of the tunnel walls and construction of portals;
5. Installation of the escape passage separation wall;
6. Construction of the roadway surface through the tunnel;
7. Installation of the mechanical, electrical and ventilation systems;
8. Tie in works to existing road;
9. Full opening of roadway.

#### 3.1 Stage 1 - Drilling, blasting and construction of the embankment at the Eastern entrance:

##### *Works:*

Drilling and blasting will be carried out to on the Eastern access point. This will involve the blasting of the portal area of the tunnel and the removal of the spoil. Material blasted out

can be used as part of the makeup for the construction of the embankment for the road access to the tunnel. It is assumed that the excess material from blasting can be either disposed of locally or sold to a local quarry.

***Road Closure:***

Road closures would be required for the initial month as blasting operations would be taking place immediately adjacent to the road. Once the tunnelling is off the road the road can be re-opened with traffic lights/convoy systems and road restrictions in place to ensure that no vehicles will be within the blasting zone during blasting operations. The blasting zone would be the area in a 45° arc from the tunnel face. Time will be required to clear any material blasted onto the road prior to vehicles being allowed to pass through the blasting zone.

***Timescale:***

Industry standards for drill and blast excavations show that the distance tunnelled is 2m per day. Assuming that the entrance blasting area is 100m long, the time involved would be 50 days. Clean up and construction of the embankment will likely increase the time to complete this stage of the works. This stage of the works would take approx. 3 months to complete.

### **3.2 Stage 2 - Drilling, blasting, rock cutting and construction of the embankment at the Western entrance:**

***Works:***

Drilling and blasting will be carried out to create the entrance to the tunnel. This will involve the blasting of the portal area of the tunnel and the removal of the spoil. Material blasted out can be used as part of the makeup for the construction of the embankment for the road access to the tunnel. It is assumed that the excess material from blasting can be either disposed of locally or sold to a local quarry.

***Road Closure:***

Road closures would be required for the initial month as blasting operations would be taking place immediately adjacent to the road. Once the tunnelling is off the road the road can be re-opened with traffic lights/convoy systems and road restrictions in place to ensure that no vehicles will be within the blasting zone during blasting operations. The blasting zone would be the area in a 45° arc from the tunnel face. Time will be required to clear any material blasted onto the road prior to vehicles being allowed to pass through the blasting zone.

***Timescale:***

Works to be carried out concurrently with the Eastern entrance. As with the Eastern entrance blasting speeds as per industry standards is 2m per day. Assuming that distance to be blasted at the entrance is 150m it would be expected to take 75 days just for drilling and blasting. Rock cutting will require additional time in the region of 3 months. This gives an approximate duration of 6 months to complete this stage of the works.

### 3.3 Stage 3 - Drilling, Blasting and excavation of the tunnel:

#### *Works:*

Drilling and blasting will be carried out to create the tunnel itself. It is assumed that the Material blasted out will be disposed of locally or alternatively sold to a local quarry. During the works there will be a requirement to install temporary ventilation systems to ensure that air quality is kept to the required levels and dust is controlled while personnel are working.

#### *Road Closure:*

Road closures should not be required although there will be traffic lights/convoy systems and road restriction in place to ensure that no vehicles will be within the blasting zone during blasting operations. This should only apply for the first and last few hundred meters of the tunnel as works will be close to the road. Time will be required to clear any material blasted onto the road prior to vehicles being allowed to pass through the blasting zone.

#### *Timescale:*

Industry standards for drill and blast excavations show that the distance tunnelled is 2m per day. Assuming that the tunnel blasting area is 1300m long (tunnel length is approx. 1500m but 100m each end will be blasted during stages 1 & 2), the time involved would be 22 Months for tunnelling to take place from one end only. If tunnelling is done from both ends the time taken would be 11 Months. This is provided that the operation does not encounter areas of poor/faulted ground. This could potentially extend the completion period by many months.

### 3.4 Stage 4 - Lining of the tunnel walls and construction of portals:

#### *Works:*

Based on a drill and blast methodology, rock support would be installed as required as the tunnel advances, including rock bolts, sprayed concrete and steel mesh or fibre reinforcement depending on rock mass quality. Installation of a permanent structural lining would follow, including the installation of a suitable drainage layer behind the permanent lining. Permanent lining could take the form of either in-situ cast or sprayed concrete. This would require a specialist contractor to ensure that all works adhere to the relevant standards and work practices. The portals will be cast last of all so as not to impede the flow of equipment into and out of the tunnel. The portals will be designed to extend out from the rock to provide a modicum of protection to the tunnel entrance in the event of minor rock fall.

#### *Road Closure:*

This work would have no effect on the road other than vehicle and plant entering/exiting the existing road to the site.

**Timescale:**

It can be assumed that this stage of the works would be completed approx. **4 months** after the tunnelling is completed.

### 3.5 Stage 5 – Installation/Construction of the escape passage separation wall:

**Works:**

In order to create a safe escape passage should there be an accident/fire in the tunnel, a separate pedestrian escape passage will be to be constructed. This will involve the construction of a concrete dividing wall as shown on drawing number 47065084 – 2-5209. This wall will be floor to ceiling with self-closing doors located every 100 meters. Both the door frames and the concrete joints will need to be fully smoke and fire resistant by the use of materials such as 3M FireDam spray 200 or Fire Barrier Sealant FD150+ to ensure that personnel can escape the tunnel without succumbing to smoke inhalation. Doors will need to be fitted with a smoke barrier to reduce smoke ingress to the escape passage. The casting process would involve the construction of formwork of length 6m and casting this section. Assuming that one cast can be made per day on a hit one miss one casting schedule, it would require 250 casts to complete the 1.5km of the tunnel. If seven day working was carried out it would require 8 months of concreting works followed by 1 month to finish the fire sealant and install access points.

**Road Closure:**

No effect on road as being carried out within the tunnel. Works traffic will be able to enter and exit the tunnel as required.

**Timescale:**

It would be expected that this work would not be able to start until the tunnelling operation is complete as the plant traffic would cause problems with the formwork erection and casting process. If seven day working was carried out it would require 8 months of concreting works followed by 1 month to finish the fire sealant and install access points. This means that it would take approx. **9 months** to complete this stage of the work.

### 3.6 Stage 6 - Construction of the roadway surface through the tunnel:

**Works:**

Road construction will be as Follows:

3.00m width per lane (2 lanes)

0.65m hard strips both sides

Single 1.00m wide footway within vehicle compartment for emergency use

3.00m wide pedestrian/ escape passage (assumed, subject to traffic requirement).

This section of the works will be treated as normal road surfacing with the limiting exception of height involved. As the tunnel will only have maximum vehicle headroom of 5.4m, the use of tippers for the delivery of asphalt to the paver will be severely restricted. This may have an effect of the speed at which they can lay the material. The escape

passage will not require Asphalt surfacing. Contractor will only need to ensure that the final concrete surface is within specification for a walkway as per SHW.

***Road Closure:***

No effect on road as being carried out within the tunnel. Works traffic will be able to enter and exit the tunnel as required.

***Timescale:***

Due to the restrictive nature of the tunnel, it can be assumed that this stage of the works would be completed in approx. **3 months**. This stage of the works will need to be carried out after the construction of the separation wall is complete as this will give equipment the most room to operate within the tunnel.

### **3.7 Stage 7 - Installation of the mechanical, electrical and ventilation systems:**

***Works:***

This will be the installation of all the M&E and ventilation equipment required for the tunnel to be adequately lit and have the required through flow of breathable air.

***Road Closure:***

No effect on road as being carried out within the tunnel. Works traffic will be able to enter and exit the tunnel as required.

***Timescale:***

It can be assumed that this stage of the works would be completed in approx. **4 months**. This stage will be carried out after completion of the surfacing works to ensure that equipment has the maximum operating headroom available to work in.

### **3.8 Stage 8 - Tie in works to existing road:**

***Works:***

Once the works are completed within the tunnel itself, the road will require to be diverted into the tunnel. This will require the old road to be tied in to the new surfacing. This will involve the closure of the existing road to provide a safe working location for personnel and to give the equipment as much room to operate as possible in order to speed up the works.

***Road Closure:***

Road closures will be required along with the use of traffic lights/convoy systems and road restrictions during the latter part of this stage to ensure the safety of the workers and to provide space for the tie in of the new road to the existing.

***Timescale:***

The works would be expected to be completed within **3 months**.

### 3.9 Stage 9 - Full opening of roadway:

*Works:*

Full opening of the carriageway will commence.

### 3.10 Conclusion for Option O3

In summary, it can be seen that for all the works as a whole, the total time that the works will take and the max length of time that the road will be closed is as follows:

**TOTAL TIME REQUIRED TO COMPLETE WORKS: 28 Months.**

**TOTAL TIME FOR ROAD CLOSURES: 5 Months**



#### 4. DEVELOPED AVALANCHE SHELTER (OPTION 07)

This alternative would re-locate the road on a viaduct above the railway, leaving sufficient width for a rock catch ditch on the line of the existing road. The benefits of this type of solution over an extended avalanche shelter are considered to be:

- less encroachment into the rockface;
- less remediation measures essential to stabilise rockface;
- open aspect;

In order to establish the disruption that will be caused to vehicular traffic by the construction of the shelter, we require to establish the probable build programme and check what the possible issues are with each stage.

The following stages are as follows:

1. Construction of the avalanche shelter piers on the shore side of the railway line;
2. Construction of the avalanche shelter piers on the land side of the railway line;
3. Installation of the avalanche shelter main support beams;
4. Installation of cross bracing;
5. 5a – Casting and 5b – Installation of deck sections;
6. Construction of the access ramps to the avalanche shelter deck;
7. Installation of bridge furniture;
8. Surfacing of deck;
9. Full opening of roadway;
10. Installation of the rockfall barrier

##### 4.1 Stage 1 - Construction of the avalanche shelter piers on the shore side of the railway line:

###### *Works:*

This section of the works will take time to complete. Due to the close proximity of the avalanche shelter piers to the railway track and the track support zone, work will need to be carried out during times that there is no rail traffic using the line. Piers will need to be piled to a suitable rock surface and anchored in place. It is assumed that piers will be at 50m centres so there will be a requirement to install 30 piers. The piers will need to be fixed into the existing rock which will require excavation and breaking out until a suitable depth is reached.

###### *Road Closure:*

This work will not require any road closures as all work will be from the railway line. There may be traffic signals in place to facilitate access to the site for the piers and equipment.

###### *Timescale:*

Assuming that the contractor can install 10 piers per month it will require **3 months** to complete this stage of the works.

## 4.2 Stage 2 - Construction of the avalanche shelter piers on the land side of the railway line:

### *Works:*

This section of the works will take time to complete. Due to the close proximity of the avalanche shelter piers to the railway track and the track support zone, work will need to be carried out during times that there is no rail traffic using the line. Piers will need to be piled to a suitable rock surface and anchored in place. It is assumed that piers will be at 50m centres so there will be a requirement to install 30 piers. The piers will need to be fixed into the existing rock which will require excavation and breaking out until a suitable depth is reached.

### *Road Closure:*

This work will require a full closure of the road and railway for the duration of this stage.

### *Timescale:*

Assuming that the contractor can install 10 piers per month it will require **3 months** to complete this stage of the works.

## 4.3 Stage 3 - Installation of the avalanche shelter main support beams:

### *Works:*

This stage will involve the installation of the main support beams onto the piers. Sections 3, 4 and 5 will need to be carried out as a larger single operation as the crane will need room to manoeuvre its load which cannot be done if all the main support beams and/or cross bracing are installed first. The procedure will be as follows:

1. Lift both main support beams into place;
2. Lift in cross bracing;
3. Lift in precast deck sections.

This will give the most operating room and continuous progress.

The main support beams will require to be welded together on site once all parts are delivered to site. The crane will then lift them into place and install the cross bracing. Once complete, the precast sections will be delivered to site and installed. Once the deck sections are in place the crane will then move to the next section and repeat the process.

### *Road Closure:*

This work will require the road to remain closed.

### *Timescale:*

This work will take approx. **4 months** to complete assuming that the deck sections can be cast and cured quickly enough to stay ahead of the installation programme.

## 4.4 Stage 4 - Installation of cross bracing:

### *Works:*

Installation of the cross bracing for the main support beams. Process will be as stated above.

**Road Closure:**

This work will require the road to remain closed.

**Timescale:**

This work will take approx. 4 months to complete assuming that the deck sections can be cast and cured quickly enough to stay ahead of the installation programme.

#### 4.5 Stage 5a – Casting of concrete deck sections:

**Works:**

The most time and cost effective method of constructing the deck itself is to precast it in 4m long sections. The deck will be precast at the Kishorn fabrication yard and transported by barge to the Stromeferry pier or Cuddies point and off loaded onto trucks or onto train cars for transportation to the construction site. Care should be taken when casting the deck sections for the access ramp connections as they will require to be curved. They will also need to be supplied to the site in the correct order.

**Road Closure:**

This will not cause road closures. Delivery to site can either be by road along the railway line to the site as the railway will not be operating during the works.

**Timescale:**

Casting could start while the piers are being installed and would continue for approx. 9 months.

#### 4.6 Stage 5b – Installation of concrete deck sections:

**Works:**

Installation of precast sections will be carried out as stated in Stage 3

**Road Closure:**

This work will require the road to remain closed.

**Timescale:**

This work will take approx. 4 months to complete assuming that the deck sections can be cast and cured quickly enough to stay ahead of the installation programme.

#### 4.7 Stage 6 - Construction of the access ramps to the avalanche shelter deck:

**Works:**

The access ramps will join the existing road level to the elevated deck of the avalanche shelter. These works will require the construction of concrete pier walls backfilled with structural fill and then asphalted over. The backfill will require surcharging to ensure settlement is within tolerance once the surface is in place.

Once the ramps are completed, the remaining main support beams, cross bracing and deck sections can be installed to join the ramps to the bridge deck.

This stage of the work will need to be constructed joining the existing road to the elevated road level so there is no other way of constructing the works other than to close the road. It should be noted that this section of the works cannot be started until the bridge deck is completed as there will be no access for equipment and materials once this starts.

***Road Closure:***

This work will require full road closure for the duration of the work and rail closure for the duration of the works being carried out over the top of the line.

***Timescale:***

Per End:

Walls to be cast:	2 weeks
Backfilling:	1 week
Surcharging:	5 weeks
Installation of deck:	2 weeks
Surfacing:	2 weeks

This work will take approx. 3 months per end to complete. This means that the total time to complete this stage of the works will be 6 months

**4.8 Stage 7 – Installation of Bridge furniture:**

***Works:***

Works will involve the installation of all bridge furniture such as parapets and emergency call boxes along the full length of the deck. It would be expected that gulleys and drainage channels would be installed during the precasting works

***Road Closure:***

This work will be done during the latter stages of stage 6 as one access should be open to allow access to the bridge deck.

***Timescale:***

This work will take approx. 3 months to complete assuming that the contractor has access to the site from one side only.

**4.9 Stage 8 – surfacing of bridge deck:**

***Works:***

Works will involve the surfacing of the bridge deck in asphalt to DMRB Specification. This will include the surfacing of both the carriageway and the pedestrian walkways located outside of the carriageway running surface.

***Road Closure:***

The road will require to remain closed for the duration of the works.

*Timescale:*

This work will take approx. **2 months** to complete.

#### 4.10 Stage 9 - Full opening of roadway:

*Works:*

Full opening of the carriageway will commence.

#### 4.11 Stage 10 – Installation of rockfall barrier:

*Works:*

Works will involve the installation of a rockfall barrier system mounted on the cliff face itself. This will require the anchoring of a baseplate into the rock to ensure no possibility of pull-out from loading and the installation of the barrier. The barrier will be mounted on the baseplate and the outermost point of the barrier will be supported by wire hawsers anchored into the rock face above. It should be noted that this particular stage could be carried out at any point during the project during any necessary road closures.

*Road Closure:*

As the road will be running on the Developed Avalanche shelter by this point there will be no impact on the road.

*Timescale:*

This work will take approx. **6 months** to complete due to the nature of the works. However, it should be pointed out that there is no critical timescale that this should be completed by.

*Works:*

Full opening of the carriageway will commence.

#### 4.12 Conclusion Option 07

In summary, it can be seen that for all the works as a whole, the total time that the works will take and the max length of time that the road will be closed is as follows:

**TOTAL TIME REQUIRED TO COMPLETE WORKS: 24 Months.**

**TOTAL TIME FOR ROAD CLOSURES: 15 Months**

## 5. CONCLUSIONS

Having looked at the available options and studied the manner of construction, the works have been summarised in table 1 below:

Item	Option	Time to complete	Road Closure	Railway Closure
1	O2 – Railway Viaduct	24 Months	<b>2 Months</b>	<b>4 Months</b>
2	O3 – Tunnel	28 Months	<b>5 Months</b>	<b>0 Months</b>
3	O7 – Developed Avalanche Shelter	24 Months	<b>15 Months</b>	<b>12 Months</b>

TABLE 1: Options summary

It can be seen that the best option to minimise road closures would be Option O2 – Railway Viaduct. It can be delivered within the two year programme and has the least road closure time period.

The 2 months of road closures would depend on the variables such as weather, available time to work from barges, railway possession, material supply, etc. These factors would need to be considered going forward for all three of the options.

It is worth noting that although the Viaduct may not be the best of the options with regard to rail closures, early consultation with Network Rail suggests they would shut the railway and bus the passengers during the closures provided the closures were kept to the smallest timescale possible. If the works were carried out during the winter months, the rail users would be at their lowest so the disruption to the users would be minimised.

As far as timescales go, almost all the works can be carried out within the two year programme. The exception to this is the tunnel. The reason for this is the speed at which drilling and blasting can be undertaken. The industry standard is 2m per day dependant on the type of rock and other geological factors. It has been estimated that, based on the industry standards, it would take 28 months to complete working from both ends simultaneously. This could potentially be reduced if the conditions were favourable for blasting, but it could equally extend if the conditions were considered difficult. This could only be confirmed by further in depth study and borehole testing.

Both the Tunnel and the Viaduct allow for off road/rail working which reduced possession/handback and road closure requirements quite significantly.

With regards to Option O7 – Developed Avalanche Shelter, this would have to be considered as the least favoured option of the three as it requires extensive closures of both the road and railway line while works are ongoing, requiring 15 months of road closures and a full year of railway closures, which Network Rail suggested would not be acceptable.

**6. APPENDIX A**

## Works Programmes

RAILWAY VIADUCT (OPTION 2)

			GUIDE PROGRAMME OF WORKS																																											ROAD CLOSURE	RAILWAY CLOSURE					
STAGE	DESCRIPTION	TIMESCALE (MONTHS)	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	TIMESCALE (MONTHS)	TIMESCALE (MONTHS)					
1	Construction of the bridge piers.	8	a	a	a	a	a	a	a	a																																					0	0				
2a	construction of precast crosshead.	4							a	a	a	a																																					0	0		
2b	Installation of the viaduct crossheads.	4									a	a	a	a																																				0	0	
3	Construction of the abutments; Piling, Backfilling and Surcharging.	10	a	a	a	a	a	a	a	a	a	a																																						0	0	
4	Installation of the half-through deck.	6							a	a	a	a	a	a																																				0	0	
5	Diversion of Railway.	4													b	b	a	a																																0	4	
6	Removal of existing railway and construction of roadway to DMRB specification.	8														b	b	b	b	b	b	b	b																											0	0	
7	Upgrading the existing road surface to DMRB specification.	8																	c	b	b	b	b	b	b	b	c																							2	0	
8	Full opening of roadway.																																																		0	0

2 4  
Items in **RED** are Critical Path Closures

Classification	
<b>a</b>	No road closure required
<b>b</b>	Traffic Lights in place
<b>c</b>	Road Closure



TUNNEL (OPTION 03)

STAGE	DESCRIPTION	TIMESCALE (MONTHS)	GUIDE PROGRAMME OF WORKS																																											ROAD CLOSURE TIMESCALE (MONTHS)	RAILWAY CLOSURE TIMESCALE (MONTHS)													
			1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43															
1	Drilling, blasting and construction of the embankment of the Eastern entrance;	3	c	b	b																																											1	0											
2	Drilling, blasting, rock cutting and construction of the embankment at the Western entrance;	6	c	b	b	b	b	b																																											1	0								
3	Drilling, blasting and excavation of the tunnel;	11				b	b	a	a	a	a	a	a	a	a	a	a	a	a	a	a	a	a	a	a	a	a	a	a	a	a	a	a	a	a	a	a	a	a	a	a	a	a	a	a	a	a	a	a	a	0	0								
4	Lining of the tunnel walls and construction of portals;	15				a	a	a	a	a	a	a	a	a	a	a	a	a	a	a	a	a	a	a	a	a	a	a	a	a	a	a	a	a	a	a	a	a	a	a	a	a	a	a	a	a	a	a	a	a	a	a	0	0						
5	Installation of the escape passage separation wall;	9													a	a	a	a	a	a	a	a	a	a	a	a	a	a	a	a	a	a	a	a	a	a	a	a	a	a	a	a	a	a	a	a	a	a	a	a	a	a	a	0	0					
6	Construction of the roadway and escape passage surface through the tunnel;	3																																																					0	0				
7	Installation of the mechanical, electrical and ventilation systems;	4																																																					0	0				
8	Tie in works to existing road;	2																																																						3	0			
9	Full opening of roadway.																																																										0	0

Classification	
a	No road closure required
b	Traffic Lights in place
c	Road Closure

5 0  
Items in RED are Critical Path Closures

Developed Avalanche Shelter (OPTION 7)

STAGE	DESCRIPTION	TIMESCALE (MONTHS)	GUIDE PROGRAMME OF WORKS																																											ROAD CLOSURE TIMESCALE (MONTHS)	RAILWAY CLOSURE TIMESCALE (MONTHS)						
			1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43								
1	Construction of the avalanche shelter piers on the shore side of the railway line;	3	a	a	a																																											0	3				
2	Construction of the avalanche shelter piers on the land side of the railway line;	3				c	c	c																																									3	3			
3	Installation of the avalanche shelter main support beams	4							c	c	c	c																																						4	4		
4	Installation of cross bracing	4							c	c	c	c																																						4	4		
5a	Casting of deck sections at Kishorn	9	a	a	a	a	a	a	a	a	a																																							0	0		
5b	Installation of precast deck sections	4							c	c	c	c																																							4	4	
6	Construction of the access ramps to the avalanche shelter deck;	6										c	c	c	c	c	c																																		6	2	
7	Installation of bridge furniture;	3										c	c	c																																				4	0		
8	Surfacing of deck;	2													c	c																																		2	0		
9	Full opening of roadway																																																	0	0		
10	Installation of the Rockfall Barrier	6																a	a	a	a	a	a																													0	0

Classification	
a	No road closure required
b	Traffic Lights in place
c	Road Closure

15 12  
Items in RED are Critical Path Closures