ANNEX H

HIGH LEVEL BRIDGE OPTION

ZETTRANS

BRESSAY LINK

HIGH LEVEL FIXED BRIDGE OPTION

April 2008

Halcrow Group Limited

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BRESSAY LINK

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Contents Amendment Record

This report has been issued and amended as follows:

Issue	Revision	Description	Date	Approved by
1	1	First Amendment	21/04	IPS

Contents

1 Introduction

The STAG 1 Report identified that a high level fixed bridge would be taken forward to detailed appraisal in STAG Part 2.

In the STAG 1 report the high level fixed bridge was taken as having an airdraft above Mean High Water Springs (MHWS) of at least 40 metres and a clear width between supports of at least 200 metres. The bridge crossing location was taken to be from Point of Scatland to Heogan on Bressay.

In appraising this option in Part 2, consultation has been undertaken with Shetland Islands Council's Roads Service and Planning Service together with Lerwick Port Authority. A site visit was also undertaken on 11th March 2008. A high level fixed bridge option has then developed on the basis of the information gathered from this consultation exercise and the site visit and is described in the following sections together with the construction methods, cost estimate and programme.

2 Design Parameters

2.1 Highway Design

The design parameters for a road bridge in the United Kingdom are generally defined in the appropriate standards contained in the Design Manual for Roads and Bridges (DMRB) although the design speed for a local road is defined by the roads authority.

For a fixed bridge link, Shetland Islands Council, as local roads authority, has confirmed that the design speed shall be 80 kilometres per hour (50mph) and that the maximum gradients shall be 8 percent although the actual the actual traffic speed would be restricted to 70 kilometres per hour (40 mph).

Shetland Islands Council also confirmed that the bridge would carry a 6.5 metre wide two lane carriageway with a 2 metre combined footway/cycleway on one side and a 0.6 metre wide verge on the other.

The bridge must also be provided with wind shielding to ensure that it can remain open to vehicular traffic in all but the most extreme wind events. Parapets complying with the requirements of TD19/06 would also be provided on the deck edges.

2.2 Navigation Clearance

During consultations in March 2008, Lerwick Port Authority advised on a range of vessels presently being planned or commissioned which could potentially visit the harbour and which have a significant air draft (see also Appendix 7.1).

These would include:

- Jumbo Javelin and Jumbo Fairpartner: heavy lift vessels constructed at the Damen Shipyards in Romania with an airdraft on 46.4 metres.

- PLSV – Seven Oceans: pipeline laying vessel with an airdraft of 47.8 metres.

Other vessels highlighted with unspecified air drafts would include heavy lift vessels for Seaway Heavy Lift, a diving support/ offshore vessel for Toisa Limited and a well intervention/ diving support vessel for Helix Energy Solutions all of which are being constructed at the Merwede Shipyard in the Netherlands.

Lerwick Port Authority also advised that as the current trend was for vessels to get higher, to future proof the harbour, a fixed bridge would require to have an airdraft of 60 metres above Mean High Water Springs.

Lerwick Port Authority also advised that a fixed bridge would be required to have a clear width of 260 metres between supports.

For a high level fixed bridge, the parameters have therefore been taken as an airdraft of 60 metres over a 260 metre wide navigation channel.

As the piers on either side of the navigation channel are in relatively shallow water; 2 to 3 metres, the size of an errant vessel which could collide with the piers would be limited by the draft but the piers would in any event be protected by caissons which would be designed for an appropriate level of ship impact. In addition, where the bridge crosses over existing roads, a minimum headroom clearance of 5.7 metres would be provided.

3 Bridge Option

3.1 Alignment

As noted in the introduction, a crossing location at Point of Scatland was considered for the high level fixed bridge in the part 1 STAG Appraisal. The Point of Scatland location has a number of advantages over the other possible bridge crossing locations at Greenhead and North Ness. One of the main advantages is that a bridge crossing at Point of Scatland would have less of an impact on vessel movements in and out of the harbour. Land has also been reserved for a fixed link at Point of Scatland above Lower Gremista Road. However the shoreline along the Lerwick side of Bressay Sound at Point of Scatland has been extensively developed. Lerwick Port Authority also advised during consultations that they are planning to extend the quays at Greenhead further south up to the land presently occupied by Shetland Transport.

Taking a bridge alignment to the north of the Shetland Transport warehouse would therefore result in at least one bridge pier in the Sound which could directly interfere with navigation in and out of these new quays. The alignment of the bridge option has therefore been taken as passing between the Shetland Transport Warehouse and the extended LFT Factory, as shown on Drawing Number H1.

To provide an airdraft of 60 metres over a 260 metre wide navigation channel, extensive approach ramps would be required on both sides of the Sound to meet the existing landform and tie into the existing road network. On the Lerwick side of the Sound, after passing over Lower Gremista Road, the elevated approaches would swing north westward to run past the Council offices and depot. The approaches would then continue on a short section of embankment before tying into a new roundabout. The roundabout would provide for a change in direction and a further section of link road would provide for a Tee junction connection to the existing two lane road leading to Rova Head and Dales Voe.

On the Bressay side of the Sound, the line would pass some 50 metres south of Annfield before swinging southwards to tie into the existing single track road at Heogan.

Maximum 8 percent gradients would be provided on both approaches with a crest curve with a minimum radius of 3000 metres over the main bridge and sag curves with a minimum radius of 2000 metres at either end of the link to tie into the existing road network on Bressay and the new roundabout and link road on the Lerwick side.

As the new approach road at Heogan would meet the existing road at a higher level the existing road would be re-aligned to the east for a short section and the access roads into the Shetland Fish Products factory would be extended to tie into the new road.

As the bridge approaches on the Lerwick side swing to the North to avoid the Council offices and depot, there are no bridge piers or embankments built on top of the existing road linking the Upper and Lower Gremista Roads hence this road could be retained.

3.2 Bridge Form

As noted in the foregoing, Lerwick Port Authority has requested that the minimum clear span should be 260 metres. Although the main pier foundations would be located in relatively shallow water they would have to be sufficiently robust to withstand ship impact loading. Consequently the pier cofferdams have been taken as 20 metres wide and the span length between centres of supports has therefore been taken as 280 metres.

For a span of this length, possible bridge forms would include a box girder bridge and a cable stayed structure. Arch bridges would provide a further alternative but they would be more difficult to construct.

A number of box girder bridges with span lengths in excess of 250 metres have been designed and constructed in recent years including the Skye Bridge which has a mainspan of 250 metres. However a major disadvantage of box girders is that for these span lengths the box girder deck has to be relatively deep, in the order of 10 to 12 metres at the piers, and so the road level has to be raised to maintain the airdraft clearance. Box girder bridges are also less efficient structurally and so require more materials in their design and construction.

A span of 280 metres is comfortably within the range of cable stayed bridges. Erskine Bridge spanning the River Clyde to the west of Glasgow has a main span length of 305m and cable stayed bridges with spans in excess of 1000 metres are presently being constructed in China.

There are also a number of precedents for bridges of this type with a relatively narrow deck in relation to the span length. Examples would include the Helgeland Bridge in Norway.

The advantages of cable stayed bridges over a box girder option are that as the cables provide support to the deck, the deck can be relatively thin; thereby reducing quantities of material required, enhancing the appearance and reducing the level of the deck while providing the required navigation clearance. The disadvantage of cable stayed bridges is that by provided the support to the deck above deck level in the form of the cables and towers the visual impact of the structure is much greater and accessing and maintaining these elements is more difficult.

3.3 Bridge Structure

A cable stayed option has therefore been considered for the main bridge.

The structure proposed effectively comprises three bridges, an approach structure on the Lerwick side of the Sound with 10 spans of 295 metres and one span of 26.5 metres giving an overall length of 321.5 metres, an approach structure on the Bressay side with identical spans and overall length, and the main bridge structure with a main span of 280 metres and back spans on each side of 117 metres giving an overall length of 514 metres. The overall length of the bridge structure is therefore 1157 metres.

3.4 Approach Bridges

The deck of each approach structure could comprise 4 precast prestressed concrete u beams and a reinforced concrete deck slab. The prestressed beams would be precast in span lengths and made continuous at each pier by a reinforced concrete diaphragm cast insitu after the beams have been placed.

The beams would be straight between piers but the deck slab would accommodate the curved alignment where required. The deck slab would be protected by a waterproofing membrane and finished with surfacing. Parapets and wind shielding would be provided on the deck edges. The deck would be supported on reinforced concrete piers and reinforced concrete foundations. Twin piers would be provided at each support with each pier comprising a concrete box section.

The Lerwick approach structure crosses over both the Lower Gremista and Upper Gremista Roads. Two piers would also be located in the site occupied by Lerwick Fish Traders; and pier number 11 is located where an LPG store is presently being constructed. This store would have to be relocated to accommodate the pier. Above Lower Gremista Road the bridge structure would cross over land which is presently utilised for rough grazing although the Port Entry Light may have to be re-located. The approach structure on the Bressay side crosses over open fields.

3.5 Main Bridge

The deck of the main bridge would comprise longitudinal concrete edge beams and transverse beams and an insitu concrete slab. The edge beams would be prestressed longitudinally and they would have an aerofoil shaped outer face to ensure dynamic stability.

The bridge deck would be supported by cables emanating in a fan configuration from the towers. The longitudinal spacing of cables on the deck would be approximately 11.25m. The cables could comprise parallel wire strands enclosed within a HDPE sheath to provide protection.

These sheaths could have an external spiral ribbing to prevent vortex excitation of the cables. Alternatively the cables could be cross tied to each other.

The cables would be connected to anchorages in the deck and the tower and the bridge would be designed with one cable removed for maintenance or due to accidental severance.

The main towers would each comprise two piers extending to approximately 120 metres above MHWS and which would be connected by cross beams at deck level and at two locations above deck level. Each pier would comprise a post tensioned concrete box section and each would contain a lift and stair access system to provide access to deck level and to the cable anchorages at the top of the tower.

The towers would be supported on a reinforced concrete foundation bearing on bedrock. The concrete foundation would be contained within a cofferdam which would provide protection to the piers from ship impact.

Aircraft warning lights would be provided on the top of the tower and navigation lights and daymarks would be provided on the bridge deck and cofferdams. Low level lighting would be provided on the bridge deck for pedestrians.

Services could be carried on the bridge in the fill material below the footpath but as the depth of this fill material is only 250 millimetres, the maximum size of services carried would be limited to 150 millimetre diameter ducts.

As the deck is relatively narrow an aerofoil profile would be required to ensure stability, however the impact of the wind shielding on the aerodynamic stability would have to be tested.

Given the height of the towers, lifts would be required inside the tower sections to access the cable anchorages at the top of the towers for inspection and maintenance. Roped access techniques would be required to inspect the external faces of the towers and the cables.

3.6 Construction Methods

Given the climatic conditions at the site and the availability of materials and labour required for the construction of a bridge of this scale, it is envisaged that bridge components would be prefabricated on the mainland and shipped to site for erection during the summer. Notwithstanding this point there would still be a significant amount of construction work required at 60 metres above ground level and for the towers at up to 120 metres above ground level.

It is envisaged that the main piers would be constructed by driving causeways out from the shore on each side of the Sound. The piers are about 50 metres from the shore and in relatively shallow water, 2-3m deep so the volume of material required and the impact on the hydrology of the Sound should not be significant. The pier foundations would be constructed in the dry within the causeways by excavating down to sound bedrock and then preparing a level surface for casting the concrete base.

The piers themselves would be constructed up to deck level by erecting precast concrete box sections one on top of the other using a crawler crane, and then stressing the boxes together. Above deck level the pylons would be constructed by erecting precast concrete shell units using a self climbing crane and casting concrete infill within the shell units.

The deck of the main bridge would be erected by progressively cantilevering out from the main piers using full width precast sections of deck. Sections of deck over land would be erected using crawler cranes. Sections of deck over water would be erected by a deck mounted gantry lifting the sections from a barge.

As the deck cantilevers progressed out from the piers, cables would be installed and stressed to provide support.

For the approach spans, the foundations would be constructed by excavating down to bedrock and casting a reinforced concrete foundation.

Erection of the piers would be as described for the main piers.

The prestressed beams for the deck would also be erected using a crawler crane but the concrete deck slab would be cast insitu on permanent formwork and the diaphragm at each pier would also be cast insitu.

3.7 Programme

As outlined in the foregoing section on construction methods the philosophy for construction of the bridge structure would be to maximise off site pre-fabrication such that the site works can generally be undertaken in spring and summer but that pre-fabrication can proceed throughout the year in environmentally controlled conditions. On this basis construction of the bridge would require three summer seasons; so the overall duration of construction would be approximately 30 months.

In the first summer, the pier bases to all the approach spans would be constructed and the causeways would be installed out to the main piers and these bases would also be constructed. Erection of the approach pier stems would also progress through the first summer. Pre-fabrication of bridge components would commence in the first summer and progress throughout the first two years of the construction period.

In the second summer period, the approach piers would be completed and the prestressed beams erected and the insitu deck slab and pier diaphragms cast on all the approach spans. The main pier towers would also be erected to their full height.

In the third summer, the deck of the main cable stayed bridge would be erected and all the roadworks and finishes completed.

3.8 Construction Cost

Capital and operation costs for a high level fixed bridge are set out below.

Construction costs are inclusive of connections to the existing road network on Lerwick and Bressay and separately include for improvements to the existing road network on Bressay. Construction costs also include for prelims and risk and are based on March 2008 prices.

The principal construction risks relate to downtime due to adverse weather conditions, together with the availability of labour and materials. All of these risks can be mitigated by maximising the prefabrication of bridge components on the mainland but this in itself can lead to further programme risks if components are damaged in transit. Notwithstanding this approach there would still be a significant requirement for labour and materials on site.

The cost of surveys and investigations, land acquisition, accommodation works and professional fees are also included.

Land acquisition costs are an estimate and would be subject to negotiation with the affected landowner or compulsory purchase. Accommodation works costs are also an estimated value and include for disruption to businesses, principally Lerwick Fish Traders and the relocation of the LPG store.

Professional fees include for design, checking, construction supervision and all the work necessary to secure consents including preparation and publication of an Environmental Statement. Cost estimates are therefore set out as follows:-

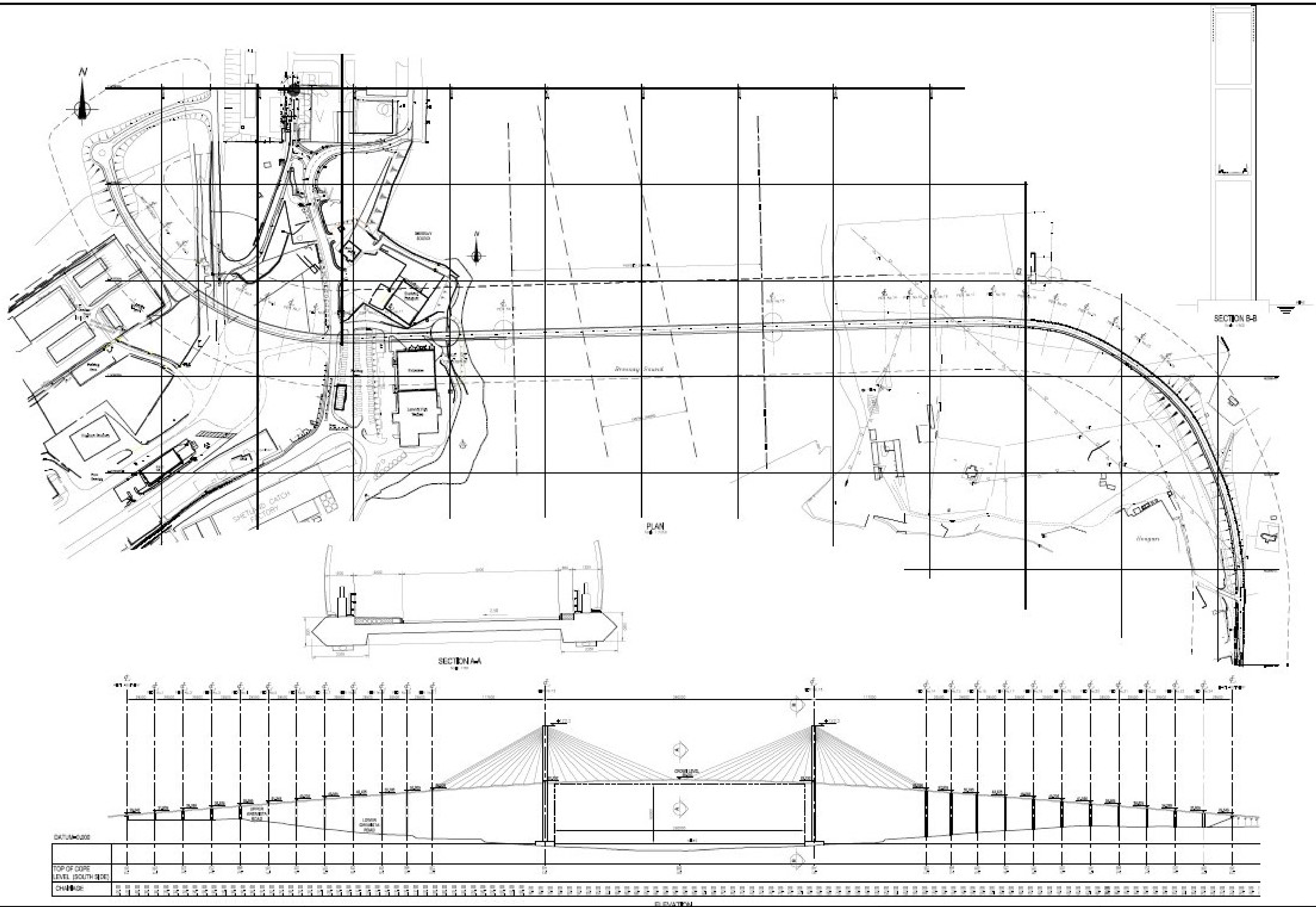
Item	Cost Estimate (£)
Professional Fees	2,200,000
Investigations and Surveys	150,000
Land Acquisition	350,000
Accommodation Works	500,000
Construction Costs	48,000,000
Heogan Road Improvements	200,000
Bressay Bus Turning Circles	50,000
Bressay Bus Stops	30,000
Sub Total	**£51,480,000**

3.9 Operating Costs

Transport Scotland own and maintain similar structures to the bridge option considered in the foregoing section. This would include Kessock Bridge near Inverness which has an overall length of 1050 metres and a cable stayed main span of 240 metres and Erskine Bridge spanning the River Clyde in Glasgow which has a main span of 305 metres and an overall length of 1321 metres. These compare with the high level fixed bridge considered above which has a main span of 280 metres and an overall length of 1157 metres. It should also be noted that both of these structures carry dual carriageways.

Transport Scotland confirmed that the approximate annual cost of maintaining Kessock Bridge is £100,000 per annum, whereas the cost of maintaining Erskine Bridge is £200,000 per annum. It should be noted that these costs exclude major expenditure such as repainting steelwork or replacing joints and bearings.

For a high level fixed bridge to Bressay, the estimate of operational costs has therefore been taken as £100,000. This figure includes for the annualised cost of replacing components such as joints and bearings.



Key	Bressay Link STAG 2 Report	DRAWN BY: Halcrow	CHECKED BY: IS	DATE: 05.08
Not to scale	Figure H1: High Level Bridge Option			

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