Shetland Islands Council

Shetland Islands Fixed Links

Yell/Unst Tunnel Crossing - Final Report
January 2001

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Yell/Unst Tunnel Crossing - Final Report

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Executive Summary

Halcrow have been commissioned by the Shetland Islands Council to investigate the feasibility of providing a sub-sea road tunnel between the islands of Yell and Unst in the Northern Shetlands. For this study the preliminary design of the tunnelled crossing has been prepared in accordance with the Norwegian Design Guide for Road Tunnels. Due to the presence of hard rock tunnelling conditions and low traffic volumes the Norwegian philosophy towards the planning, design and construction of sub-sea road tunnels is to provide a tunnel with little or no secondary lining and limited equipment.

The proposed tunnel alignment lies between the Head of Gutcher on Yell and Hoga Ness on Unst and will cross the Bluemull Sound. The proposed alignment is approximately 2.5km long. The vertical alignment of the tunnel is fixed by the requirement to provide 50m of rock cover to the tunnel crown where the alignment lies under the Bluemull Sound. The maximum vertical gradient is 8%.

No site-specific geological information was available for the study. The geology along the proposed alignment is based on information obtained from "solid" geological maps and selected geological memoirs and texts.

Tunnel safety equipment in the tunnel will be located in niches in the tunnel walls every 100m. Every niche will be provided with an emergency telephone and a fire extinguisher.

Forced ventilation is not required during normal operation of the tunnel as the traffic volumes are very low. However roof mounted axial flow jet fans will be provided to remove smoke in the event of an emergency. The tunnel will be lit with low pressure sodium luminaires mounted in the tunnel crown at 25m centres.

The tunnel will be drained via a pump sump located at the tunnel low point.

Two tunnel cross-sections have been investigated:

- Norwegian cross-section T8 in accordance with the Norwegian Design Guide for Road Tunnels; and

- UK cross-section in accordance with BD78/99 Design of Road Tunnels.

The UK cross-section was included to provide a tunnel that would offer the geometry prescribed by Highways Agency standards whilst maintaining both the advantages of tunnelling in hard rock and a limited equipment provision commensurate with the low traffic volumes.

The cost of the tunnelling works is directly related to the quality of the rock encountered during construction. The geological conditions along the tunnel alignment have been estimated and any difference between the predicted conditions and those actually encountered has been allowed for by a 25% addition to the contractor's estimates.

The estimates received suggest an out-turn cost for a T8 cross-section tunnel of £18,600,000.00 and an out-turn cost for a cross-section to BD78/99 of £20,000,000.00.

1 Introduction

1.1 *General*

Halcrow has been commissioned by the Shetland Islands Council to prepare an outline design, specification and quantities and obtain cost estimates for construction from experienced tunnelling contractors for a sub-sea road tunnel between the islands of Yell and Unst in the Northern Shetlands. For this study the preliminary design of the tunnelled crossing was to be prepared in accordance with the Norwegian Design Guide for Road Tunnels.

Due to the presence of hard rock tunnelling conditions and low traffic volumes the Norwegian philosophy towards the planning, design and construction of sub-sea road tunnels is to provide a tunnel with little or no secondary lining and limited equipment. This study was therefore prepared by adopting a "Norwegian" approach; using the experience available to the tunnelling industry following construction of numerous sub-sea road tunnels in Norway and neighbouring Scandinavian countries.

Both UK and Scandinavian contractors were approached with respect to obtaining cost estimates for the proposed tunnel crossing.

2 Geotechnical Setting

2.1 *General*

The proposed tunnel alignment lies between the Head of Gutcher on Yell and Hoga Ness on Unst and will cross the Bluemull Sound. The following section describes the anticipated geology along the proposed alignment. It should be noted that no site-specific geological information is available. Some borehole records have been provided but the borehole locations are over 2km north of the proposed alignment. The following discussion on geology describes information obtained from "solid" geological maps and selected geological memoirs and texts (see references).

2.2 *Head of Gutcher - Yell*

The ground conditions at the Head of Gutcher are shown on the geological maps to comprise peat over undifferentiated drift over gneiss. Boreholes carried out in the Bluemull Sound by Fugro, suggest that the undifferentiated drift may comprise stiff clay with sand and gravel pockets/laminations; possibly Glacial Till. The gneiss is a quartz, feldspathic and hornblende rich banded strong, slightly to moderately weathered metamorphic rock.

2.3 *Bluemull Sound*

Boreholes have been carried out by Holequest Ltd., which extended part way across the Bluemull Sound approximately 2km north of the proposed alignment. These show that the ground conditions at the west side of the Bluemull Sound comprise loose becoming medium dense sand over the strong slightly weathered gneiss. The gneiss is encountered beneath the sand at depths of between -9mOD and -18.5mOD, the greatest depths being furthest from the shoreline.

The newest geological map indicates that a fault passes north south through the centre of the Bluemull Sound.

No information is available about the ground conditions in the Bluemull Sound to the east of the fault line.

2.4 *Seismic Survey*

As part of this commission, a geophysical and hydrographic survey along the subsea section of the tunnel was undertaken by Caledonian Geotech. This survey

comprised one traverse on the line of the proposed tunnel together with two further traverses on each side and offset by 25m. The survey utilised acoustic and sonar techniques to establish the nature and depth of the granular deposits on the sea bed together with the bedrock profile but did not determine the nature and integrity of these rocks other than on a conjectural basis. The seismoc survey report is included as Appendix E to this report.

2.5 *Hoga Ness - Unst*

The ground conditions at Hoga Ness are indicated on the maps to comprise Drift deposits over boulder clay (glacial till deposits) over gneiss to the south of Hoga Ness and mica schist to the north. The gneiss at this location dips towards the south east and the mica schist dips towards the north. Mica schist is also a metamorphic rock and can be expected to be less obviously banded or striped than the gneiss and will probably retain more cleavage (thinner bedding and more platy).

2.6 *Geological Units*

The following section describes the individual rock types expected along the route.

2.6.1 *Gneiss*

Gneiss has a banded texture, foliation, in which light and dark bands alternate; the light bands are composed essentially of feldspar and quartz, the dark bands or streaks of one or more mafic minerals such as biotite, hornblende or in some cases pyroxene. A gneiss breaks less readily than a schist, and commonly splits across the foliation instead of along it; it is often coarser in texture than many schists, though some gneisses are relatively fine-grained. [1] pg213-214

Gneiss can be categorised as a very strong rock with a typical compressive strength of $>100\ MN/m^2$. [2] pg 212

2.6.2 *Schist*

These are crystalline rocks of schistose texture and are moderately coarse-grained. Schist is formed from sedimentary or igneous material by the operation of moderately high temperatures and pressures. Schists are largely composed of flaky minerals such as micas, chlorite, talc, or of prismatic, minerals such as amphiboles, which have the predominantly parallel arrangement called schistosity; the flakes or foliae into which the rock breaks all have a similar mineral composition and their surfaces are lustrous. [1] pg211.

Decomposed mica-schists may be a source of weakness and fail easily by shearing along the foliae. [1] pg 213

Schists can be categorised as moderately strong rocks with compressive strengths of 12.5 - 100 MN/m^2. [2] pg 212

2.7 *Tunnel Alignment*

The proposed alignment is approximately 2.5km long between portals. Two tunnel cross-sections are being considered as described in the drawings. The Yell portal is located east of the Head of Gutcher at the end of a proposed rock cutting. From the portal the alignment falls at 8% to the tunnel low point under Bluemull Sound. The tunnel drainage sump is to be located at the low point of the tunnel. The tunnel alignment climbs towards Hoga Ness on Unst at a gradient of 8% with the Unst portal again located at the end of a proposed rock cutting.

2.8 *Conditions Along the Alignment*

It is proposed that the permanent tunnel support consists of steel fibre reinforced shotcrete and "double" protected rock bolts and it should be noted that exposed rock will be visible inside the tunnel. Limiting the amount of secondary lining will reduce the cost of the tunnel and the need for a secondary lining will depend upon the rock mass quality and the amount of water ingress. Neither of these can be clearly defined at this stage. However the rock conditions along the tunnel alignment have been predicted to provide a "benchmark" on which the cost estimates from each contractor can be compared. It is not suggested that the conditions described in this document or on the drawings exactly reflect the actual conditions that may be encountered along the alignment.

Provision has been made in the outline bill of quantities for a mass concrete lining through the fault zones.

The rock grades have been described in terms of the Rock Quality Index Q and in the absence of site specific data the following assumptions have been made:

- Rock near the ground surface is assumed to be "very poor" due to possible weathering.

- Rock conditions associated with the fault zones are assumed to be "extremely poor".

- Weathered zones and fault zones have been assumed to be associated with adjacent areas of "fair" rock.

- Elsewhere the rock quality has been assumed to be "good".

The vertical alignment of the tunnel is fixed by the requirement to provide 50m of rock cover to the tunnel crown where the alignment lies under the Bluemull Sound.

3 Tunnel Specification

3.1 *General*

This section describes the tunnel including the safety equipment provision, tunnel geometry and tunnel alignment.

3.2 *Traffic Volumes*

The predicted traffic volume for the tunnel has been based on the current ferry traffic, which is reported to be an average of 53,000 vehicles per year. For the tunnel design this is equivalent to an annual average daily traffic flow (AADT) of 150. For preliminary design an AADT of 300 has been adopted. At such low traffic volumes an increase from 150 to 300 has no effect on the tunnel design or equipment provision.

3.3 *Tunnel Geometry*

There are two options for the tunnel cross-section:

- Norwegian cross-section T8 providing a maintained headroom of 4.6m and a carriageway width of 6.0m.

- BD 78/99 Cross-section providing a maintained headroom of 5.3m over a width of 7.2m with a carriageway width of 6.0m (Clause 3.4 TD 27/96 Cross Sections and Headrooms).

Both these cross-sections have been costed and outline bills of quantities have been prepared accordingly.

The vertical and horizontal alignment has been defined in accordance with TD 9/93 Highway Link Design for a design speed of 85kph.

The maximum gradient is 8% and the Stopping Sight Distance (SSD) is 160m.

In the absence of a climbing lane it is proposed that lay-by niches be provided every 250m along the 8% gradient sections of the alignment.

3.4 *Safety Facilities*

It is proposed that the "Normal Provision" for safety equipment be provided in accordance with BD78/99 Design of Road Tunnels. Where provided the clause numbers refer to clauses in BD 78/99.

3.4.1 *Structural Features*

The following section describes the structural features that will be incorporated in the tunnel.

(a) Emergency Points

The Emergency Points will be located in niches in the tunnel walls and will be large enough to house an emergency telephone and fire fighting facilities. The normal spacing shall be 100m. The facilities provided shall include a fire extinguisher and an emergency telephone.

(b) Emergency Walkways

A paved walkway will be installed on each side of the carriageway to provide unobstructed pedestrian access to the emergency points.

(c) Drainage Sumps

The road drainage system in the tunnel will discharge into a drainage sump located at the tunnel low point. The sump shall be split into two cells, one cell shall be for normal drainage water and one cell shall be for storage of petrochemicals in the event of a spill. The minimum volume of the petrochemical sump shall be $30m^3$, which is approximately the volume of a large petrol tanker. The normal sump shall be $100m^3$ and shall incorporate a floating weir to facilitate separation of oil, diesel or petrol. The atmosphere in the sump shall be monitored for the presence of hydrocarbons.

3.5 *Emergency Facilities*

The following section describes the facilities that are to be provided in the tunnel. Table 3.1 details the "Normal Provision" for road tunnels in accordance with BD78/99. With an AADT of 300 and a length of 2.4km this tunnel is Category B in accordance with the Norwegian Design Guide for Road Tunnels.

3.5.1 *Monitoring Systems*

Monitoring systems shall be provided as follows:

(i) Carbon monoxide infrared absorption monitors (three locations with stand-by).

(ii) Hydrocarbon monitoring at the low point sump.

3.5.2 *Ventilation*

With the low traffic volumes predicted there is no need for ventilation to dilute the concentrations of carbon monoxide and nitric oxide. However it is proposed that ceiling mounted reversible axial flow fans be provided for smoke extract in the event of a fire in the tunnel.

3.5.3 *Tunnel Lighting*

Norwegian practice is to provide low pressure sodium (SOX) lighting with 35W lamps at 25m intervals along the tunnel. Closing the lamp spacing to 10m increases the lighting intensity at the tunnel threshold zones. For a design speed of 80kph the threshold zone is 70m long with Transition zones I and II at 100m respectively.

Tunnel lighting to BD 78/99 is designed in accordance with BS 5489 Part 7 Code of Practice for the Lighting of Tunnels and Underpasses. Low pressure sodium lighting has been used in the UK for road tunnels and it is proposed to follow the Norwegian practice here.

Table 3.1 - Safety and Fire Prevention Equipment		Provided
Communications and Alarm Equipment	Emergency Telephones	☑
	Radio Rebroadcasting	☒
	Traffic Loops	☒
	CCTV	☒
Fire Extinguishing Equipment	Hand held extinguishers	☑
	Pressurised fire hydrants	☑
	Fire hose reels	☒
Signs and rescue Equipment	Emergency exit signs	☑
	Lane control and closure signs	☑
Other provisions	Emergency stopping lane	☑
	Emergency walkway	☑
	Escape doors	☒
	Turning bays	☒
	Ventilation for smoke control	☑

4 Cost Estimates

4.1 ***Provision of estimates***

Six tunnelling contractors were approached and asked to provide a cost estimate for the tunnel and associated works. The contractors were:

- Balfour Beatty
- Amec
- Nuttall
- Veidekke
- NCC
- Skanska

It was assumed that the Scandinavian contractors would be more competitive as they have the plant and the in-house expertise for this type of tunnelling. The intention was to provide a balance between estimates received from contractors in the UK and Scandinavia. Inclusion of the UK contractors was also intended to establish estimates of costs for complying with tax, health, safety welfare and quality assurance regulations pertaining to construction projects undertaken in the UK. However Balfour Beatty and Nuttall declined to provide an estimate stating that they did not think that they could be competitive against the Scandinavian contractors.

4.2 ***Bill of Quantities***

Each contractor was sent two Bills of Quantities to price. One related to the "Norwegian" cross-section and the other to the "British Standard" cross-section in accordance with BD78/99. For each cross-section the ancillary works were the same and the principal difference between the two bills was the amount of excavation and support.

To enable a valid comparison between estimates the quantities were based on an assumed geological profile for the tunnel alignment. This avoided the need for the contractors to make assumptions about ground conditions and ensured that all the estimates were based on the same assumptions.

The two Bills of Quantities are included in Appendix B.

The following section will describe the estimates received from the contractors.

4.2.1 *Veidekke*

The cost estimate submitted by Viedekke was as follows:

	NOK	£
T8 Cross-section	118,681,900.00	8,923,692.06
BD78/99 Cross-section	131,991,050.00	9,924,407.05

Veidekke did not provide an estimate for the mechanical and electrical items and made the following comments in their covering letter:

"... ... ... General issues

- *The estimate is given in NOK (Norwegian Kroner)*
- *Taxes and duties are not included.*
- *The cost estimate shall be considered as not binding.*
- *The offer is based on Norwegian prices and cost level.*
- *The offer is based on Norwegian practice and methods, and is according to Norwegian law as far as working regulations and environmental legislation.*
- *It is foreseen that the majority of the equipment will be brought in from Norway.*
- *Based on experience, we expect the price estimate should be within +/- 15%*

Technical issues

- *The estimate is priced according to the described items in the bill of quantity. The item no´s in the estimate correspond to the same in the BoQ.*
- *We have included an item no 0 under civil. This covers general cost including mob/demob of facilities, site and administration.*
- *Electric and mechanical equipment is not included in the cost estimate, i.e. the estimate only covers civil works*
- *Items that are not listed in the BoQ are not included in the cost estimate, for example items like:*
  - *Tunnel portals*
  - *Civil works for pump sump*
  - *Fixtures/bolts for el-mech installations... ... ..."*

4.2.2 *Skanska*

The cost estimate submitted by Skanska was as follows:

	NOK	£
T8 Cross-section	123,906,150.00	9,316,503.42
BD78/99 Cross-section	132,889,750.00	9,991,980.30

Skanska provided estimates for all the works included in the Bills of Quantities and made the following comments in relation to the costs provided:

"... ... ... Please find our rough estimate for the Shetland tunnels, the costs are based on Nordic conditions and price levels and could vary in UK.
We have added the following to your Bills

- *Probe drilling includes also drilling for grouting. Quantity in Bill revised to be = 40000m*
- *Mobilisation item added to Bill*
- *Extra cost for not quantified items for spiling bolts*
- *Extra cost for water-shielding of tunnel, in Norway required for 20 to 90 % of the tunnel length depending on the rock, pre-grouting and requirements*
- *Extra cost for excavation of pump storage at bottom of tunnel, normally a storage volume of one to some days of water ingress is required*
- *Extra cost for portal works*
- *Extra cost for unforeseen or other items... ... ..."*

4.2.3 *Amec*

The cost estimate submitted by Amec was as follows:

	NOK	£
T8 Cross-section		18,461,629.00
BD78/99 Cross-section		18,800,935.00

Amec provided estimates on the basis of UK costs and approached Halcrow during preparation of their estimates for contact details of local suppliers to improve their estimate of local rates. In this regard it should be noted that they were the only contractor to obtain local rates. Amec made the following comments in their submission:

"... ... . We include an indicative programme for the works which is based on a single face operation. The program could be significantly shortened by working from both ends simultaneously but at the expense of greater resource and cost.

In the short time available we have based our assessment of the works on the provision of materials and resources from the UK. Clearly in reality economies could be made by a more global approach when time permits.

It is not practical at this stage to consider the scale of ground risk on such limited site information but it is unlikely that any contractor would take such a risk at less than 10% of the contract sum. The likelihood of such an acceptance will depend greatly on the extent and quality of the ground investigation.

Our assessment includes a contingency allowance of 7.5% of the works as described , to cover details of the construction that would only emerge during detailed design... ... ..."

4.2.4 *NCC*

The cost estimate submitted by NCC was as follows:

	NOK	£
T8 Cross-section	108,586,429.00	8,164,613.60
BD78/99 Cross-section	120,029,505.00	9,025,018.48

NCC provided cost estimates for both Bills of Quantities but only provided a preliminary estimate for the mechanical and electrical items. NCC made the following comments when submitting their tender:

"... ... The cost estimate is to understand as a budget cost.

We do not know the cost level at the Shetland Islands in detail, for this reason the estimation is based on our cost level established at the Faroe Islands.

There has not been time to study/look for alternative solutions. However we foresee considerable savings if the whole design could be changed to a description more like what the Road Authorities in Norway use.

Mechanical and electrical works are normal not part of our scope of work and the prices are stipulated.

We recommend you raise the price with about 5% for missing details in the described design.

The price is given in Norwegian Kroner (NOK)... ... ... "

4.3 ***Summary of Cost Estimates***

It was considered necessary to revise adjust the estimates received form contractors to allow for uncertainties relating to ground conditions and additional items not included in the original Bills of Quantities. Also some adjustment was considered necessary in order to respond to comments that contractors had submitted with their estimates.

For each estimate the basic civil works estimate was increased as follows:

- The original estimate was increased by 25% to allow for Ground Risk. This may increase or decrease depending on further site investigation but a percentage will always remain if the contractor is to carry ground risk.

- The original estimate for civil works has been increased by further 8% to allow for longer tunnel in light of seismic survey findings.

- The civil works estimates from non UK contractors increased by 5% to allow for UK H&S legislation, EU working time directive etc.

The estimate of the M&E works has been taken as that supplied by AMEC - this has been added to or replaces the figure in the other contractor's estimates. Scandinavian Contractors don't normally price for M&E works.

Additional items have been allowed for as follows:

- The approach cuttings to take road to the existing road level valued at £750,000.

- Additional site investigation valued at £300,000.

- Design and preparation of the tender documents including tender assessment, valued at +3.5% of the contract value.

- Site supervision, valued at £550,000.
- General items/contingency valued at +10% of the contract value.
- Exchange rate risk for non-UK estimates, valued at +5% of the works value to allow for the difference between the long term Kroner exchange rate and that used in this study.

All the estimates include for mobilisation/accommodation/demobilisation and it is also assumed that disposal sites fall within boundary of site and excavated spoil is not subject to landfill tax. The additional item "General items/contingency" includes for accommodation works, public utilities diversions and connections, land acquisition, environmental mitigation. It should also be noted that at the present time, the hard rock tunnelling market is relatively flat and hence the prices submitted are likely to be competitive. There is also likely to be an element of inducement within the contractors pricing policy to encourage the council to proceed with the scheme.

Any effect of UK tax legislation on Norwegian contractors working in the UK has not been included.

The following table summarises the revised cost estimates.

Contractor	T8 Cross-section	BD78/99 Cross-section
Viedekke	19,472,349.47	21,104,370.85
Skanska	18,885,145.87	19,985,318.11
Amec	23,134,438.00	24,550,697.10
NCC	17,156,306.22	18,558,883.98
Mean Estimate	**19,662,205.89**	**21,049,817.51**

The detailed breakdown of the individual revised estimates is included in Appendix D.

5 Conclusion and Recommendations

5.1 *Conclusions*

As described earlier in this report two tunnel cross-sections have been investigated:

- Norwegian cross-section T8 in accordance with the Norwegian Design Guide for Road Tunnels; and
- UK cross-section in accordance with BD78/99 Design of Road Tunnels.

The UK cross-section was included to provide a tunnel that would offer the geometry prescribed by Highways Agency standards whilst maintaining both the advantages of tunnelling in hard rock and a limited equipment provision commensurate with the low traffic volumes.

The cost of the tunnelling works is directly related to the quality of the rock encountered during construction. The geological conditions along the tunnel alignment have been estimated and any difference between the predicted conditions and those actually encountered has been allowed for by a 25% addition to the contractor's estimates.

The safety provision allowed for in the estimates includes equipment which is commensurate with the predicted traffic flow including tunnel lighting, emergency telephones, fire extinguishers and roof mounted jet fans for emergency smoke extract. The philosophy adopted reflects a provision that meets the anticipated risk in purely statistical terms whilst preserving a low maintenance requirement. Social perceptions of the risks, particularly associated with fire may well require further study.

In Table 4.1 below the "best estimate" reflects the mean of the estimates received but excluding the estimate from Amec. Amec's estimate is considered high as they, unlike the Scandinavian contractors, have had to build plant costs into all their rates.

The range of estimates is as follows:

Table 4.1 – Summary of Revised Estimates

	T8 Cross-section	BD78/99 Cross-section
Maximum	23,134,438.00	24,550,697.10
Minimum	17,156,306.22	18,558,883.98
Mean	19,662,205.89	21,049,817.51
Best Estimate	**18,504,600.52**	**19,882,857.65**

In summary the estimates received suggest an out-turn cost for a T8 cross-section tunnel of £18,600,000.00 and an out-turn cost for a cross-section to BD78/99 of £20,000,000.00.

5.2 ***Recommendations***

Given the limited difference in price, it is recommended that the larger tunnel cross-section is adopted for any future development of the crossing between Yell and Unst. The BD78/99 cross-section has headroom clearances that conform to the standards in force elsewhere on the national road network.. It seems appropriate that these standards should be applied here as vehicles from the mainland will frequently use this road crossing and may well require the greater headroom provided elsewhere on the network.

As discussed above 25% of the estimated out-turn cost is related to "ground risk" due to the uncertainty about the rock mass quality at tunnel depth. If this project is to be considered further, it is recommended that the next stage should comprise a seismic refraction survey of the proposed alignment together with land based boreholes particularly on the Unst side of the crossing to determine the rock mass quality at tunnel depth. This will enable the rock support requirements to be defined with a greater degree of confidence and therefore provide a more realistic out-turn cost for the crossing.

6 References

[1] A Geology for Engineers. F.G.H. Blyth and M.H. de Freitas. 1974, Edward Arnold (Publishers) Limited.

[2] Geology for Civil Engineers. A.C. McLean and C.D. Gribble. 1979, George Allen and Unwin.

[3] Handbook of Geology in Civil Engineering. Robert F. Legget and Paul F. Karrow. 1983, McGraw-Hill inc.

[4] Cullivoe Pier Development Ground Investigation and Wave Study Information report (Fugro No 94509-1), 1999.

[5] Marine Site Investigation Cullivoe, Yell, Shetland. Holequest Report No. LC/C/Y/0787. (1987).

Note, the boreholes from these reports give some indication of strata depth but are located 2km north of the alignment and extend about 200m into the Bluemull Sound from a more westerly starting point.

[6] British Geological Survey map, Scotland Series 130, Yell, Solid and Drift, 1994.

[7] Ordnance Survey of Great Britain, Geological Survey of Great Britain (Scotland), Parts of Sheet 129, 130 and 131. 1:63360, 1968. Solid and drift editions.

[8] British Standard: BS 5489 Part 7 Code of Practice for the Lighting of Tunnels and Underpasses

[9] Highways Agency Bridges Directive: BD78/99 Design of Road Tunnels

[10] Highways Agency Traffic Directive: TD 9/93 Highway Link Design

[11] Highways Agency Traffic Directive: TD 27/96 Cross Sections and Headrooms

[12] Norwegian Design Guide – Road Tunnels, The Directorate for Public Roads, December 1990

Appendix A
Drawings

Appendix B
Original Bills of Quantities

Bill of Quantities
Norwegian Cross-Section

Preamble

1. Excavation items to include for excavation by ripping or drill and blast.

2. Excavation items to include for scaling and where necessary for trimming to the required profile.

3. Excavation items shall include for disposal of excavated material off site to a disposal site no further than 3miles from each portal.

4. Excavation volumes do not allow for bulking.

5. Allowance shall be made for control of seepage water into the tunnel during construction.

6. Excavation quantities include an allowance for shotcrete support where applicable.

7. Probe drilling is assumed to include for two inclined holes ahead of the face, drilling as part of the tunnelling cycle such that 10m of proven ground lies ahead of the tunnel at all times.

8. Grouting is measured in tonnes of cement but shall include for drilling grout holes, mixing and pumping grout.

Page Total Carried to Summary	

Item No.	Description	Unit	Quantity	Rate	Amount
	Approach Cuttings – Excavation and Support				
1.	Cutting excavation in fair rock associated Q 1 - 4	m^3	11,825		
2.	Installation at the tunnel portal of fully grouted, double protection rockbolts, CT bolts or similar approved, length not exceeding 3m, any inclination.	no	80		
3.	Steel fibre reinforced shotcrete (30kg/m^3) - 50 thick	m^2	512		
	Approach Cuttings - Ancillary Works				
4.	Road drainage pipe, concrete, 250 ND	m	2,400		
5.	Drainage gullies (25m c/c)	no	96		
6.	Concrete kerb	m	2,400		
	Approach Cuttings - Road Construction				
7.	40mm Hot rolled asphalt wearing course	m^2	11,400		
8.	290mm Dense bitumen macadam 50 roadbase	m^2	11,400		
9.	150mm Type 1 sub base	m^2	11,400		
	Tunnel – Excavation and Support				
10.	Excavation in extremely poor rock at thrusts and faults Q 0.01 - 0.1	m^3	15,510		
	Page Total Carried to Summary				

Item No.	Description	Unit	Quantity	Rate	Amount
11.	Excavation in very poor rock associated with weathered zones at portals Q 0.1 - 1.0	m^3	5,120		
12.	Excavation in fair associated with faults and thrusts Q 4 – 10	m^3	29,880		
13.	Excavation in good rock Q 10 - 40	m^3	73,650		
14.	Installation of fully grouted, double protection rockbolts, CT bolts or similar approved, length not exceeding 3m, any inclination.	no	12,812		
15.	Steel fibre reinforced shotcrete (30kg/m^3) - 50 thick	m^2	21,855		
16.	Steel fibre reinforced shotcrete (30kg/m3) – 125 thick	m^2	1,930		
17.	Steel fibre reinforced shotcrete (30kg/m3) – 150 thick	m^2	5,790		
18.	Probe drilling from tunnel face (40m holes)	m	4,266		
19.	Grouting to reduce water seepage into the tunnel.	t	300		
20.	Mass concrete secondary lining in fault zones, 300 thick, concrete grade C40	m^3	1,737		
21.	PVC waterprroof membrane 2mm thick with 500 g/m^2 fleece	m^2	5,790		
	Tunnel - Ancillary Works				
22.	Mass concrete surround to drainage pipes and cable ducts	m^3	3,007		
23.	Cable ducts	m	25,000		
24.	Cable draw pits c/w Elkington Gattic heavy duty cover and frame 900x600 clear (50m c/c both sides)	no	100		
25.	Tunnel sump discharge pipework, 250 ND ductile iron	m	1300		
26.	Tunnel drainage pipe MDPE 250 ND	m	3,050		
27.	Drainage gullies (40m c/c inside of curves	no	76		
Page Total Carried to Summary					

Item No.	Description	Unit	Quantity	Rate	Amount
	only)				
28.	Concrete kerb	m	5,000		
	Tunnel - Road Construction				
29.	40mm Hot rolled asphalt wearing course	m^2	15,000		
30.	290mm Dense bitumen macadam 50 roadbase	m^2	15,000		
31.	150mm Type 1 sub base	m^2	15,000		
	Building Works				
32.	Tunnel services building located at Yell Portal – single storey double skin brick building on mass concrete raft foundation, 15m x 5m plan area.	Lump Sum			

Page Total Carried to Summary	

Summary	Amount
Page S3 – 2 Total	
Page S3 – 3 Total	
Page S3 – 4 Total	
Estimated Total for Civil Works Carried to Grand Summary	

Item No.	Description	Unit	Quantity	Rate	Amount
	Power Supply				
1.	Supply and installation of 11kV power supply including switchgear and transformers in tunnel	Lump Sum			
	Tunnel Lighting				
2.	Low-pressure sodium lighting – Interior zone - single lamps at 25m spacing, Entry /exit zone – 10m spacing (total of 135 lamps). To include for power supply, cabling and provision of emergency lighting of UPS.	Lump Sum			
	Tunnel Sump				
3.	Submersible sump pumps (2 pumps – 1 duty and 1 stand-by) including switchgear, cabling, connection to power supply, float switches, pump guide rails and supports, Flygt Bibo 2400 (Stainless steel) or similar approved	Lump Sum			
4.	Hydrocarbon monitoring system at low point sump including cabling and connection to power supply and UPS.	Lump Sum			
	Ventilation				
5.	12 No. 1120mm dia roof mounted axial flow ventilation fans including switchgear, cabling and connection to power supply, Howden APR-1120/403 (45kW) or similar approved.	Lump Sum			

Page Total Carried to Summary	

Item No.	Description	Unit	Quantity	Rate	Amount
	Monitoring Systems				
6.	Carbon monoxide monitoring system including stand-by provision and cabling and connection to power supply and UPS.	Lump Sum			
	Safety Systems				
7.	Fire extinguishers mounted in Emergency Point niches (25no).	Lump Sum			
8.	Emergency telephone system including cabling and installation at Emergency Point niches (25no).	Lump Sum			
9.	Tunnel closure barriers and tunnel/lane closure signage.	Lump Sum			
	Plant at Tunnel Services Building				
10.	Plant includes: • HV Switchgear • LV Switchgear • Transformers • Uninterrupted Power Supply (UPS) • Stand-by diesel generator	Lump Sum			
	Page Total Carried to Summary				

Summary	Amount
Page S3 – 6 Total	
Page S3 – 7 Total	
Estimated Total for M&E Works Carried to Grand Summary	

Grand Summary	Amount
Estimated Total for Civil Works	
Estimated Total for M&E Works	
Estimated Total	
Estimated Additional Lump Sum for "Ground Risk"	
Estimated Total Including "Ground Risk"	

Bill of Quantities
BD78/99 Cross-Section

Preamble

1. Excavation items to include for excavation by ripping or drill and blast.

2. Excavation items to include for scaling and where necessary for trimming to the required profile.

3. Excavation items shall include for disposal of excavated material off site to a disposal site no further than 3miles from each portal.

4. Excavation volumes do not allow for bulking.

5. Allowance shall be made for control of seepage water into the tunnel during construction.

6. Excavation quantities include an allowance for shotcrete support where applicable.

7. Probe drilling is assumed to include for two inclined holes ahead of the face, drilling as part of the tunnelling cycle such that 10m of proven ground lies ahead of the tunnel at all times.

8. Grouting is measured in tonnes of cement but shall include for drilling grout holes, mixing and pumping grout.

Page Total Carried to Summary	

Item No.	Description	Unit	Quantity	Rate	Amount
	Approach Cuttings – Excavation and Support				
1.	Cutting excavation in fair rock associated Q 1 - 4	m^3	11,825		
2.	Installation at the tunnel portal of fully grouted, double protection rockbolts, CT bolts or similar approved, length not exceeding 3m, any inclination.	no	80		
3.	Steel fibre reinforced shotcrete (30kg/m^3) - 50 thick	m^2	512		
	Approach Cuttings - Ancillary Works				
4.	Road drainage pipe, concrete, 250 ND	m	2,400		
5.	Drainage gullies (25m c/c)	no	96		
6.	Concrete kerb	m	2,400		
	Approach Cuttings - Road Construction				
7.	40mm Hot rolled asphalt wearing course	m^2	11,400		
8.	290mm Dense bitumen macadam 50 roadbase	m^2	11,400		
9.	150mm Type 1 sub base	m^2	11,400		
	Tunnel – Excavation and Support				
10.	Excavation in extremely poor rock at thrusts and faults Q 0.01 - 0.1	m^3	19,200		
	Page Total Carried to Summary				

Item No.	Description	Unit	Quantity	Rate	Amount
11.	Excavation in very poor rock associated with weathered zones at portals Q 0.1 - 1.0	m^3	6,350		
12.	Excavation in fair associated with faults and thrusts Q 4 – 10	m^3	37,080		
13.	Excavation in good rock Q 10 - 40	m^3	91,650		
14.	Installation of fully grouted, double protection rockbolts, CT bolts or similar approved, length not exceeding 3m, any inclination.	no	13,839		
15.	Steel fibre reinforced shotcrete (30kg/m^3) - 50 thick	m^2	24,360		
16.	Steel fibre reinforced shotcrete (30kg/m3) – 125 thick	m^2	2,210		
17.	Steel fibre reinforced shotcrete (30kg/m3) – 150 thick	m^2	6,630		
18.	Probe drilling from tunnel face (40m holes)	m	4,266		
19.	Grouting to reduce water seepage into the tunnel.	t	300		
20.	Mass concrete secondary lining in fault zones, 300 thick, concrete grade C40	m^3	1,989		
21.	PVC waterprroof membrane 2mm thick with 500 g/m^2 fleece	m^2	6,630		
	Tunnel - Ancillary Works				
22.	Mass concrete surround to drainage pipes and cable ducts	m^3	3,007		
23.	Cable ducts	m	25,000		
24.	Cable draw pits c/w Elkington Gattic heavy duty cover and frame 900x600 clear (50m c/c both sides)	no	100		
25.	Tunnel sump discharge pipework, 250 ND ductile iron	m	1300		
26.	Tunnel drainage pipe MDPE 250 ND	m	3,050		
27.	Drainage gullies (40m c/c inside of curves	no	76		
Page Total Carried to Summary					

Item No.	Description	Unit	Quantity	Rate	Amount
	only)				
28.	Concrete kerb	m	5,000		
	Tunnel - Road Construction				
29.	40mm Hot rolled asphalt wearing course	m^2	15,000		
30.	290mm Dense bitumen macadam 50 roadbase	m^2	15,000		
31.	150mm Type 1 sub base	m^2	15,000		
	Building Works				
32.	Tunnel services building located at Yell Portal – single storey double skin brick building on mass concrete raft foundation, 15m x 5m plan area.	Lump Sum			

Page Total Carried to Summary	

Summary	Amount
Page S4 – 2 Total	
Page S4 – 3 Total	
Page S4 – 4 Total	
Estimated Total for Civil Works Carried to Grand Summary	

Item No.	Description	Unit	Quantity	Rate	Amount
	Power Supply				
1.	Supply and installation of 11kV power supply including switchgear and transformers in tunnel	Lump Sum			
	Tunnel Lighting				
2.	Low-pressure sodium lighting – Interior zone - single lamps at 25m spacing, Entry /exit zone – 10m spacing (total of 135 lamps). To include for power supply, cabling and provision of emergency lighting of UPS.	Lump Sum			
	Tunnel Sump				
3.	Submersible sump pumps (2 pumps – 1 duty and 1 stand-by) including switchgear, cabling, connection to power supply, float switches, pump guide rails and supports, Flygt Bibo 2400 (Stainless steel) or similar approved	Lump Sum			
4.	Hydrocarbon monitoring system at low point sump including cabling and connection to power supply and UPS.	Lump Sum			
	Ventilation				
5.	12 No. 1120mm dia roof mounted axial flow ventilation fans including switchgear, cabling and connection to power supply, Howden APR-1120/403 (45kW) or similar approved.	Lump Sum			

Page Total Carried to Summary	

Item No.	Description	Unit	Quantity	Rate	Amount
	Monitoring Systems				
6.	Carbon monoxide monitoring system including stand-by provision and cabling and connection to power supply and UPS.	Lump Sum			
	Safety Systems				
7.	Fire extinguishers mounted in Emergency Point niches (25no).	Lump Sum			
8.	Emergency telephone system including cabling and installation at Emergency Point niches (25no).	Lump Sum			
9.	Tunnel closure barriers and tunnel/lane closure signage.	Lump Sum			
	Plant at Tunnel Services Building				
10.	Plant includes: • HV Switchgear • LV Switchgear • Transformers • Uninterrupted Power Supply (UPS) • Stand-by diesel generator	Lump Sum			

Page Total Carried to Summary	

Summary	Amount
Page S4 – 6 Total	
Page S4 – 7 Total	
Estimated Total for M&E Works Carried to Grand Summary	

Grand Summary	**Amount**
Estimated Total for Civil Works	
Estimated Total for M&E Works	
Estimated Total	
Estimated Additional Lump Sum for "Ground Risk"	
Estimated Total Including "Ground Risk"	

Appendix C
Contractor's Estimates

Skanska

Skanska - Norwegian T8

Item No.	Description	Unit	Quantity	Rate	Amount	Amount
	CIVIL WORKS				NOK	£
	Preliminaries					
	Mobilisation	LS	1	21,000,000	21,000,000	1,578,952
	Approach Cuttings – Excavation and Support					
1	Cutting excavation in fair rock associated Q 1 - 4	m3	11,825	100	1,182,500	88,910
2	Install at the tunnel portal of fully grouted, double prot rockbolts, CT bolts or similar approved, length not exceeding 3m, any inclination.	no	80	400	32,000	2,406
3	Steel fibre reinforced shotcrete (30kg/m3) - 50 thick	m2	512	250	128,000	9,624
	Approach Cuttings - Ancillary Works					
4	Road drainage pipe, concrete, 250 ND	m	2,400	400	960,000	72,181
5	Drainage gullies (25m c/c)	no	96	5,000	480,000	36,090
6	Concrete kerb	m	2,400	400	960,000	72,181
	Approach Cuttings - Road Construction					
7	40mm Hot rolled asphalt wearing course	m2	11,400	70	798,000	60,000
8	290mm Dense bitumen macadam 50 roadbase	m2	11,400	140	1,596,000	120,000
9	150mm Type 1 sub base	m2	11,400	50	570,000	42,857
	Tunnel – Excavation and Support					
10	Excavation in extremely poor rock at thrusts and faults Q 0.01 - 0.1	m3	15,510	300	4,653,000	349,851
11	Excavation in very poor rock associated with weathered zones at portals Q 0.1 - 1.0	m3	5,120	250	1,280,000	96,241
12	Excavation in fair associated with faults and thrusts Q 4 – 10	m3	29,880	220	6,573,600	494,257
13	Excavation in good rock Q 10 - 40	m3	73,650	220	16,203,000	1,218,274
14	Installation of fully grouted, double protection rockbolts, CT bolts or similar approved, length not exceeding 3m, any inclination.	no	12,812	450	5,765,400	433,490
15	Steel fibre reinforced shotcrete (30kg/m3) - 50 thick	m2	21,855	250	5,463,750	410,810
16	Steel fibre reinforced shotcrete (30kg/m3) – 125 thick	m2	1,930	470	907,100	68,203
17	Steel fibre reinforced shotcrete (30kg/m3) – 150 thick	m2	5,790	550	3,184,500	239,437
18	Probe drilling from tunnel face (40m holes)+ groutholes	m	40,000	70	2,800,000	210,527
19	Grouting to reduce water seepage into the tunnel.	t	300	6,000	1,800,000	135,339
20	Mass concrete secondary lining in fault zones, 300 thick, concrete grade C40	m3	1,737	2,500	4,342,500	326,505
21	PVC waterprroof membrane 2mm thick with 500 g/m2 fleece	m2	5,790	400	2,316,000	174,136
	Tunnel - Ancillary Works					
22	Mass concrete surround to drainage pipes and cable ducts	m3	3,007	1,800	5,412,600	406,964
23	Cable ducts	m	25,000	50	1,250,000	93,985
24	Cable draw pits c/w Elkington Gattic heavy duty cover and frame 900x600 clear (50m c/c both sides)	no	100	11,000	1,100,000	82,707
25	Tunnel sump discharge pipework, 250 ND ductile iron	m	1,300	1,000	1,300,000	97,745
26	Tunnel drainage pipe MDPE 250 ND	m	3,050	300	915,000	68,797
27	Drainage gullies (40m c/c inside of curves only)	no	76	5,700	433,200	32,572
28	Concrete kerb	m	5,000	200	1,000,000	75,188
	Tunnel - Road Construction					
29	40mm Hot rolled asphalt wearing course	m2	15,000	70	1,050,000	78,948
30	290mm Dense bitumen macadam 50 roadbase	m2	15,000	140	2,100,000	157,895
31	150mm Type 1 sub base	m2	15,000	50	750,000	56,391
	Building Works					

32	Tunnel services building located at Yell Portal – single storey double skin brick building on mass concrete raft foundation, 15m x 5m plan area.	L S	1	600,000	600,000	45,113
	Additional items added by Skanska for spiling, "watershield works" excavation of sump and portals plus a contingency	L S	1	15,000,000	15,000,000	1,127,823
	ESTIMATED SUB-TOTAL FOR CIVIL WORKS				**113,906,150**	8,564,398
	M&E WORKS					
	Power Supply					
1	Supply and installation of 11kV power supply including switchgear and transformers in tunnel	LS	1			
	Tunnel Lighting					
2	Low-pressure sodium lighting – Interior zone - single lamps at 25m spacing, Entry /exit zone – 10m spacing (total of 135 lamps). To include for power supply, cabling and provision of emergency lighting of UPS.	LS	1			
	Tunnel Sump					
3	Submersible sump pumps (2 pumps – 1 duty and 1 stand-by) including switchgear, cabling, connection to power supply, float switches, pump guide rails and supports, Flygt Bibo 2400 (Stainless steel) or similar approved	LS	1			
4	Hydrocarbon monitoring system at low point sump including cabling and connection to power supply and UPS.	LS	1			
	Ventilation					
5	12 No. 1120mm dia roof mounted axial flow ventilation fans including switchgear, cabling and connection to power supply, Howden APR-1120/403 (45kW) or similar approved.	LS	1			
	Monitoring Systems					
6	Carbon monoxide monitoring system including stand-by provision and cabling and connection to power supply and UPS.	LS	1			
	Safety Systems					
7	Fire extinguishers mounted in Emergency Point niches (25no).	LS	1			
8	Emergency telephone system including cabling and installation at Emergency Point niches (25no).	LS	1			
9	Tunnel closure barriers and tunnel/lane closure signage.	LS	1			
	Plant at Tunnel Services Building					
10	Plant includes: - HV Switchgear - LV Switchgear - Transformers - Uninterrupted Power Supply (UPS) - Stand-by diesel generator	LS	1			
	ESTIMATED SUB-TOTAL FOR M&E WORKS				**10,000,000**	751,882
	ESTIMATED TOTAL COST				**123,906,150**	9,316,280

Item No.	Description	Unit	Quantity	Rate	Amount	Amount
	CIVIL WORKS					£
	Preliminaries					
	Mobilisation	LS	1	21,500,000	21,500,000	1,616,546
	Approach Cuttings – Excavation and Support					
1	Cutting excavation in fair rock associated Q 1 - 4	m3	11,825	100	1,182,500	88,910
2	Install at the tunnel portal of fully grouted, double prot rockbolts, CT bolts or similar approved, length not exceeding 3m, any inclination.	no	80	400	32,000	2,406
3	Steel fibre reinforced shotcrete (30kg/m3) - 50 thick	m2	512	250	128,000	9,624
	Approach Cuttings - Ancillary Works					
4	Road drainage pipe, concrete, 250 ND	m	2,400	400	960,000	72,181
5	Drainage gullies (25m c/c)	no	96	5,000	480,000	36,090
6	Concrete kerb	m	2,400	400	960,000	72,181
	Approach Cuttings - Road Construction					
7	40mm Hot rolled asphalt wearing course	m2	11,400	70	798,000	60,000
8	290mm Dense bitumen macadam 50 roadbase	m2	11,400	140	1,596,000	120,000
9	150mm Type 1 sub base	m2	11,400	50	570,000	42,857
	Tunnel – Excavation and Support					
10	Excavation in extremely poor rock at thrusts and faults Q 0.01 - 0.1	m3	19,200	280	5,376,000	404,212
11	Excavation in very poor rock associated with weathered zones at portals Q 0.1 - 1.0	m3	6,350	235	1,492,250	112,200
12	Excavation in fair associated with faults and thrusts Q 4 – 10	m3	37,080	215	7,972,200	599,415
13	Excavation in good rock Q 10 - 40	m3	91,650	215	19,704,750	1,481,565
14	Installation of fully grouted, double protection rockbolts, CT bolts or similar approved, length not exceeding 3m, any inclination.	no	13,839	450	6,227,550	468,238
15	Steel fibre reinforced shotcrete (30kg/m3) - 50 thick	m2	24,360	250	6,090,000	457,896
16	Steel fibre reinforced shotcrete (30kg/m3) – 125 thick	m2	2,210	470	1,038,700	78,098
17	Steel fibre reinforced shotcrete (30kg/m3) – 150 thick	m2	6,630	550	3,646,500	274,174
18	Probe drilling from tunnel face (40m holes)+ groutholes	m	40,000	70	2,800,000	210,527
19	Grouting to reduce water seepage into the tunnel.	t	300	6,000	1,800,000	135,339
20	Mass concrete secondary lining in fault zones, 300 thick, concrete grade C40	m3	1,989	2,500	4,972,500	373,873
21	PVC waterprroof membrane 2mm thick with 500 g/m2 fleece	m2	6,630	400	2,652,000	199,399
	Tunnel - Ancillary Works					
22	Mass concrete surround to drainage pipes and cable ducts	m3	3,007	1,800	5,412,600	406,964
23	Cable ducts	m	25,000	50	1,250,000	93,985
24	Cable draw pits c/w Elkington Gattic heavy duty cover and frame 900x600 clear (50m c/c both sides)	no	100	11,000	1,100,000	82,707
25	Tunnel sump discharge pipework, 250 ND ductile iron	m	1,300	1,000	1,300,000	97,745
26	Tunnel drainage pipe MDPE 250 ND	m	3,050	300	915,000	68,797
27	Drainage gullies (40m c/c inside of curves only)	no	76	5,700	433,200	32,572
28	Concrete kerb	m	5,000	200	1,000,000	75,188
	Tunnel - Road Construction					
29	40mm Hot rolled asphalt wearing course	m2	15,000	70	1,050,000	78,948
30	290mm Dense bitumen macadam 50 roadbase	m2	15,000	140	2,100,000	157,895
31	150mm Type 1 sub base	m2	15,000	50	750,000	56,391
	Building Works					

32	Tunnel services building located at Yell Portal – single storey double skin brick building on mass concrete raft foundation, 15m x 5m plan area.	L S	1	600,000	600,000	45,113
	Additional items added by Skanska for spiling, "watershield works" excavation of sump and portals plus a contingency	L S	1	15,000,000	15,000,000	1,127,823
	ESTIMATED SUB-TOTAL FOR CIVIL WORKS				**122,889,750**	**9,239,859**
	M&E WORKS					
	Power Supply					
1	Supply and installation of 11kV power supply including switchgear and transformers in tunnel	LS	1			
	Tunnel Lighting					
2	Low-pressure sodium lighting – Interior zone - single lamps at 25m spacing, Entry /exit zone – 10m spacing (total of 135 lamps). To include for power supply, cabling and provision of emergency lighting of UPS.	LS	1			
	Tunnel Sump					
3	Submersible sump pumps (2 pumps – 1 duty and 1 stand-by) including switchgear, cabling, connection to power supply, float switches, pump guide rails and supports, Flygt Bibo 2400 (Stainless steel) or similar approved	LS	1			
4	Hydrocarbon monitoring system at low point sump including cabling and connection to power supply and UPS.	LS	1			
	Ventilation					
5	12 No. 1120mm dia roof mounted axial flow ventilation fans including switchgear, cabling and connection to power supply, Howden APR-1120/403 (45kW) or similar approved.	LS	1			
	Monitoring Systems					
6	Carbon monoxide monitoring system including stand-by provision and cabling and connection to power supply and UPS.	LS	1			
	Safety Systems					
7	Fire extinguishers mounted in Emergency Point niches (25no).	LS	1			
8	Emergency telephone system including cabling and installation at Emergency Point niches (25no).	LS	1			
9	Tunnel closure barriers and tunnel/lane closure signage.	LS	1			
	Plant at Tunnel Services Building					
10	Plant includes: HV Switchgear LV Switchgear Transformers Uninterrupted Power Supply (UPS) Stand-by diesel generator	LS	1			
	ESTIMATED SUB-TOTAL FOR M&E WORKS				**10,000,000**	751,882
	ESTIMATED TOTAL COST				**132,889,750**	**9,991,741**

Veidekke

Veidekke - Norwegian T8

Item No.	Description	Unit	Quantity	Rate	Amount	Amount £
	CIVIL WORKS					
	Preliminaries					
	Mobilisation	LS	1	30,000,000	30,000,000	2,255,646
	Approach Cuttings – Excavation and Support					
1	Cutting excavation in fair rock associated Q 1 - 4	m3	11,825	120	1,419,000	106,692
2	Install at the tunnel portal of fully grouted, double prot rockbolts, CT bolts or similar approved, length not exceeding 3m, any inclination.	no	80	1,000	80,000	6,015
3	Steel fibre reinforced shotcrete (30kg/m3) - 50 thick	m2	512	250	128,000	9,624
	Approach Cuttings - Ancillary Works					
4	Road drainage pipe, concrete, 250 ND	m	2,400	800	1,920,000	144,361
5	Drainage gullies (25m c/c)	no	96	8,500	816,000	61,354
6	Concrete kerb	m	2,400	350	840,000	63,158
	Approach Cuttings - Road Construction					
7	40mm Hot rolled asphalt wearing course	m2	11,400	100	1,140,000	85,715
8	290mm Dense bitumen macadam 50 roadbase	m2	11,400	120	1,368,000	102,857
9	150mm Type 1 sub base	m2	11,400	70	798,000	60,000
	Tunnel – Excavation and Support					
10	Excavation in extremely poor rock at thrusts and faults Q 0.01 - 0.1	m3	15,510	350	5,428,500	408,159
11	Excavation in very poor rock associated with weathered zones at portals Q 0.1 - 1.0	m3	5,120	280	1,433,600	107,790
12	Excavation in fair associated with faults and thrusts Q 4 – 10	m3	29,880	250	7,470,000	561,656
13	Excavation in good rock Q 10 - 40	m3	73,650	220	16,203,000	1,218,274
14	Installation of fully grouted, double protection rockbolts, CT bolts or similar approved, length not exceeding 3m, any inclination.	no	12,812	650	8,327,800	626,152
15	Steel fibre reinforced shotcrete (30kg/m3) - 50 thick	m2	21,855	180	3,933,900	295,783
16	Steel fibre reinforced shotcrete (30kg/m3) – 125 thick	m2	1,930	440	849,200	63,850
17	Steel fibre reinforced shotcrete (30kg/m3) – 150 thick	m2	5,790	530	3,068,700	230,730
18	Probe drilling from tunnel face (40m holes)+ groutholes	m	4,266	100	426,600	32,075
19	Grouting to reduce water seepage into the tunnel.	t	300	16,000	4,800,000	360,903
20	Mass concrete secondary lining in fault zones, 300 thick, concrete grade C40	m3	1,737	3,200	5,558,400	417,926
21	PVC waterprroof membrane 2mm thick with 500 g/m2 fleece	m2	5,790	500	2,895,000	217,670
	Tunnel - Ancillary Works					
22	Mass concrete surround to drainage pipes and cable ducts	m3	3,007	2,600	7,818,200	587,836
23	Cable ducts	m	25,000	60	1,500,000	112,782
24	Cable draw pits c/w Elkington Gattic heavy duty cover and frame 900x600 clear (50m c/c both sides)	no	100	8,000	800,000	60,151
25	Tunnel sump discharge pipework, 250 ND ductile iron	m	1,300	900	1,170,000	87,970
26	Tunnel drainage pipe MDPE 250 ND	m	3,050	400	1,220,000	91,730
27	Drainage gullies (40m c/c inside of curves only)	no	76	7,500	570,000	42,857
28	Concrete kerb	m	5,000	350	1,750,000	131,579
	Tunnel - Road Construction					
29	40mm Hot rolled asphalt wearing course	m2	15,000	100	1,500,000	112,782
30	290mm Dense bitumen macadam 50 roadbase	m2	15,000	130	1,950,000	146,617
31	150mm Type 1 sub base	m2	15,000	80	1,200,000	90,226
	Building Works					

32	Tunnel services building located at Yell Portal – single storey double skin brick building on mass concrete raft foundation, 15m x 5m plan area.	L S	1	300,000	300,000	22,556
	ESTIMATED SUB-TOTAL FOR CIVIL WORKS				**118,681,900**	**8,923,478**
	M&E WORKS					
	Power Supply					
1	Supply and installation of 11kV power supply including switchgear and transformers in tunnel	LS	1			
	Tunnel Lighting					
2	Low-pressure sodium lighting – Interior zone - single lamps at 25m spacing. Entry /exit zone – 10m spacing (total of 135 lamps). To include for power supply, cabling and provision of emergency lighting of UPS.	LS	1			
	Tunnel Sump					
3	Submersible sump pumps (2 pumps – 1 duty and 1 stand-by) including switchgear, cabling, connection to power supply, float switches, pump guide rails and supports, Flygt Bibo 2400 (Stainless steel) or similar approved	LS	1			
4	Hydrocarbon monitoring system at low point sump including cabling and connection to power supply and UPS.	LS	1			
	Ventilation					
5	12 No. 1120mm dia roof mounted axial flow ventilation fans including switchgear, cabling and connection to power supply, Howden APR-1120/403 (45kW) or similar approved.	LS	1			
	Monitoring Systems					
6	Carbon monoxide monitoring system including stand-by provision and cabling and connection to power supply and UPS.	LS	1			
	Safety Systems					
7	Fire extinguishers mounted in Emergency Point niches (25no).	LS	1			
8	Emergency telephone system including cabling and installation at Emergency Point niches (25no).	LS	1			
9	Tunnel closure barriers and tunnel/lane closure signage.	LS	1			
	Plant at Tunnel Services Building					
10	Plant includes: HV Switchgear LV Switchgear Transformers Uninterrupted Power Supply (UPS) Stand-by diesel generator	LS	1			
	ESTIMATED SUB-TOTAL FOR M&E WORKS					
	ESTIMATED TOTAL COST				**118,681,900**	**8,923,478**

Item No.	Description	Unit	Quantity	Rate	Amount	Amount
	CIVIL WORKS					£
	Preliminaries					
	Mobilisation	LS	1	33,000,000	33,000,000	2,481,211
	Approach Cuttings – Excavation and Support					
1	Cutting excavation in fair rock associated Q 1 - 4	m3	11,825	120	1,419,000	106,692
2	Install at the tunnel portal of fully grouted, double prot rockbolts, CT bolts or similar approved, length not exceeding 3m, any inclination.	no	80	1,000	80,000	6,015
3	Steel fibre reinforced shotcrete (30kg/m3) - 50 thick	m2	512	250	128,000	9,624
	Approach Cuttings - Ancillary Works					
4	Road drainage pipe, concrete, 250 ND	m	2,400	800	1,920,000	144,361
5	Drainage gullies (25m c/c)	no	96	8,500	816,000	61,354
6	Concrete kerb	m	2,400	350	840,000	63,158
	Approach Cuttings - Road Construction					
7	40mm Hot rolled asphalt wearing course	m2	11,400	100	1,140,000	85,715
8	290mm Dense bitumen macadam 50 roadbase	m2	11,400	120	1,368,000	102,857
9	150mm Type 1 sub base	m2	11,400	70	798,000	60,000
	Tunnel – Excavation and Support					
10	Excavation in extremely poor rock at thrusts and faults Q 0.01 - 0.1	m3	19,200	350	6,720,000	505,265
11	Excavation in very poor rock associated with weathered zones at portals Q 0.1 - 1.0	m3	6,350	280	1,778,000	133,685
12	Excavation in fair associated with faults and thrusts Q 4 – 10	m3	37,080	250	9,270,000	696,995
13	Excavation in good rock Q 10 - 40	m3	91,650	220	20,163,000	1,516,020
14	Installation of fully grouted, double protection rockbolts, CT bolts or similar approved, length not exceeding 3m, any inclination.	no	13,839	650	8,995,350	676,344
15	Steel fibre reinforced shotcrete (30kg/m3) - 50 thick	m2	24,360	180	4,384,800	329,685
16	Steel fibre reinforced shotcrete (30kg/m3) – 125 thick	m2	2,210	440	972,400	73,113
17	Steel fibre reinforced shotcrete (30kg/m3) – 150 thick	m2	6,630	530	3,513,900	264,204
18	Probe drilling from tunnel face (40m holes)+ groutholes	m	4,266	100	426,600	32,075
19	Grouting to reduce water seepage into the tunnel.	t	300	16,000	4,800,000	360,903
20	Mass concrete secondary lining in fault zones, 300 thick, concrete grade C40	m3	1,989	3,200	6,364,800	478,558
21	PVC waterprroof membrane 2mm thick with 500 g/m2 fleece	m2	6,630	500	3,315,000	249,249
	Tunnel - Ancillary Works					
22	Mass concrete surround to drainage pipes and cable ducts	m3	3,007	2,600	7,818,200	587,836
23	Cable ducts	m	25,000	60	1,500,000	112,782
24	Cable draw pits c/w Elkington Gattic heavy duty cover and frame 900x600 clear (50m c/c both sides)	no	100	8,000	800,000	60,151
25	Tunnel sump discharge pipework, 250 ND ductile iron	m	1,300	900	1,170,000	87,970
26	Tunnel drainage pipe MDPE 250 ND	m	3,050	400	1,220,000	91,730
27	Drainage gullies (40m c/c inside of curves only)	no	76	7,500	570,000	42,857
28	Concrete kerb	m	5,000	350	1,750,000	131,579
	Tunnel - Road Construction					
29	40mm Hot rolled asphalt wearing course	m2	15,000	100	1,500,000	112,782
30	290mm Dense bitumen macadam 50 roadbase	m2	15,000	130	1,950,000	146,617
31	150mm Type 1 sub base	m2	15,000	80	1,200,000	90,226
	Building Works					

32	Tunnel services building located at Yell Portal – single storey double skin brick building on mass concrete raft foundation, 15m x 5m plan area.	L S	1	300,000	300,000	22,556
	ESTIMATED SUB-TOTAL FOR CIVIL WORKS				**131,991,050**	**9,924,169**
	M&E WORKS					
	Power Supply					
1	Supply and installation of 11kV power supply including switchgear and transformers in tunnel	LS	1			
	Tunnel Lighting					
2	Low-pressure sodium lighting – Interior zone - single lamps at 25m spacing, Entry /exit zone – 10m spacing (total of 135 lamps). To include for power supply, cabling and provision of emergency lighting of UPS.	LS	1			
	Tunnel Sump					
3	Submersible sump pumps (2 pumps – 1 duty and 1 stand-by) including switchgear, cabling, connection to power supply, float switches, pump guide rails and supports, Flygt Bibo 2400 (Stainless steel) or similar approved	LS	1			
4	Hydrocarbon monitoring system at low point sump including cabling and connection to power supply and UPS.	LS	1			
	Ventilation					
5	12 No. 1120mm dia roof mounted axial flow ventilation fans including switchgear, cabling and connection to power supply, Howden APR-1120/403 (45kW) or similar approved.	LS	1			
	Monitoring Systems					
6	Carbon monoxide monitoring system including stand-by provision and cabling and connection to power supply and UPS.	LS	1			
	Safety Systems					
7	Fire extinguishers mounted in Emergency Point niches (25no).	LS	1			
8	Emergency telephone system including cabling and installation at Emergency Point niches (25no).	LS	1			
9	Tunnel closure barriers and tunnel/lane closure signage.	LS	1			
	Plant at Tunnel Services Building					
10	Plant includes: HV Switchgear LV Switchgear Transformers Uninterrupted Power Supply (UPS) Stand-by diesel generator	LS	1			
	ESTIMATED SUB-TOTAL FOR M&E WORKS					
	ESTIMATED **TOTAL COST**				**131,991,050**	**9,924,169**

NCC

Item No.	Description	Unit	Quantity	Rate	Amount	Amount
	CIVIL WORKS					£
	Preliminaries					
	Mobilisation	LS	1	31,362,659	31,362,659	2,358,102
	Approach Cuttings – Excavation and Support					
1	Cutting excavation in fair rock associated Q 1 - 4	m3	11,825	110	1,300,750	97,801
2	Install at the tunnel portal of fully grouted, double prot rockbolts, CT bolts or similar approved, length not exceeding 3m, any inclination.	no	80	400	32,000	2,406
3	Steel fibre reinforced shotcrete (30kg/m3) - 50 thick	m2	512	270	138,240	10,394
	Approach Cuttings - Ancillary Works					
4	Road drainage pipe, concrete, 250 ND	m	2,400	400	960,000	72,181
5	Drainage gullies (25m c/c)	no	96	4,000	384,000	28,872
6	Concrete kerb	m	2,400	250	600,000	45,113
	Approach Cuttings - Road Construction					
7	40mm Hot rolled asphalt wearing course	m2	11,400	70	798,000	60,000
8	290mm Dense bitumen macadam 50 roadbase	m2	11,400	100	1,140,000	85,715
9	150mm Type 1 sub base	m2	11,400	65	741,000	55,714
	Tunnel – Excavation and Support					
10	Excavation in extremely poor rock at thrusts and faults Q 0.01 - 0.1	m3	15,510	254	3,939,540	296,207
11	Excavation in very poor rock associated with weathered zones at portals Q 0.1 - 1.0	m3	5,120	187	957,440	71,988
12	Excavation in fair associated with faults and thrusts Q 4 – 10	m3	29,880	157	4,691,160	352,720
13	Excavation in good rock Q 10 - 40	m3	73,650	127	9,353,550	703,277
14	Installation of fully grouted, double protection rockbolts, CT bolts or similar approved, length not exceeding 3m, any inclination.	no	12,812	380	4,868,560	366,058
15	Steel fibre reinforced shotcrete (30kg/m3) - 50 thick	m2	21,855	250	5,463,750	410,810
16	Steel fibre reinforced shotcrete (30kg/m3) – 125 thick	m2	1,930	565	1,090,450	81,989
17	Steel fibre reinforced shotcrete (30kg/m3) – 150 thick	m2	5,790	630	3,647,700	274,264
18	Probe drilling from tunnel face (40m holes)+ groutholes	m	4,266	80	341,280	25,660
19	Grouting to reduce water seepage into the tunnel.	t	300	5,000	1,500,000	112,782
20	Mass concrete secondary lining in fault zones, 300 thick, concrete grade C40	m3	1,737	5,750	9,987,750	750,961
21	PVC waterprroof membrane 2mm thick with 500 g/m2 fleece	m2	5,790	250	1,447,500	108,835
	Tunnel - Ancillary Works					
22	Mass concrete surround to drainage pipes and cable ducts	m3	3,007	1,700	5,111,900	384,355
23	Cable ducts	m	25,000	80	2,000,000	150,376
24	Cable draw pits c/w Elkington Gattic heavy duty cover and frame 900x600 clear (50m c/c both sides)	no	100	16,300	1,630,000	122,557
25	Tunnel sump discharge pipework, 250 ND ductile iron	m	1,300	200	260,000	19,549
26	Tunnel drainage pipe MDPE 250 ND	m	3,050	120	366,000	27,519
27	Drainage gullies (40m c/c inside of curves only)	no	76	4,700	357,200	26,857
28	Concrete kerb	m	5,000	250	1,250,000	93,985
	Tunnel - Road Construction					
29	40mm Hot rolled asphalt wearing course	m2	15,000	70	1,050,000	78,948
30	290mm Dense bitumen macadam 50 roadbase	m2	15,000	100	1,500,000	112,782
31	150mm Type 1 sub base	m2	15,000	65	975,000	73,308
	Building Works					

32	Tunnel services building located at Yell Portal – single storey double skin brick building on mass concrete raft foundation, 15m x 5m plan area.	L S	1	600,000	600,000	45,113
	ESTIMATED SUB-TOTAL FOR CIVIL WORKS				**99,845,429**	**7,507,198**
	M&E WORKS					
	Power Supply					
1	Supply and installation of 11kV power supply including switchgear and transformers in tunnel	LS	1	5500000	5,500,000	413,535
	Tunnel Lighting					
2	Low-pressure sodium lighting – Interior zone - single lamps at 25m spacing, Entry /exit zone – 10m spacing (total of 135 lamps). To include for power supply, cabling and provision of emergency lighting of UPS.	LS	1	500000	500,000	37,594
	Tunnel Sump					
3	Submersible sump pumps (2 pumps – 1 duty and 1 stand-by) including switchgear, cabling, connection to power supply, float switches, pump guide rails and supports, Flygt Bibo 2400 (Stainless steel) or similar approved	LS	1	300000	300,000	22,556
4	Hydrocarbon monitoring system at low point sump including cabling and connection to power supply and UPS.	LS	1	100000	100,000	7,519
	Ventilation					
5	12 No. 1120mm dia roof mounted axial flow ventilation fans including switchgear, cabling and connection to power supply, Howden APR-1120/403 (45kW) or similar approved.	LS	1	706000	706,000	53,083
	Monitoring Systems					
6	Carbon monoxide monitoring system including stand-by provision and cabling and connection to power supply and UPS.	LS	1	100000	100,000	7,519
	Safety Systems					
7	Fire extinguishers mounted in Emergency Point niches (25no).	LS	1	200000	200,000	15,038
8	Emergency telephone system including cabling and installation at Emergency Point niches (25no).	LS	1	375000	375,000	28,196
9	Tunnel closure barriers and tunnel/lane closure signage.	LS	1	150000	150,000	11,278
	Plant at Tunnel Services Building					
10	Plant includes: HV Switchgear LV Switchgear Transformers Uninterrupted Power Supply (UPS) Stand-by diesel generator	LS	1	810000	810,000	60,902
	ESTIMATED SUB-TOTAL FOR M&E WORKS				**8,741,000**	657,220
	ESTIMATED TOTAL COST				**108,586,429**	**8,164,418**

Item No.	Description	Unit	Quantity	Rate	Amount	Amount
	CIVIL WORKS					£
	Preliminaries					
	Mobilisation	LS	1	34,859,155	34,859,155	2,620,997
	Approach Cuttings – Excavation and Support					
1	Cutting excavation in fair rock associated Q 1 - 4	m3	11,825	110	1,300,750	97,801
2	Install at the tunnel portal of fully grouted, double prot rockbolts, CT bolts or similar approved, length not exceeding 3m, any inclination.	no	80	400	32,000	2,406
3	Steel fibre reinforced shotcrete (30kg/m3) - 50 thick	m2	512	270	138,240	10,394
	Approach Cuttings - Ancillary Works					
4	Road drainage pipe, concrete, 250 ND	m	2,400	400	960,000	72,181
5	Drainage gullies (25m c/c)	no	96	4,000	384,000	28,872
6	Concrete kerb	m	2,400	250	600,000	45,113
	Approach Cuttings - Road Construction					
7	40mm Hot rolled asphalt wearing course	m2	11,400	70	798,000	60,000
8	290mm Dense bitumen macadam 50 roadbase	m2	11,400	100	1,140,000	85,715
9	150mm Type 1 sub base	m2	11,400	65	741,000	55,714
	Tunnel – Excavation and Support					
10	Excavation in extremely poor rock at thrusts and faults Q 0.01 - 0.1	m3	19,200	254	4,876,800	366,678
11	Excavation in very poor rock associated with weathered zones at portals Q 0.1 - 1.0	m3	6,350	187	1,187,450	89,282
12	Excavation in fair associated with faults and thrusts Q 4 – 10	m3	37,080	157	5,821,560	437,713
13	Excavation in good rock Q 10 - 40	m3	91,650	127	11,639,550	875,157
14	Installation of fully grouted, double protection rockbolts, CT bolts or similar approved, length not exceeding 3m, any inclination.	no	13,839	380	5,258,820	395,401
15	Steel fibre reinforced shotcrete (30kg/m3) - 50 thick	m2	24,360	250	6,090,000	457,896
16	Steel fibre reinforced shotcrete (30kg/m3) – 125 thick	m2	2,210	565	1,248,650	93,884
17	Steel fibre reinforced shotcrete (30kg/m3) – 150 thick	m2	6,630	630	4,176,900	314,054
18	Probe drilling from tunnel face (40m holes)+ groutholes	m	4,266	80	341,280	25,660
19	Grouting to reduce water seepage into the tunnel.	t	300	5,000	1,500,000	112,782
20	Mass concrete secondary lining in fault zones, 300 thick, concrete grade C40	m3	1,989	5,750	11,436,750	859,909
21	PVC waterprroof membrane 2mm thick with 500 g/m2 fleece	m2	6,630	250	1,657,500	124,624
	Tunnel - Ancillary Works					
22	Mass concrete surround to drainage pipes and cable ducts	m3	3,007	1,700	5,111,900	384,355
23	Cable ducts	m	25,000	80	2,000,000	150,376
24	Cable draw pits c/w Elkington Gattic heavy duty cover and frame 900x600 clear (50m c/c both sides)	no	100	16,300	1,630,000	122,557
25	Tunnel sump discharge pipework, 250 ND ductile iron	m	1,300	200	260,000	19,549
26	Tunnel drainage pipe MDPE 250 ND	m	3,050	120	366,000	27,519
27	Drainage gullies (40m c/c inside of curves only)	no	76	4,700	357,200	26,857
28	Concrete kerb	m	5,000	250	1,250,000	93,985
	Tunnel - Road Construction					
29	40mm Hot rolled asphalt wearing course	m2	15,000	70	1,050,000	78,948
30	290mm Dense bitumen macadam 50 roadbase	m2	15,000	100	1,500,000	112,782
31	150mm Type 1 sub base	m2	15,000	65	975,000	73,308
	Building Works					

32	Tunnel services building located at Yell Portal – single storey double skin brick building on mass concrete raft foundation, 15m x 5m plan area.	L S	1	600,000	600,000	45,113
	ESTIMATED SUB-TOTAL FOR CIVIL WORKS				**111,288,505**	**8,367,582**
	M&E WORKS					
	Power Supply					
1	Supply and installation of 11kV power supply including switchgear and transformers in tunnel	LS	1	5500000	5,500,000	413,535
	Tunnel Lighting					
2	Low-pressure sodium lighting – Interior zone - single lamps at 25m spacing, Entry /exit zone – 10m spacing (total of 135 lamps). To include for power supply, cabling and provision of emergency lighting of UPS.	LS	1	500000	500,000	37,594
	Tunnel Sump					
3	Submersible sump pumps (2 pumps – 1 duty and 1 stand-by) including switchgear, cabling, connection to power supply, float switches, pump guide rails and supports, Flygt Bibo 2400 (Stainless steel) or similar approved	LS	1	300000	300,000	22,556
4	Hydrocarbon monitoring system at low point sump including cabling and connection to power supply and UPS.	LS	1	100000	100,000	7,519
	Ventilation					
5	12 No. 1120mm dia roof mounted axial flow ventilation fans including switchgear, cabling and connection to power supply, Howden APR-1120/403 (45kW) or similar approved.	LS	1	706000	706,000	53,083
	Monitoring Systems					
6	Carbon monoxide monitoring system including stand-by provision and cabling and connection to power supply and UPS.	LS	1	100000	100,000	7,519
	Safety Systems					
7	Fire extinguishers mounted in Emergency Point niches (25no).	LS	1	200000	200,000	15,038
8	Emergency telephone system including cabling and installation at Emergency Point niches (25no).	LS	1	375000	375,000	28,196
9	Tunnel closure barriers and tunnel/lane closure signage.	LS	1	150000	150,000	11,278
	Plant at Tunnel Services Building					
10	Plant includes: HV Switchgear LV Switchgear Transformers Uninterrupted Power Supply (UPS) Stand-by diesel generator	LS	1	810000	810,000	60,902
	ESTIMATED SUB-TOTAL FOR M&E WORKS				**8,741,000**	657,220
	ESTIMATED **TOTAL COST**				**120,029,505**	**9,024,802**

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Item No.	Description	Unit	Quantity	Rate	Amount
	CIVIL WORKS				
	Preliminaries				
	Mobilisation	LS	1		
	Approach Cuttings – Excavation and Support				
1	Cutting excavation in fair rock associated Q 1 - 4	m3	11,825	64.57	763,540
2	Install at the tunnel portal of fully grouted, double prot rockbolts, CT bolts or similar approved, length not exceeding 3m, any inclination.	no	80	49.94	3,995
3	Steel fibre reinforced shotcrete (30kg/m3) - 50 thick	m2	512	31.96	16,364
	Approach Cuttings - Ancillary Works				
4	Road drainage pipe, concrete, 250 ND	m	2,400	36.00	86,400
5	Drainage gullies (25m c/c)	no	96	80.77	7,754
6	Concrete kerb	m	2,400	39.24	94,176
	Approach Cuttings - Road Construction				
7	40mm Hot rolled asphalt wearing course	m2	11,400	14.46	164,844
8	290mm Dense bitumen macadam 50 roadbase	m2	11,400	32.12	366,168
9	150mm Type 1 sub base	m2	11,400	9.35	106,590
	Tunnel – Excavation and Support				
10	Excavation in extremely poor rock at thrusts and faults Q 0.01 - 0.1	m3	15,510	71.20	1,104,312
11	Excavation in very poor rock associated with weathered zones at portals Q 0.1 - 1.0	m3	5,120	71.20	364,544
12	Excavation in fair associated with faults and thrusts Q 4 – 10	m3	29,880	71.20	2,127,456
13	Excavation in good rock Q 10 - 40	m3	73,650	71.20	5,243,880
14	Installation of fully grouted, double protection rockbolts, CT bolts or similar approved, length not exceeding 3m, any inclination.	no	12,812	49.94	639,831
15	Steel fibre reinforced shotcrete (30kg/m3) - 50 thick	m2	21,855	31.96	698,486
16	Steel fibre reinforced shotcrete (30kg/m3) – 125 thick	m2	1,930	69.92	134,946
17	Steel fibre reinforced shotcrete (30kg/m3) – 150 thick	m2	5,790	83.91	485,839
18	Probe drilling from tunnel face (40m holes)+ groutholes	m	4,266		
19	Grouting to reduce water seepage into the tunnel.	t	300	199.77	59,931
20	Mass concrete secondary lining in fault zones, 300 thick, concrete grade C40	m3	1,737	507.85	882,135
21	PVC waterprroof membrane 2mm thick with 500 g/m2 fleece	m2	5,790	11.49	66,527
	Tunnel - Ancillary Works				
22	Mass concrete surround to drainage pipes and cable ducts	m3	3,007	239.73	720,868
23	Cable ducts	m	25,000	13.03	325,750
24	Cable draw pits c/w Elkington Gattic heavy duty cover and frame 900x600 clear (50m c/c both sides)	no	100	679.55	67,955
25	Tunnel sump discharge pipework, 250 ND ductile iron	m	1,300	67.20	87,360
26	Tunnel drainage pipe MDPE 250 ND	m	3,050	11.27	34,374
27	Drainage gullies (40m c/c inside of curves only)	no	76	80.77	6,139
28	Concrete kerb	m	5,000	39.24	196,200
	Tunnel - Road Construction				
29	40mm Hot rolled asphalt wearing course	m2	15,000	14.46	216,900
30	290mm Dense bitumen macadam 50 roadbase	m2	15,000	32.12	481,800

31	150mm Type 1 sub base	m2	15,000	9.35	140,250
	Building Works				
32	Tunnel services building located at Yell Portal – single storey double skin brick building on mass concrete raft foundation, 15m x 5m plan area.	L S	1	149830.50	149,831
	ESTIMATED SUB-TOTAL FOR CIVIL WORKS				**15,845,144**
	M&E WORKS				
	Power Supply				
1	Supply and installation of 11kV power supply including switchgear and transformers in tunnel	LS	1	131850.84	131,851
	Tunnel Lighting				
2	Low-pressure sodium lighting – Interior zone - single lamps at 25m spacing, Entry /exit zone – 10m spacing (total of 135 lamps). To include for power supply, cabling and provision of emergency lighting of UPS.	LS	1	259706.20	259,706
	Tunnel Sump				
3	Submersible sump pumps (2 pumps – 1 duty and 1 stand-by) including switchgear, cabling, connection to power supply, float switches, pump guide rails and supports, Flygt Bibo 2400 (Stainless steel) or similar approved	LS	1	699209.00	699,209
4	Hydrocarbon monitoring system at low point sump including cabling and connection to power supply and UPS.	LS	1	79909.60	79,910
	Ventilation				
5	12 No. 1120mm dia roof mounted axial flow ventilation fans including switchgear, cabling and connection to power supply, Howden APR-1120/403 (45kW) or similar approved.	LS	1	339615.80	339,616
	Monitoring Systems				
6	Carbon monoxide monitoring system including stand-by provision and cabling and connection to power supply and UPS.	LS	1	13430.07	13,430
	Safety Systems				
7	Fire extinguishers mounted in Emergency Point niches (25no).	nr	25	799.10	19,978
8	Emergency telephone system including cabling and installation at Emergency Point niches (25no).	nr	25	5993.22	149,831
9	Tunnel closure barriers and tunnel/lane closure signage.	LS	1	99887.00	99,887
	Plant at Tunnel Services Building				
10	Plant includes: HV Switchgear LV Switchgear Transformers Uninterrupted Power Supply (UPS) Stand-by diesel generator	LS	1	823068.88	823,069
	ESTIMATED SUB-TOTAL FOR M&E WORKS				**2,616,485**
	ESTIMATED **TOTAL COST**				**18,461,629**

Item No.	Description	Unit	Quantity	Rate	Amount
	CIVIL WORKS				
	Preliminaries				
	Mobilisation	LS	1		
	Approach Cuttings – Excavation and Support				
1	Cutting excavation in fair rock associated Q 1 - 4	m3	11,825	64.48	762,476
2	Install at the tunnel portal of fully grouted, double prot rockbolts, CT bolts or similar approved, length not exceeding 3m, any inclination.	no	80	49.88	3,990
3	Steel fibre reinforced shotcrete (30kg/m3) - 50 thick	m2	512	31.92	16,343
	Approach Cuttings - Ancillary Works				
4	Road drainage pipe, concrete, 250 ND	m	2,400	35.95	86,280
5	Drainage gullies (25m c/c)	no	96	80.66	7,743
6	Concrete kerb	m	2,400	39.18	94,032
	Approach Cuttings - Road Construction				
7	40mm Hot rolled asphalt wearing course	m2	11,400	14.44	164,616
8	290mm Dense bitumen macadam 50 roadbase	m2	11,400	32.08	365,712
9	150mm Type 1 sub base	m2	11,400	9.34	106,476
	Tunnel – Excavation and Support				
10	Excavation in extremely poor rock at thrusts and faults Q 0.01 - 0.1	m3	19,200	57.26	1,099,392
11	Excavation in very poor rock associated with weathered zones at portals Q 0.1 - 1.0	m3	6,350	57.26	363,601
12	Excavation in fair associated with faults and thrusts Q 4 – 10	m3	37,080	57.26	2,123,201
13	Excavation in good rock Q 10 - 40	m3	91,650	57.26	5,247,879
14	Installation of fully grouted, double protection rockbolts, CT bolts or similar approved, length not exceeding 3m, any inclination.	no	13,839	49.88	690,289
15	Steel fibre reinforced shotcrete (30kg/m3) - 50 thick	m2	24,360	31.92	777,571
16	Steel fibre reinforced shotcrete (30kg/m3) – 125 thick	m2	2,210	69.83	154,324
17	Steel fibre reinforced shotcrete (30kg/m3) – 150 thick	m2	6,630	83.79	555,528
18	Probe drilling from tunnel face (40m holes)+ groutholes	m	4,266		
19	Grouting to reduce water seepage into the tunnel.	t	300	199.50	59,850
20	Mass concrete secondary lining in fault zones, 300 thick, concrete grade C40	m3	1,989	507.15	1,008,721
21	PVC waterprroof membrane 2mm thick with 500 g/m2 fleece	m2	6,630	11.47	76,046
	Tunnel - Ancillary Works				
22	Mass concrete surround to drainage pipes and cable ducts	m3	3,007	239.40	719,876
23	Cable ducts	m	25,000	13.01	325,250
24	Cable draw pits c/w Elkington Gattic heavy duty cover and frame 900x600 clear (50m c/c both sides)	no	100	678.62	67,862
25	Tunnel sump discharge pipework, 250 ND ductile iron	m	1,300	67.11	87,243
26	Tunnel drainage pipe MDPE 250 ND	m	3,050	11.25	34,313
27	Drainage gullies (40m c/c inside of curves only)	no	76	80.66	6,130
28	Concrete kerb	m	5,000	39.18	195,900
	Tunnel - Road Construction				
29	40mm Hot rolled asphalt wearing course	m2	15,000	14.44	216,600
30	290mm Dense bitumen macadam 50 roadbase	m2	15,000	32.08	481,200

31	150mm Type 1 sub base	m2	15,000	9.34	140,100
	Building Works				
32	Tunnel services building located at Yell Portal – single storey double skin brick building on mass concrete raft foundation, 15m x 5m plan area.	L S	1	149625.00	149,625
	ESTIMATED SUB-TOTAL FOR CIVIL WORKS				**16,188,170**
	M&E WORKS				
	Power Supply				
1	Supply and installation of 11kV power supply including switchgear and transformers in tunnel	LS	1	131670.00	131,670
	Tunnel Lighting				
2	Low-pressure sodium lighting – Interior zone - single lamps at 25m spacing, Entry /exit zone – 10m spacing (total of 135 lamps). To include for power supply, cabling and provision of emergency lighting of UPS.	LS	1	259350.00	259,350
	Tunnel Sump				
3	Submersible sump pumps (2 pumps – 1 duty and 1 stand-by) including switchgear, cabling, connection to power supply, float switches, pump guide rails and supports, Flygt Bibo 2400 (Stainless steel) or similar approved	LS	1	698250.00	698,250
4	Hydrocarbon monitoring system at low point sump including cabling and connection to power supply and UPS.	LS	1	79800.00	79,800
	Ventilation				
5	12 No. 1120mm dia roof mounted axial flow ventilation fans including switchgear, cabling and connection to power supply, Howden APR-1120/403 (45kW) or similar approved.	LS	1	339150.00	339,150
	Monitoring Systems				
6	Carbon monoxide monitoring system including stand-by provision and cabling and connection to power supply and UPS.	LS	1	13280.00	13,280
	Safety Systems				
7	Fire extinguishers mounted in Emergency Point niches (25no).	nr	25	798.00	19,950
8	Emergency telephone system including cabling and installation at Emergency Point niches (25no).	nr	25	5985.00	149,625
9	Tunnel closure barriers and tunnel/lane closure signage.	LS	1	99750.00	99,750
	Plant at Tunnel Services Building				
10	Plant includes: HV Switchgear LV Switchgear Transformers Uninterrupted Power Supply (UPS) Stand-by diesel generator	LS	1	821940.00	821,940
	ESTIMATED SUB-TOTAL FOR M&E WORKS				**2,612,765**
	ESTIMATED TOTAL COST				**18,800,935**

Appendix D
Summary of Revised Estimates

Shetland Islands Fixed Links
Yell/Unst Crossing
Summary of Revised Estimates

16-Jan-01

Exchange Rate: **1 NOK = £0.07519**

Skanska

Amount
£

T8 Cross-Section

Civil Works	11,818,869.77	
M&E Works	2,616,485.39	
Sub-Total		14,435,355.16
Approach roads		750,000.00
Exchange Rate Risk @ 5%		759,267.76
Site Investigation, Other Surveys		300,000.00
Design, Checking, Preparation @ 3.5%		541,987.43
Site Supervision for 24 months		550,000.00
General Contingency @10%		1,548,535.52
Total		**18,885,145.87**

BD78 Cross-Section

Civil Works	12,751,005.56	
M&E Works	2,612,765.00	
Total		15,363,770.56
Approach roads		750,000.00
Exchange Rate Risk @ 5%		805,688.53
Site Investigation, Other Surveys		300,000.00
Design, Checking, Preparation @ 3.5%		574,481.97
Site Supervision for 24 months		550,000.00
General Contingency @10%		1,641,377.06
Total		**19,985,318.11**

Veidekke

T8 Cross-Section

Civil Works	12,314,400.24	
M&E Works	2,616,485.39	
Total		14,930,885.63
Approach roads		750,000.00
Exchange Rate Risk @ 5%		784,044.28
Site Investigation, Other Surveys		300,000.00
Design, Checking, Preparation @ 3.5%		559,331.00
Site Supervision for 24 months		550,000.00
General Items/Contingency @10%		1,598,088.56
Total		**19,472,349.47**

BD78 Cross-Section

Civil Works	13,695,353.86	
M&E Works	2,612,765.00	
Total		16,308,118.86
Approach roads		750,000.00
Exchange Rate Risk @ 5%		852,905.94
Site Investigation, Other Surveys		300,000.00
Design, Checking, Preparation @ 3.5%		607,534.16
Site Supervision for 24 months		550,000.00
General Contingency @10%		1,735,811.89
Total		**21,104,370.85**

NCC

T8 Cross-Section

Civil Works	10,359,933.36	
M&E Works	2,616,485.39	
Total		12,976,418.75
Approach roads		750,000.00
Exchange Rate Risk @ 5%		686,320.94
Site Investigation, Other Surveys		300,000.00
Design, Checking, Preparation @ 3.5%		490,924.66
Site Supervision for 24 months		550,000.00
General Contingency @10%		1,402,641.87
Total		**17,156,306.22**

BD78 Cross-Section

Civil Works	11,547,263.67	
M&E Works	2,612,765.00	
Total		14,160,028.67
Approach Roads		750,000.00
Exchange Rate Risk @ 5%		745,501.43
Site Investigation, Other Surveys		300,000.00
Design, Checking, Preparation @ 3.5%		532,351.00
Site Supervision for 24 months		550,000.00
General Contingency @10%		1,521,002.87
Total		**18,558,883.98**

AMEC

T8 Cross-Section

Civil Works	17,112,755.14	
M&E Works	2,616,485.39	
Total		19,729,240.53
Approach roads		750,000.00
Site Investigation, Other Surveys		300,000.00
Design, Checking, Preparation @ 3.5%		727,273.42
Site Supervision for 24 months		550,000.00
General Contingency @10%		2,077,924.05
Total		**24,134,438.00**

BD78 Cross-Section

Civil Works	17,483,223.63	
M&E Works	2,612,765.00	
Total		20,095,988.63
Approach roads		750,000.00
Site Investigation		300,000.00
Design, Checking, Preparation @ 3.5%		740,109.60
Site Supervision for 24 months		550,000.00
General Contingency @10%		2,114,598.86
Total		**24,550,697.10**

Notes:

1 Original estimate for civil works has been increased by 25% to allow for Ground
2 Original estimate for civil works has been increased by further 8% to allow for
3 M&E Works value has been taken as that supplied by AMEC - this has been added
4 Original estimate for tunnel includes approach cuttings to take road to the existing
5 All estimates include for mobilisation/ accomodation.
6 The effect of UK tax legislation on Norwegian contractors yet to be confirmed.
7 It is assumed that disposal sites fall within boundary of site and excavated spoil is
8 Civil estimates from non UK contractors increased by 5% to allow for UK H&S
9 General Items includes for accomodation works, Public Utilities diversions/ connections, land acquisition, environmental mitigation etc etc

Appendix E
Caledonian Geotech – Survey Report

1.0 INTRODUCTION

Caledonian Geotech were contracted by Messrs Halcrow Crouch on behalf of Shetland Islands Council and Phillips Petroleum, to carry out hydrographic and geophysical surveys across Bluemull Sound, which separates the islands of Yell and Unst. The site of interest lies between Virdi Point and Hoga Ness, approximately 1km north of the existing ferry crossing between Gutcher, on Yell, and Belmont, on Unst, and is under consideration as part of the North Isles Fixed Link Project. Whilst the precise nature of the proposed new link is not yet fully determined – it could be tunnel or bridge – the seabed and landfalls required to be investigated, at a reconnaissance level, by geophysical methods.

The contract was awarded on the 22nd September, 2000 and mobilisation to Shetland commenced on the 29th September when the vessel and equipment were mobilised to Aberdeen for trans-shipment to Lerwick. Survey crews departed Dundee on Monday 2nd October 2000. Whilst roadworks between Lerwick and Cullivoe impeded progress, all crews and resource were fully established on site as programmed on 3rd October, 2000.

Fieldwork commenced with the establishment of survey control stations on 4th October and marine surveys commenced on 5th October and were concluded on 6th October, 2000.

SCIENTIFIC PERSONNEL

The following personnel were dedicated to this project:

Project Manager/Party Chief/Geophysicist	:	R.J.Robinson
Senior Acoustic Engineer	:	P. Hubert
Surveyor	:	D.Koe
Geologist		M. O'Neill
Geophysicist	:	R.J.Sorapure

MARINE PERSONNEL

Survey/Marine Assistants	J. Gouk/D. Reidie/N. Ross
Vessel Skipper	R. Anderson

1.1 SURVEY OPERATIONS

Detailed daily logs are provided in Appendix 1 of this report

1.2 SURVEY REQUIREMENTS

Shetland Islands Council are in process of having links between various islands improved. In some cases, the links constitute Ro-Ro ferry terminal developments or improvements, whilst in others, fixed links are being considered. One of the latter links is between the islands of Yell and Unst, across Bluemull Sound. The site of interest lies between Virdi Point and Hoga Ness, approximately 1km north of the existing ferry crossing between Gutcher, on Yell, and Belmont, on Unst. Whilst the precise nature of the proposed new link is not fully determined – it could be tunnel or bridge – the sea bed and landfalls are to be investigated by geophysical methods.

1.3 SURVEY AREA

All surveys were timed to coincide with the neap tidal cycle between Tuesday, 5th October and Sunday 8th October, to minimise the effect of currents in Bluemull Sound, which during a Spring tidal cycle can achieve 4 – 6 knots. Even on a neap tidal cycle, it was anticipated that currents would be uncomfortably fast; and reference to the Admiralty Chart (scale 1:15,000) will reveal the presence of the whirlpool off Hoga Ness, on the Unst side of the proposed crossing. As a consequence of the anticipated marine conditions, all surveys were planned to be undertaken over the slack-water period, and a local boat skipper, with comprehensive local knowledge and experience, was also employed.

1.4 SURVEY WORKSCOPE

The original workscope, whilst not specifying the precise methods to be employed, was for three seismic lines to be surveyed; one along the proposed route centreline, and two other lines being orientated parallel to this, but offset 25m to each side. In the event, hydrographic survey, sidescan sonar survey and sub bottom profiling surveys, using two separate seismic systems, were conducted over the area of interest.

2.0 EQUIPMENT AND METHODS

2.1 EQUIPMENT SUMMARY

The following equipment was mobilised to site

Vessel	Surveyor II, amphibious survey vessel.
Navigation	XR6 RTK DGPS (± 3cm) XR5 DGPS (±0.8m) Geodimeter 140T Geodimeter 460 and Sokkisha level.
Sub bottom Profilers	Innerspace 100 Joule Sparker 305-7Khz ORE Pinger
Sidescan Sonar	Klein 521 sidescan sonar system
Echo sounder	Odom digitised hydrographic echo sounder Raytheon DE719B
Heave Compensator	TSS 320/325 Heave compensator
Tidal Control	Microtide Tide Gauge supplemented by tidal dipping.

2.2 SURVEY VESSEL

The geophysical and hydrographic surveys were conducted from Caledonian Geotech's purpose-built amphibious survey vessel, Surveyor II (Appendix 2). The vessel is 8.3m in length, has built-in wheels for landing and recovery, and is road transportable. The vessel was mobilised into the water at Cullivoe where all survey equipment was put on board. Echo-sounder and 'pinger' seismic transducers are mounted through the 'moonpool', situated in the foredeck; geographical positioning systems are mounted coaxially, above roof level. The sparker 'eel', containing the hydrophone array and seismic source, and the sidescan sonar 'fish', were offset three metres to starboard of the vessel. The position of data acquired with these systems was 'laid back' in post-processing to accommodate the difference between the position-fixing antenna on the boat, and the receiver(s) in the water.

2.3 SURVEY CONTROL

Survey stations were established by Caledonian Geotech from local OS Trig Pillars and benchmarks. The Triangulation pillar at Gallow Hill, Unst, was used for the establishment of local stations, which were established at Virdi Point, on Yell.

2.4 VESSEL POSITION

The vessel was positioned using a NAVSYMM RTK Differential GPS System, comprising two, 12-channel receivers. The base station receiver, positioned over the chosen survey station transmitted pseudo-range and carrier phase corrections via a Satel VHF radio telemetry link to the mobile GPS receiver onboard the survey vessel. The mobile GPS receiver outputs the differentially corrected vessel position to the vessel's navigation software, loaded onto an IBM compatible Pentium computer.

Position fixing, seismic and echo-sounding data collection was controlled and collated using the EIVA suite of software. All records were automatically marked-or 'fixed' at ten seconds, to allow corroboration with positional information. ('Fix' intervals of 10 seconds are selected for convenient marking of the records only; the seismic and echo-sounding records are continuous, and position updates are obtained and recorded at intervals of one second). All positions were measured and calculated with reference to OSGB36, with all levels being reduced to Chart Datum (1.37m below Ordnance Datum Lerwick).

2.5 ECHO-SOUNDER

Bathymetric information was acquired by means of an Odom Hydrotrac 200KHz hydrographic echo-sounder. Corrections for the draught of the transducer, and speed of sound in water, were determined at the start and end of survey periods by the standard bar-check method. The bar-check ensures the accuracy of depth information, to the maximum depth of the seabed being surveyed, to within ±0.1m.

The echo-sounder was operated continuously throughout the sub-bottom profiler and sidescan sonar surveys. The echo-sounder data was reduced using tidal information obtained from a tide-gauge deployed by Caledonian Geotech. The data was further correlated with the R.T.K. D.G.P.S. heights and with shore-based tidal levelling, carried out throughout the survey period. Levels from the shore-based differential stations were set from the O.S. Bench Mark OSBM VP (Appendix 2).

2.6 SUB-BOTTOM PROFILERS

Two sub-bottom profiling systems were deployed. The first, an ORE model 140 sub-bottom profiler 'Pinger' system, linked to an EPC model GSP-1086 thermal paper, graphic recorder, was used to provided high resolution information of the seabed sediments at the site. This seismic system consists of a transceiver/amplifier and filter, which is sited in the wheelhouse. This, in turn, is linked to transducers, mounted in the ship's moonpool, forward of the propellers and engines, resulting in low levels of ambient noise. This allowed clear acoustic records to be obtained. The system was operated at frequencies between 3.5kHz and 7kHz, with a variable receiver bandwidth and transmitter pulse length. The EPC recorder scale was set at 33msec. Reflected seismic energy is displayed on the EPC graphic recorder, after amplification and filtering.

The second system, a lower frequency (0.5kHz-3kHz), Innerspace 'Sparker' system enabled a greater degree of penetration of superficial sediments, thereby providing information on the surfaces of more deeply buried strata.

2.7 SIDESCAN SONAR

The survey corridor was investigated using a Klein 521 sidescan sonar and towfish. The transceiver was linked to an EPC 1086 thermal recorder and to the towfish by a signal-conducting towcable. Acoustic pulses were generated from transducers mounted on either side of the towfish; reflected acoustic energy was received by the towfish transducers and the information was passed to the graphic recorder via the transceiver/filter unit. This, in turn, provided a paper record of the seabed relief and texture along a corridor extending 75m each side of the vessel. Survey lines were run parallel to the route centre line. Layback corrections between the towfish and navigation antenna were calculated from a measured offset and the length of cable over the stern (taking account of tow-angle); these were applied during interpretation of the sidescan sonar records.

2.8 TIDE GAUGE

A Microtide, self-recording tide-gauge (Coastal Leasing Inc.), was deployed proximal to the survey area in approximately 10m of water. The tide-gauge records the variation in water depth with time and in order to relate these depths to a level datum (in this case L.A.T.), during the period of tide-gauge deployment, a Sokkisha level was deployed at Station VP DP. Tidal 'dippings' fulfil the following, useful functions:

1. They provide duplication of data and a means of cross-checking the on-site tide-gauge data (once it has been reduced);
2. They allow identification of localised, near-shore tidal surges/fluctuations - to which an offshore tide-gauge is not susceptible - which may affect the accuracy of the tidal reduction in the very inshore zone of a survey area.

Information from the tidal dippings and the tide gauge was further checked by comparison with the R.T.K. D.G.P.S. height, which was obtained on-line.

2.9 HEAVE COMPENSATION

A TSS320B surface unit was coupled to a TSS325 motion sensor, and installed on the moonpool cover of Surveyor II. Heave compensation was applied during echo-sounder and sub-bottom profiler inspections from this vessel.

3.0 GEOLOGICAL BACKGROUND

The North-Eastern Shetlands comprise a complex suite of metasediments (phyllites,schists, gneisses) and metamorphosed igneous rocks, termed the East Mainland Succession. The islands of Unst and Fetlar occupy a zone which was formerly a tectonic plate margin, along which one of the earth's plates was driven down below another in a 'subduction zone'. The Unst/Fetlar subduction zone has been correlated with the Highland Boundary Fault, which has a NE-SW orientation and crosses the mainland of Scotland from Stonehaven, south of Aberdeen, through the Mull of Kintyre in the west, and onward toward Ireland.

During the process of subduction, a complex, mixed assemblage of thrusted, folded and faulted rocks is formed at the junction of the two colliding plate boundaries. The NNE-SSW general strike of foliation noted on Unst is parallel to the strike of the thrust planes. As subduction and accretion progress, the materials which are being buckled and piled up along the margin can be displaced upward, by thrusting along shear surfaces. This can result in a series of slices of older rocks being thrust up, and on top of, younger successions.

In the case of Unst, it is considered that such thrusting has translated parts of the accreting pile of rocks over the underlying East Mainland Succession basement rocks as seen on the island of Yell. The folded and thrust rocks forming such a cover are termed 'nappes' (after the French word for table cloth 'nappe' - the cover), and two such planes, along which thrusting has occurred, outcrop along the ground surface, their lines of outcrop being orientated NNE-SSW from Burra Firth in the north, across the island and into Bluemull Sound, immediately south of the proposed crossing.

Past geological mapping has revealed that imbricate zones occur between the nappes, below the lower nappe, and above the upper nappe. The imbricate zones comprise complex slices of meta-basic rocks and low-grade metasediments such as phyllites, meta-limestones, together with horneblende schists. One imbricate zone occurs between the Wick of Belmont and the present ferry landing on Unst, though it is probable that the proposed route lies just to the north of this zone.

In the region of Virdi Point, on Yell, outcrops of schists and gneisses exhibit a N-S strike and



westerly dip, characteristic of the East Mainland Succession Moine Group. It is postulated that the rocks of Yell and those of Unst, beneath the nappes, have been folded into an antiform (an inverted 'U'), about a N-S dipping axis, the orientation of which coincides locally with that of Bluemull Sound.

Rock exposures in the region of Hoga Ness, on Unst mainland, display faulted blocks of mica schists and banded hornblende gneisses, with occasional vertical foliation, dipping towards the SE. Approximately in mid-channel of Bluemull Sound, the present survey located a 500m wide rock outcrop orientated approximately NW-SE which may represent the western limit of the thrust zone. To the west of this point the overburden materials are thinner and the coarser sediments overlying rock are closer to the seabed.

It is believed that the schists and gneisses observed on both shore landings will be typical of the basement rocks along the route. In fresh condition such rocks can be hard and very strong, although imbricate zone materials or certain meta-igneous rocks (such as those contained in the nappes), can be more susceptible to weathering degradation. Evidence of this is seen along the foreshore, where topographic lows in the onshore topography are reflected by the absence of outcrop on the foreshore; these are almost certainly areas where geological faulting has facilitated preferential weathering and erosion. Whilst no landbased field mapping was undertaken on this exercise, the BGS Sheet for the area does show two faults in the region of Hoga Ness, and the Wick of Belmont is, undoubtedly, fault controlled. On the geophysical records, the rockhead contours clearly display the control being exerted by fault structures upon their surface expression.

4.0 SURVEY RESULTS

The results of the hydrographic and seismic surveys are presented in the following charts which are contained in Appendix 6.0 of this report:

Drawing No	Drawing Title	Scale
MM0008/1	Bathymetry Chart	1:1000
MM0008/2	Seabed Features Chart	1:1000
MM0008/3	Isopachyte Chart of Upper Sand (Unit A)	1:1000
MM0008/4	Isopachyte Chart of all materials above rockhead	1:1000
MM0008/5	Interpreted Geological Profiles A-A', B-B',C-C'	1:1000 Horizontal 1:250 Vertical

4.1 BATHYMETRY

The bathymetry of the survey area is shown on Drawing No. MM0008/1 at a scale of 1:1000. All depths are shown relative to Ordnance Datum (Lerwick). ACD is 1.37m below O.D. Lerwick.

Due to the rapid shoaling at Virdi Point and Hoga Ness it was not possible to survey closer than approximately 25m from the shoreline. Minimum water depths of 3.9m were surveyed off Hoga Ness and 6.1m off the north of Virdi Point. Along the proposed route centreline, however, it was not possible to acquire soundings shallower than 13m O.D at Virdi Point (a point 30m from the shoreline). The maximum water depth (38.7m) was encountered towards the Hoga Ness side of the channel.

The seabed slopes initially at a very steep gradient of 1:4 from both shorelines down to about 20-25m. From this point the seabed contours run parallel to the coastlines, falling with an average gradient of 1:15. From 35m O.D on the Virdi Point side, the seabed contours are undulating and irregular, reflecting the presence of a large outcrop of shallow relief rock outcrop at the seabed. Extensive flats of low-lying, undulating rock outcrop fringe the shore approaches to both landfalls.

4.2 SEABED FEATURES

Seabed features within the survey area are shown on Drawing No. M0008/2.

All contacts have been derived from an interpretation of the sidescan sonar data correlated with the seismic and bathymetric data in order to locate areas of rock outcrop and any other significant features.

The seabed over the survey area appears to comprise two, distinct, recent, sedimentary units overlying a basal rock formation. Rock outcrops show a high sonar reflectivity and are seen to comprise a well foliated, massive rock assemblage fringing both shorelines.

Off Hoga Ness, the rock extends in a 100m wide expanse, with pockets of thin sand covering it at the shoreward limit. Off Virdi Point, the rock is confined to a 20-30m wide, shore-parallel band which is covered at its shoreward limit, by a fringing cover of sands, up to 20m wide and of indeterminate thickness. Rock also outcrops towards the centre of the channel in a 140m x 35m expanse which trends NNW-SSE and crosses route profiles A-A' and B-B'. A smaller rock outcrop is located to the south of the area and is shown on route profile C-C'.

The lowest sedimentary unit which overlies the rock comprises a coarse sand or gravel, possibly containing occasional cobbles and boulders. This unit is generally observed draping the sides of the rock outcrops where they are exposed on the seabed.

The final sedimentary unit comprises a uniform, highly reflective, fine-grained sand which is best seen between Hoga Ness and the central rock band. The sand in this area averages 3m in thickness and overlies the coarser sand unit. To the west of the central rock band the upper sand is much thinner, being typically less than 1m thick.

The side scan sonar survey did not detect any man-made debris, hazards or obstructions.

4.3 SEISMIC PROFILING

The shallow geology of the site has been interpreted from the results of the 'pinger' survey whilst the deeper geological units and structure have been interpreted using the 'sparker' seismic records.

For time to depth conversions of the data, an assumed acoustic velocity of 1675 m/s has been used for all units above rockhead (Unit C).

The results of the geological and seismic interpretation are presented as three profiles:

- Proposed Route centreline (Profile A-A');
- 25m north of centreline (Profile B-B');
- 25m south of centreline (Profile C-C').

In addition, two isopachyte charts have been presented to show:

- thickness of upper sand (Unit A);
- thickness of all marine deposits - comprising Units A and B - above rockhead level.

4.3.1 SEDIMENTARY OVERBURDEN

Drawing No. M0008/3 illustrates the thickness of the upper sand unit, Unit A . The sand is planar-bedded and uniform in character, both laterally and vertically, across the site. It is likely to be a loose, medium-coarse grained, shelly sand. The unit varies from a maximum thickness of 4m towards Hoga Ness, although it is, generally, much thinner (less than 1m on average).

Drawing No. M0008/4 presents an isopachyte showing the total thickness of overburden over rockhead. This combines the sand of Unit A with the coarse sand and gravel which comprises Unit B. The maximum overburden thickness is 9m off Hoga Ness, thinning to an average of 3m off Virdi Point.

4.3.2 ROCKHEAD LEVEL & STRUCTURES

Drawing No. M0008/5 comprises three interpreted Geological Profiles, A-A', B-B' and C-C', to illustrate the variations across the survey corridor.

From Hoga Ness the rock fabric is seen to dip towards the SW. An apparent folded structure is present in this vicinity which leads to a thickening of the infill sediments - up to 9m- in the region of chainage 500. Whilst this structure may be true folding, it is quite possible that it is, in fact, representative of localised faulting. Rock outcrops at the seabed in the centre of the channel although the precise structural setting of this outcrop had not been determined. The outcrop is, however, almost certainly, fault bounded: to the west of the outcrop, the character of the rock beneath the seabed appears to be different to that in the east, the rock surface here being represented by a shallow, undulating subcrop, covered by coarse gravels, cobbles and occasional boulders.

The seismic characteristics of the rock are such that they show a high impedance contrast within overlying soils The reflections from the rock surface vary laterally, providing evidence of occasional undulations, corresponding to weaker, weathered gullies. Seismic penetration into the unit is poor indicating that, with the exception of such gullies, the rock is hard and fairly fresh.

Reference has been made to the fairly complex structural geology. The dominant trend of outcrops - and valleys - is parallel to that of the Sound, approximately N-S. The isopachytes generally follow the line of the outcrop, as might be expected. Reference to these does indicate that a strong N-S ridge/trough grain is present within the bedrock topography. (NB whilst the contours shown are not those of rockhead, but, rather, isopachytes, they do - where there is not great seabed relief - demonstrate the trends which would be adopted by rockhead contours.) The strong N-S control which is being exerted by the strata (see Fig 2, at Virdi Point) is evident throughout the drawings.

The BGS sheet shows that a 'crush belt' is present between striped and banded granulitic gneiss and mica schists. This belt runs through (and is probably responsible for), the Lochs of Belmont, Snarravoe, Stiurhoul and Watlee. Such structures, sub-parallel to the route, may well be represented by the 'kinks' observed in that orientation - which can be seen in the isopachytes where variations in strength have resulted in differential erosion taking place. The

'kinks' in these isopachytes demonstrate the presence of a subordinate grain in the rock topography, which can be seen throughout the Sound (the 4.0m contour, for example, between the two outcrops in the centre of the drawing, whilst having a principal orientation slightly west of north, changes direction abruptly, 25m south of the centreline, at which position it follows the axis of the crossing). Similar, though less marked, deviations to the other isopachytes can be seen elsewhere.

Should it be the case that the main thrust zone does lie to the south of the crossing, it is still the case that faulting should be anticipated within the Sound, since the axis of the anticlinal fold in the underlying East Mainland Succession does pass, roughly N-S, along the Sound, dipping toward the south. Frequently, near-vertical, fold-axis parallel, tension fractures are associated with the convex surfaces of folded rocks: the presence of such structures would be manifest along the route as steeply-dipping (near vertical) fault and joint planes, orientated N-S. It is very probable that the intra-formational reflections shown on the profile drawing, to either side of the mid-sound outcrop, are fault/joint structures. The change in outcrop patterns in the rocks which flank the Sound - from N-S (± 20°) to almost E-W (in the case of the calcareous schists, to the north of the crossing, ie the blue coloured unit, at Ness of Wadbister), does provide a second mechanism for a route parallel lithological 'grain', within the Sound and is a direct consequence of the presence of the plunging anticline.

In summary, at least three controls are being exerted by the geological structure within the Sound, and whilst the intact rock units may be expected to be quite dense and hard in their fresh state, lithologies will change across the Sound; their mechanical strengths will vary, according to the degrees - and directions of - fractures and weathering zones which are present.

6.0 RECOMMENDTIONS

It is recommended to conduct a number of deep, marine boreholes along the line of the proposed route. The selection of suitable points is dependent on the choice of fixed link between Virdi Point and Hoga Ness. We would be pleased to advise specific co-ordinates for the borehole programme.

It is appreciated that this marine environment does not lend itself to easy drilling; the holding ground will not be good for barges; the water depths are greater than can be offered by most engineering investigation jack ups, and the currents present a real hazard.

An alternative - or at least a limitation to the numbers of necessary boreholes - would be deeper digital seismic. Inevitably, some boreholes would be necessary, but from the viewpoints of safety and cost, the fewer the better in this setting.

The geological structure would require to be very carefully monitored during any drilling works and we would strongly recommend the presence on site of both an engineering geologist and a geotechnical engineer, during any further physical investigations.